

Chelsea Community Microgrid Feasibility Assessment

Task 6 Report

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A note on section headings and building data

Chapter headings are labeled as “task” numbers, corresponding to the series of tasks assigned by the Massachusetts Clean Energy Center (CEC) in their “feasibility assessment” contract. This report fulfills the final Task (number 6), and is written two years after the CEC work was initiated. During that period, some of the buildings described herein have undergone changes in their energy systems or load. The numbers in this report may in some cases be consistent with earlier Task reports but not with current or planned energy demand. This does not affect our findings, design, or recommendations.

Introduction

For communities to flourish and local economies to thrive, reliable, affordable, and accessible energy sources are essential. Communities face losses associated with the impacts of climate change and extreme weather, as these can — in many cases — result in costly power outages. As the Resilient Urban Neighborhoods-Green Justice Coalition partnership (RUN-GJC), we recognize this concern and seek to address it. RUN-GJC is a collaborative of nine organizations dedicated to environmental justice and energy democracy, and is working in the City of Chelsea to assess the benefits of microgrids and complete a microgrid feasibility study.

The RUN-GJC Team was formed to develop a community-controlled microgrid as a replicable model of equity-driven climate disaster planning and to help advance our vision for an energy system that is clean, equitable, and democratic. RUN-GJC brings together the technical and financial expertise of RUN (Clean Energy Solutions Inc., Climable.org, Climate Action Business Association, Peregrine Energy Group, and Synapse Energy Economics) with the grassroots organizing and strategic campaigning practices of GJC (GreenRoots, Clean Water Action, Chinese Progressive Association, and Community Labor United). The Team centers leadership and decision-making around these grassroots organizations to ensure the most affected communities have agency over this work. To advance the microgrid project and policy interventions on the municipal level, RUN-GJC's work involves developing and deepening partnerships with local stakeholders, including local healthcare facilities and other anchor institutions, the local utility, and City departments including critical services in Chelsea. Additionally, to help advance supportive and complementary policy interventions on the regional and state level, RUN-GJC will coordinate its efforts with other partners in the Green Justice Coalition.

The U.S. Department of Energy (DOE) found that approximately 78% of all power outages from 1992 to 2010 were due to weather-related events.¹ Exposure to these risks disproportionately affects coastal and low-income communities, as they threaten business operations and can result in expensive losses, endanger the vulnerable populations that live there, and further isolate immobile residents and their support systems. Immobility may be a consequence of physical factors such as age, disability, or health, or it may be a consequence of social factors such as poverty, isolation, or a language barrier. Without the needed resources for isolated residents to prosper-in-place² during extreme weather events, risks of fatalities and displacement will only increase.³

With natural disasters, like hurricanes and Nor'easters, the delicate nature of centralized grids has come into question; microgrids can provide much-needed grid resilience and increase energy reliability. Major distribution lines and poles can be disrupted or destroyed by falling trees, fires and flooding, or by

¹ Campbell, Richard J. "Weather-related power outages and electric system resiliency." *Washington, DC: Congressional Research Service, Library of Congress, 2012.*

² Prosper-in-place is a term the Team uses in contrast to the more commonly used *shelter-in-place*. The idea behind it is that residents are able to maintain as close to normal habits as possible despite there being a power outage. Furthermore, people who are less mobile or who have medical concerns are safe, able to refrigerate medications, use electric medical equipment, and still rely on elevators, if applicable.

³ Corvidae, Jacob and Ayyagari, Sneha. "How Many Hours-of-Safety Do Our Homes Have in Extreme Weather?" Rocky Mountain Institute, 24 July 2019.

<https://rmi.org/how-many-hours-of-safety-do-our-homes-have-in-extreme-weather/>

intentional interference or human error, affecting not only local communities but entire regions. Microgrids have the power to keep the lights on when the larger grid goes dark. These local energy systems can minimize the scale of the impact that power outages have by sourcing power from multiple streams and using energy storage technologies. With a microgrid, a neighborhood or even a few separate buildings can use a localized power system that is separate from larger regional grids.

Microgrids can also support emergency communications capabilities. After Hurricane María hit Puerto Rico, 91% of cell towers were out of service.⁴ After Hurricane Harvey hit Texas, 95% of cell towers in Aransas County were out of service.⁵ After Superstorm Sandy hit New York and New Jersey, a quarter of cellphone towers were out of service.⁶ The stories that emerged as a result of these experiences underscore why having a means of contacting both emergency services and loved ones after a catastrophe is so crucial.

When considering the vulnerability of the grid, the capabilities of microgrids clearly open the door for new technologies and promote greater innovation to update infrastructure. These innovations will allow communities to keep the power and heat or cooling on and communication and transportation available when the traditional grid is unable to operate, leading to greater resilience and mitigating adverse impacts.

RUN-GJC is a mission-driven project team. Our ultimate objective is to demonstrate a viable model for resilience that fully protects and empowers those populations that are most vulnerable in the face of climate change impacts. This means that a key measure of success will be the extent to which our microgrid model enables vulnerable residents and communities to prosper-in-place during extreme weather events or power outages. The community and social benefits of our proposed microgrid also include:

- A more democratic decision-making process, driving more transparency and accountability within our energy system
- A strong social network that helps the community generally, but also the microgrid's efficacy
- A scalable model, without finite boundaries, that can expand membership opportunities to serve an even greater number of people over time, increasing communal benefits
- Added economic security and stabilized local economies
- Sustainable job creation in implementation phase and throughout maintenance of the microgrid
- Helping households save on housing and utility expenses

⁴ Weise, Elizabeth. "Puerto Rico Is Nearly Entirely Cut off from Cellphone Service, Leading to Low Tech Solutions." *USA Today*, 28 September 2017. <https://www.usatoday.com/story/tech/2017/09/28/puerto-rico-cell-phone-service-tmobile-att-hurricane/710775001/>

⁵ Reardon, Marguerite. "How Phone Networks Fared during Hurricane Harvey." *CNET*, 3 September 2017. <https://www.cnet.com/news/hurricane-harvey-phone-service/>

⁶ Samuelson, Tracy. "After Sandy, Questions Linger Over Cellphone Reliability." *NPR*, 29 April 2013. <https://www.npr.org/sections/alltechconsidered/2013/04/29/179243218/after-sandy-questions-linger-over-cellphone-reliability>

- Strengthened collaboration between local businesses and local government to streamline community-backed energy policies
- A “Just Transition”⁷ model, to further aid surrounding areas
- Giving communities a chance to prosper-in-place during emergencies and raise the standard of living during times without environmental crisis

More broadly, our desired outcomes include increased access to clean energy technology; improved economic and health outcomes during and following extreme weather events; decreased rates of populations being displaced from their community, especially following extreme weather events; and increased social cohesion and connectivity. The value of these outcomes is only further highlighted when considering the public health issues and economic impacts Chelsea has struggled with in the face of the COVID-19 pandemic. We hope to achieve decreased greenhouse gas emissions in our region, eventually resulting in carbon-free zones, and to model viable public and community-controlled alternatives to conventional investor-owned fossil fuel-based infrastructure.

This project has been largely driven by community groups and their members through neighborhood surveying and community meetings. For the process to be informed and driven by those most impacted, community members need to be engaged from the beginning. The cooperative nature of this project is unlike that of most other microgrid studies happening in the state by allowing for community control over design, contracting, and operation of the microgrid resources.

Chelsea is a community with a large immigrant, working class population, with historically low incomes, and prone to the effects of climate change due to its proximity to three waterways and its large impervious surfaces. While the solar industry in Massachusetts has grown to become one of the best in the country, it has catered to upper and middle classes, leaving low-income households unable to benefit from the green economy. Compounded by a lack of financial capital, more often than not, low-income residents also face greater requirements for building upgrades to be eligible for solar access, only further exacerbating such issues. These factors are exacerbated by language barriers among the most vulnerable and isolated residents.

This microgrid project is neighborhood-oriented and its inclusive nature gives constituents a chance to be involved in their own energy system. In Chelsea, our Team collected 190 surveys. 85% of the businesses leaders and 89% of the residents we spoke with in the community were interested in learning more about microgrids and how they could benefit the community. The microgrid feasibility project is exploring what services and local buildings are essential when there is a larger grid outage and the microgrid goes into island mode. These buildings and services can include affordable housing complexes, community centers, food distribution centers, key businesses, hospitals, municipal government, public safety, and education centers. By ensuring that critical services and community centers have power, vulnerable communities can be better protected. It is our hope that residents of a building that does not opt-in to our microgrid will speak to their neighbors throughout this process and will learn about buildings in their area that they can turn to in an emergency, be it for cooling/heating centers, refrigeration of medications, or emergency shelter.

Furthermore, mutual support among residents will increase the overall resilience of the neighborhood to deal with crises. Simply by canvassing the area and hosting public meetings, we are raising awareness

⁷ “Just Transition.” Climate Justice Alliance, 21 Apr. 2020, <https://climatejusticealliance.org/just-transition/>.

about climate vulnerability, the importance of resilience, and the need for strong social networks in emergency preparedness. We want our neighborhood residents and community members to be united and work together, whether it is to address rising housing costs or climate disaster. We hope to leverage the process of developing and operating the microgrid as a community to strengthen neighborhood ties and reduce social isolation, which can reduce loss of life in emergency scenarios.⁸

Microgrids have the potential to become a cornerstone piece of infrastructure for any community. Grid modernization, cloud-based connectivity, storage capabilities, and the protection of critical facilities are just some of the ways in which microgrids can increase a community's climate resilience. With electricity generation and storage happening locally from within the microgrid, combined with energy-efficiency upgrades of participating facilities, those who participate in the microgrid could experience overall energy costs lower than what utilities are charging consumers today. For low-income residents and cash-strapped small businesses, reduced energy bills alone could serve as a major asset to their safety and social resilience. Low-income and vulnerable communities are particularly well-positioned to receive the greatest share of benefits from the development of this community-based microgrid.

The model our Team has developed is being tailored to the specific local context of this particular neighborhood, but we hope for our design to be replicable in other places. The project team believes it is important to use this virtual microgrid model as an opportunity to develop replicable systems and practices by which difficult-to-monetize benefits can be quantified in a collaborative relationship between the utility, the municipality, and the community.

⁸ Dudley, David. "When Heat Waves Kill." *CityLab*, 26 July 2016.
<https://www.citylab.com/life/2016/07/how-to-survive-a-heat-wave/493049/>

Task 2: Site Assessment and Microgrid Characteristics

Chelsea Overview

Chelsea, MA is a frontline community burdened by life-threatening public health effects directly related to environmental and industrial hazards.⁹ Chelsea residents are some of Massachusetts's most diverse and vulnerable, yet they bear much of New England's industrial and public health burden. Chelsea's social determinants of health are among the state's most severe, and are exacerbated by climate change.

Though Chelsea is spatially the smallest city in the state, it is one of the most densely populated and diverse in the nation, with more than 35 languages spoken among approximately 45,000+ residents, of which 73% identify as ethnic/ racial minorities and 24% live below the federal poverty level (compared to state's 10.5%). Residents live in just over a third of the City's total land mass, as only 37.6% of the city is zoned for residential use. 74% of the units in Chelsea are renter-occupied, adding an additional layer of vulnerability to displacement from gentrification as the cost of living increases.¹⁰

Chelsea and its waterways serve all of New England (NE), some mid-Atlantic states, and southern Canadian regions with industrial burdens including: storage for 100% of Logan International Airport's jet fuel, 70-80% of NE's heating fuel, road salt for 350+ cities and towns, and produce for much of the Northeast. These industrial uses severely impact Chelsea residents' environment, health, and quality of life.

Public Health and Climate Change

According to The Center for Effective Government, Massachusetts is just 1 of only 2 states with an "F" grade for disproportionately exposing people of color and low-income communities to toxic facilities. The Center determined that low-income, Latino children in MA are almost four times more likely to live near a hazardous chemical facility than their white counterparts.¹¹ Every neighborhood in Chelsea is designated as an environmental justice population¹², the only Commonwealth municipality declared as such.

Chelsea is already facing very real climate impacts with severe public health consequences. As more than 80% of the city's land surface is impervious to water, and there is a dearth of open green space and a

⁹ Faber, Daniel, and Eric Krieg. "Unequal Exposure to Ecological Hazards: Environmental Injustices in the Commonwealth of Massachusetts." *Environmental Health Perspectives* 110 no. 2 (1 April 2002): 277-288
<https://ehp.niehs.nih.gov/doi/10.1289/ehp.02110s2277>

¹⁰ "Community Health Needs Assessment Report", Massachusetts General Hospital Center for Community Health Improvement, 2019.
<https://www.massgeneral.org/assets/MGH/pdf/community-health/cchi/20191016-CHNA-report.pdf>

¹¹ "Low-Income Residents and People of Color in Massachusetts Are Living Near Chemical Dangers." The Center for Effective Government, Washington, DC, January 2016.
<https://www.foreffectivegov.org/sites/default/files/info/factsheet-massachusetts.pdf>

¹² Office of Administration and Finance. "2010 Environmental Justice Populations, Boston Area", Massachusetts Executive Office of Energy and Environmental Affairs, last updated 27 August 2017.
<https://www.mass.gov/info-details/environmental-justice-communities-in-massachusetts>

below-average tree canopy cover, Chelsea is considered a heat island.¹³ Mapping conducted by the Trust for Public Land, as depicted in the two images below, showed parts of Chelsea averaging 140 degrees in summer on the day testing was conducted (July 7, 2015), despite ambient air temperatures around 80. Satellite data supports this research, with Chelsea often averaging 20-40 degrees higher than nearby Boston suburbs.¹⁴

Preliminary results of surveys conducted by GreenRoots in Chelsea have found that most residents have less than a week of stored food, are unaware of emergency shelter in the city, and do not know if the city even has an environmental emergency plan. While these survey results are independently worrying, highlighting the gaps in community knowledge that municipal governments should be working to address, these holes in knowledge also show the importance of outreach on microgrids and clean energy.

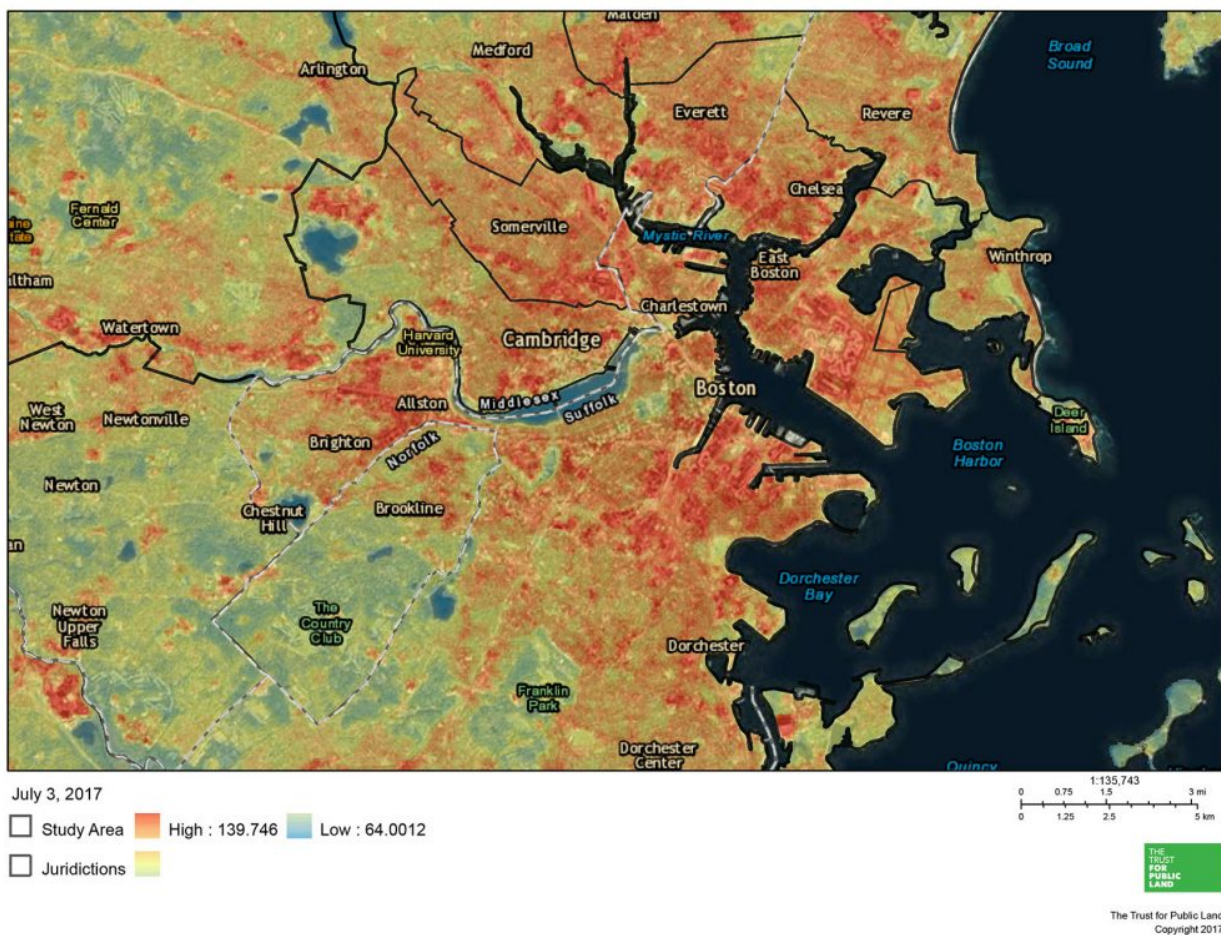


Figure 1: Map depicting average summer temperatures in coastal Massachusetts cities.¹⁵

¹³ Beringer, Martha. "No Tropical Paradise: Urban 'Heat Islands' Are Hotbeds For Health Problems." *Climate Change in Mass.*, WBUR, 7 July 2017. www.wbur.org/commonhealth/2017/07/05/greater-boston-heat-islands

¹⁴ Ibid.

¹⁵ Ibid.



Figure 2: Map depicting summer temperatures in Chelsea on extreme day.¹⁶

Compounding the heat island impacts are additional respiratory and cardiovascular challenges. Chelsea’s overall diesel exhaust levels exceed the EPA’s reference concentration by 20%, and exceeds the US average by five times.¹⁷ Chelsea is in the highest category for expected lifetime cancer cases from diesel pollution, and has the highest rate of strokes, heart disease and major cardiovascular disease when compared to Boston and abutting communities. Chelsea’s rate of hospitalizations for all respiratory illnesses for children, 0 -14, is 54% higher than the state of Massachusetts; and is 53% higher for seniors ages 65 and older.¹⁸ Chelsea is also in the highest category for expected lifetime cancer risks from diesel exposure, and has increased risk for other illnesses such as premature death, heart attack, and chronic respiratory disease.¹⁹

These health challenges have recently become painfully obvious in light of the COVID-19 pandemic. The same characteristics that define environmental justice populations (language isolation, race and income)

¹⁶ Ibid.

¹⁷ Durrant, Colin. “Developer Pulls Plans for Chelsea Power Plant.” Conservation Law Foundation, 14 November 2007. <https://www.clf.org/newsroom/developer-pulls-plans-for-chelsea-power-plant/>

¹⁸ Estrella-Luna, Neenah, PhD. “Rate of Hospitalizations for Respiratory Illnesses, 1990 – 2003”, MassCHIP, Massachusetts Department of Public Health.

¹⁹ Ibid.

are the same characteristics leading to greater COVID-19 impacts. The aforementioned respiratory and cardiovascular illnesses (specifically hypertension, diabetes, respiratory illnesses and obesity) coupled with key social determinants of health such as poor and overcrowded housing conditions, poor public transit infrastructure among others, are making Chelsea the most impacted community in Massachusetts. The City's workforce consists mainly of 'essential employees,' with nearly 80% of Chelsea's workers considered essential per the Governor's advisory. This has made social distancing almost impossible and resulted in a disproportionate number of Latinos and non-English speakers infected with the disease and overwhelming intensive care units. While the infection rate changes daily, the rate is currently at least six times higher than the State of Massachusetts as a whole.

These are unprecedented times for Chelsea and EJ communities like it across the world. GreenRoots will continue to work hand in hand with City officials, members and neighbors, and organizational partners to ensure the protection of all Chelsea residents, in particular the most vulnerable. Given these recent events, the need for the lowered emissions and the resulting public health benefits of clean energy infrastructure (along with its potential for easing the energy burden in low-income households) are only more apparent.

Site Assessment

Due to the key role Chelsea plays in the New England region and beyond, and due to its vulnerability to climate change and gentrification, it is imperative to take steps to create resilience for Chelsea's working-class families. For the microgrid feasibility study, our Team has decided to focus on affordable housing and key facilities. During the feasibility study, we conducted site visits of over a dozen buildings during 2018 and had discussions with building owners/managers. These initial buildings were chosen based on the following criteria:

- Importance to the community
- Evident opportunities to invest in cost-effective energy-efficiency improvements
- Cooperation of building owner/manager, availability of key data
- Critical functions in emergencies, protection of vulnerable residents
- Potential to install clean/renewable energy generation, storage and load management

The properties most consistent with our mission would include those housing low-income or elderly residents, municipal facilities, critical health and community facilities, nonprofit organizations, and small businesses.

After these site visits, the Team narrowed down the number of facilities that would be studied in more depth for the feasibility assessment to a representative sample of three. We consider this subset of facilities sufficient to test the feasibility of a community microgrid that will meet the Team's goals of neighborhood leadership, accommodation of distributed buildings, and optimization of multiple revenue streams to support sustainability. This sample includes: Buckley Apartments, Beth Israel Deaconess Medical Center, and City Hall. The following map shows the three buildings in this study, as well as the addresses of the other buildings that would like to be included once the feasibility work is complete.

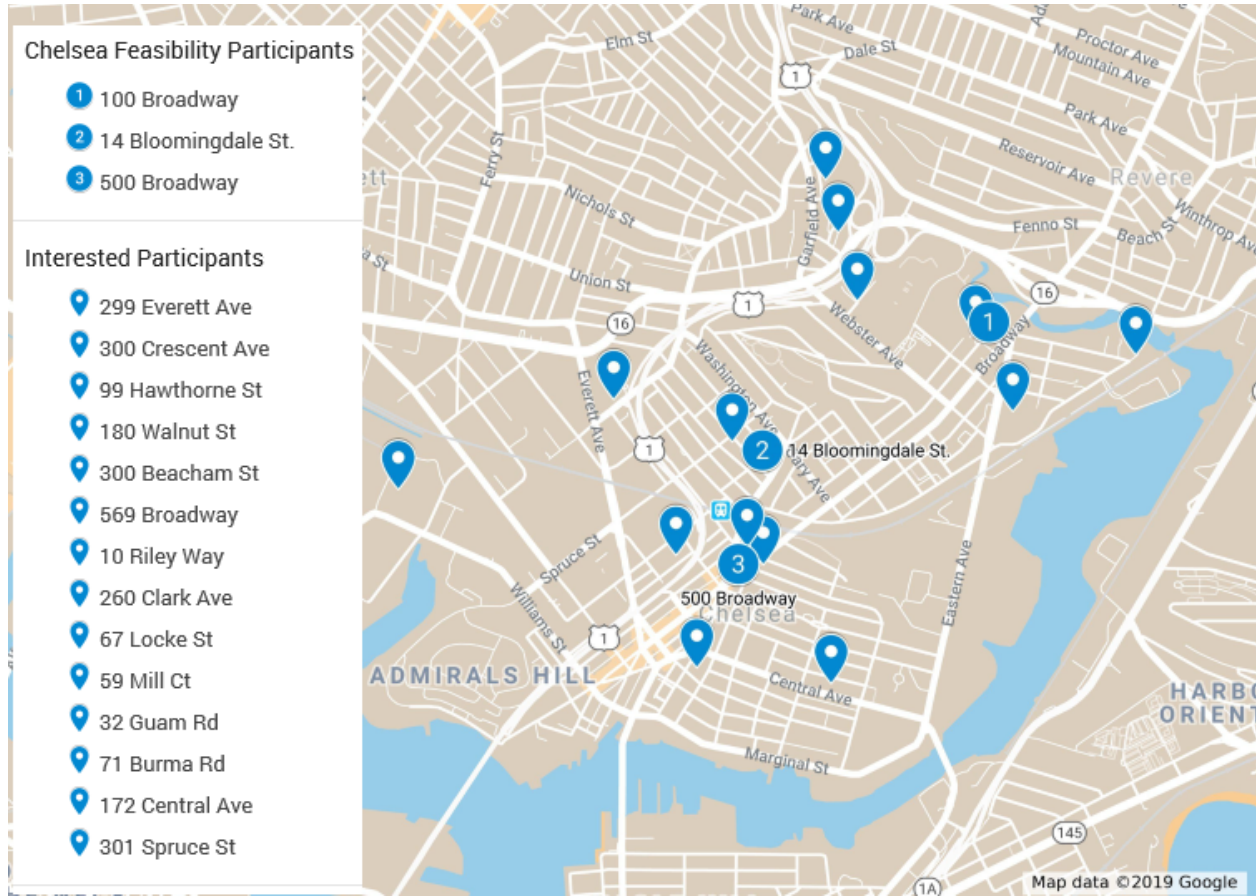


Figure 3: Map of buildings included in feasibility study (numbered 1-3) and buildings to be considered for microgrid participation after feasibility study is complete. Image source: Google Maps

Buckley Apartments

Buckley is an 8-story brick masonry low-income apartment building located at 14 Bloomingdale Street in Chelsea. It spans approximately 63,954 square feet and was built in 1972 as housing for the elderly. The Chelsea Housing Authority (CHA) website describes it as a “high-rise state-aided elderly/disabled development with two elevators, a large community room and 210 units; all one-bedroom apartments.”²⁰ Each apartment houses 1-2 people; there are 300 residents on average. Buckley has the largest number of units of all the Chelsea Housing Authority projects. CHA owns the building (meaning it is a state-funded public housing development),²¹ which is master-metered. There is a preexisting 100 kW diesel generator onsite.

The current summer peak for the site is 275 kW (of which 88 kW can be attributed to cooling and 187 kW to lights and appliances). Of the 650 kW for winter peak, heating accounts for 463 kW, whereas lights and appliances account for 187 kW. The building is completely electrified and has completed an energy efficiency lighting upgrade through the Mass Save program.



Figure 4: Buckley Apartments at 14 Bloomingdale Street, Chelsea.
Image source: Google Earth

²⁰ “Buckley Apartments”, Public Housing, *Chelsea Housing Authority*, Accessed 5 July, 2019.
<http://www.chelseaha.com/publicHousing.aspx>

²¹ There are eight public housing developments in Chelsea, five of which are state-funded and three federally funded. See previous citation.

Beth Israel Deaconess Medical Center (BIDMC)

BIDMC is located at 1000 Broadway. It is one of only two health care centers in all of Chelsea. The 3-story, 34,929 square foot building was built in 1996 and has an urgent care center (one of only two in the city), primary care offices, radiology department, physical therapy, laboratory, and optometry services. It also has a heavily-used pediatrics department and serves the entire community of Chelsea and beyond. The building has a large parking lot and Mill Creek runs behind it. The property is on a 99,658 square foot parcel.

The current summer peak for the site is 180 kW (of which 105 kW can be attributed to cooling and 75 kW to lights and appliances). Of the 167 kW for winter peak, heating accounts for 99 kW, whereas lights and appliances account for 68 kW. The building is master-metered and currently heated with a natural gas boiler.

At the time of the energy audit walk-through the team participated in (summer of 2018) the center did not have an emergency generator. They also indicated they had not pursued any energy efficiency upgrades besides upgrading to energy efficient lighting.



Figure 5: Beth Israel Deaconess Medical Center (BIDMC) at 1000 Broadway, Chelsea. Image source: Google Earth

Chelsea City Hall

City Hall is located at 500 Broadway; it is the center for all municipal services. The 2.5-story building is flanked by two single-story wings. It also connects to the 911 emergency center, a separate building on the site, via tunnel. These buildings are constructed of brick and cast concrete. The facility was built in 1910 after the Great Fire of 1908 and it houses approximately 30 offices within its 49,728 square feet. These offices include the City's Health and Human Services, Department of Public Works, Planning and Development Department, Inspectional Services, City Clerk, Treasury and Assign. On any given week, City Hall serves thousands of residents, visitors, and business. City Hall Chambers, within City Hall, is a central point for larger community meetings. During an emergency, City Hall could serve as a community shelter for Chelsea residents. City Hall falls within the Bellingham Square Historic District that was designated a National Historic Landmark District in 1985.

The current summer peak at this master-metered site is 115 kW (of which 40 kW can be attributed to cooling and 75 kW to lights and appliances). Of the 120 kW for winter peak, heating accounts for 45 kW, whereas lights and appliances account for 75 kW. The building is currently heated with five natural gas boilers. There is a 100 kW emergency generator onsite. Within the past few years, the lighting in the building was switched to LEDs as part of a grant from the Green Communities Division. They have also installed Coolnomix technology with financial assistance from the MassCEC through the DeployMass program.



Figure 6: Chelsea City Hall at 500 Broadway, Chelsea. Image source: Google Earth

Task 3: Technical Design Costs and Configuration

RUN-GJC's mission is to demonstrate a microgrid model that supports climate change resilience for vulnerable populations. The technological design of our model reflects that mission. The RUN-GJC microgrid is not a microgrid in the traditional sense. The typical microgrid of today is sited within the boundaries of a facility or campus. The Department of Energy defines a microgrid as "a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. A microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected or island-mode."²²

Our design intentionally allows for energy generation and storage assets to be sited on non-contiguous properties. In normal conditions, i.e. a blue sky scenario, our microgrid does act as a single controllable entity with respect to the grid. And, like a traditional microgrid, it switches automatically and seamlessly into island-mode in the event of an outage. However, in an outage scenario in our model, each individual building functions as an independent island. Each building has a microgrid controller that can route electricity within that building from on-site sources to the loads (See Appendix A Tables i, ii, and iii. "Loads by Facility and How Served") in an outage, which makes independent islanding possible.

Our model for buildings that are not wired together has two key advantages that support our mission. The first advantage is that some regulatory uncertainties are less likely to be relevant, and therefore such issues would not slow down future steps in the development process. Such uncertainties could include selling power between customers, or use of utility distribution wires or other assets between customers. The second advantage is that by adding individual buildings, the microgrid has flexibility and does not have to have buy-in from all facilities within a defined boundary or on a radial line to operate. Instead, geographically diverse buildings can opt-in.

This arrangement of non-contiguous buildings creates a "microgrid without borders," allowing expansion of subscribers without limit. There is no technical or economic limit to scaling up the design. It could even be considered an example of a non-wires solution.

Since our design involves a "group of interconnected loads and distributed energy resources that acts as a single controllable entity with respect to the grid," and since it can be grid-connected or islanded, we consider it to be a microgrid. In addition, should regulations change so as to favor or allow buildings to be wired together despite crossing rights of way, we would love to leverage that opportunity to connect them and have all buildings operating as a microgrid in the more traditional sense.

²² Ton, Dan T, and Merrill A Smith. "The U.S. Department of Energy's Microgrid Initiative." *The Electricity Journal* 25 no. 8 (October 2012): 84-94. <http://dx.doi.org/10.1016/j.tej.2012.09.013>

Table I: Traditional Microgrid vs. RUN-GJC Microgrid

Characteristics of a Microgrid	Traditional Microgrid	RUN-GJC Microgrid
Interconnected loads	✓	X
Distributed energy resources	✓	✓
Single controllable entity	✓	✓
Clearly defined electrical boundaries	✓	X
Grid-connected	✓	✓
Islanding capability	✓	✓

The loads and distributed energy resources (DERs) in this design are controlled by a cloud-based aggregation and optimization platform. When the microgrid is operating in grid-connected mode (a blue sky scenario, i.e. normal conditions) cloud-based software is able to compute the total energy generated, stored, and available (i.e. the aggregate) at all of the facilities in the microgrid. In the aggregate, there is enough energy on hand to participate in wholesale markets,²³ which is where some of the revenues to pay for assets, operation and maintenance come from. The software platform receives signals from entities like ISO-NE and Eversource and can optimize value to the grid by dispatching batteries, shedding load, or a number of monetizable functions. In island-mode, the cloud software isn't necessary as the microgrid is not intended to generate revenues during an outage. Instead, it is meant to provide continuity of electric service to the residents of the participating buildings. Ensuring energy reliability is thus a form of resilience.

In normal mode (grid operating), when the loads in every facility are connected to the grid but disconnected from the local DERs, the IT/telecommunications infrastructure is devoted entirely to generating maximum revenues (largely through grid support functions). This is achieved by the cloud-based combining of DER capacities from all subscribers, irrespective of location. The purpose of the cloud-based logic platform is to coordinate and sum the resources (storage, distributed generation [DG], load management) of all the distributed microgrid subscribers. This maximizes revenues by dispatching available resources together in near-real-time, to match grid needs, savings opportunities, and wholesale markets as they vary, choosing the best options at any point in time.

The general protocol is for the cloud-based logic platform to send commands to each facility's dynamically-controlled inverter (DCI), directing it to connect single or multiple DERs to the load or to the grid, via the on-site transfer switches that the DCI controls. The cloud-based controller's protocol is designed to maximize revenues by dispatching the best combination of DERs from all (distributed)

²³ Per FERC Order 841, the "minimum size requirement for participation in the RTO/ISO markets does not exceed 100 kW."

"Electric Storage Participation in Markets Operated by Regional Transmission Organizations and Independent System Operators." *Code of Federal Regulations*, title 18 (15 February 2018): 5-234.

<https://www.ferc.gov/whats-new/comm-meet/2018/021518/E-1.pdf>.

subscribers continuously. The logic is informed by both stored information (e.g., tariffs, DER capacities, wholesale market parameters, etc.) and by real-time inputs (e.g., telemetry from ISO-NE or Eversource, market trends, weather, current load, time of day, etc.).

In island-mode, the DERs in each facility and the facility-specific IT infrastructure are capable of extended operation independent of grid power or communication, as described in their design features later in this chapter. The operating protocol in island mode is simply for the DCI to measure the load in its facility and supply it from the available DERs. No attempt is made to earn revenue from the DERs in island mode, but only to maximize resilience for subscribers. The DCI is programmed to use solar energy first when available, and then stored energy from the batteries on site. In prolonged outages, it will sense battery discharge conditions and start the green-fueled DC generator to serve loads. It keeps the pre-existing manual-start emergency generator (alternator) locked out unless the new DC generator fails or exhausts its fuel source. It can access parked vehicle batteries if manually enabled in the event of further failures.

The following two images (Figures 7 and 8) illustrate the differences between blue and black sky (outage, i.e. emergency) scenarios.



Figure 7: The above image shows how buildings that are dispersed across a city can aggregate their energy when connected to the grid. By installing DERs behind the meter, the design has the unique ability to circumvent known, current barriers to microgrids like franchise law. Image: Climable

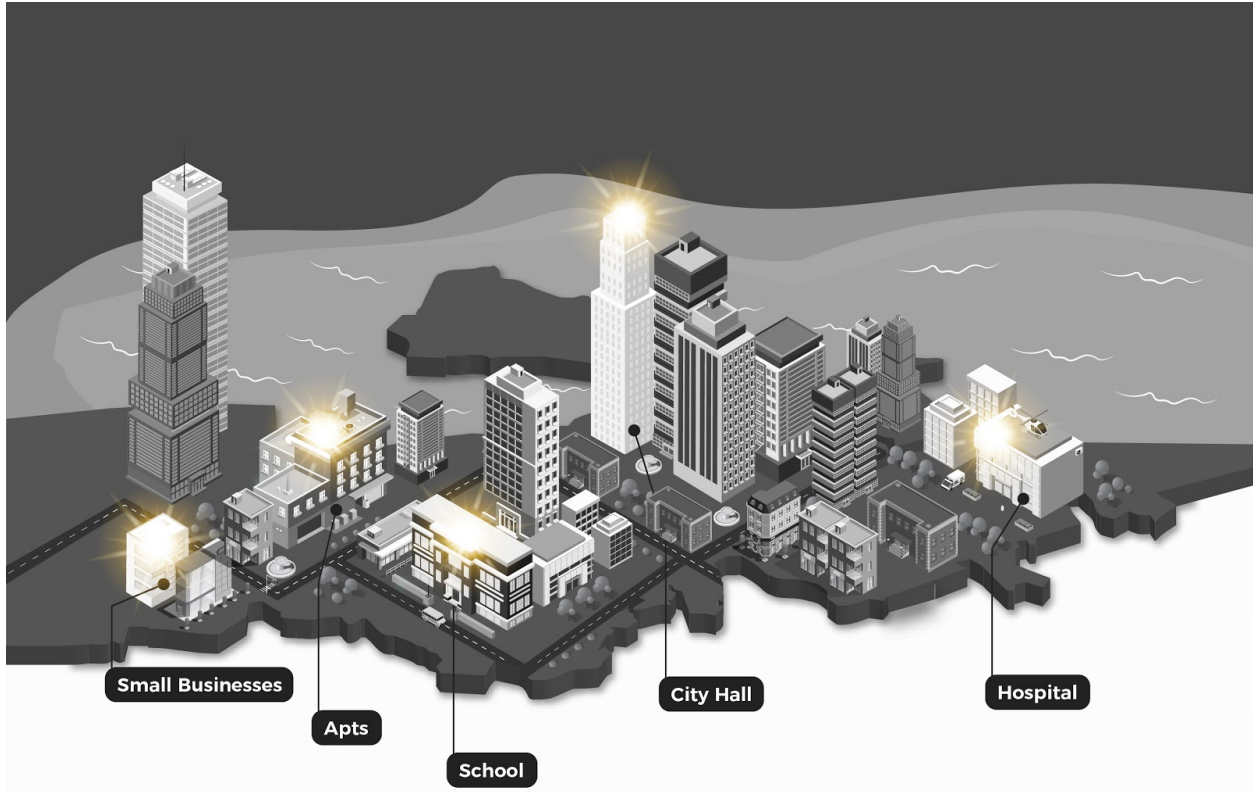


Figure 8: The image above shows that in a grid outage (black sky scenario), buildings that participate in the microgrid still have electricity whereas the surrounding buildings that don't participate in the microgrid do not have electricity. In this scenario, the cloud-based software is not necessary as the goal of the microgrid is to guarantee energy to the people in those buildings without requiring their interconnection. Image: Climable

Components

There are certain components that every building that participates in the microgrid will have. These components are: a transfer switch(es), a dynamically-controlled inverter (DCI), battery storage, DC green-fueled generators and revenue meters. These components are at the crux of our design.

A **transfer switch** will be installed behind every meter. It transfers the building's load(s) between grid supply (blue sky) and local supply (grey sky) when grid power is interrupted, and back again when it is restored, and ensures that no local power can inadvertently be backfed onto the grid. It will be installed in a waterproof and tamper-proof enclosure. In a master-metered building, there is only one transfer switch. In a multi-metered building, there is one transfer switch per meter. Regardless, in a blue sky scenario the switch will remain in a grid-connected position. Should an outage occur, the dynamically-controlled inverter will send a signal to the transfer switch and flip it into island-mode. Because this happens instantly, there should be no loss of power.

The **DCI** is a "smart" inverter. It senses grid interruptions and voltage or frequency sags. A DCI monitors and controls the transfer switches, battery banks, generators and any other on-site DERs. Smart inverters

that meet IEEE Standard 1547-2018²⁴ have this capability. Examples of companies that manufacture them are SolarEdge, Enphase, Schneider and others. In a blue sky scenario, the cloud-based software communicates with the DCI to manage loads across the microgrid. In a grey sky scenario, the DCI manages the equipment on-site and acts as that facility's 'brain' by connecting available DERs to the local load(s).

Batteries are crucial in the design since they can immediately dispatch (or absorb) energy; that makes them a valuable asset for organizations like ISO-NE and Eversource. These services are monetizable in a blue sky scenario. In an outage, the batteries seamlessly take over the facility's load within milliseconds. The amount of battery storage is designed to meet the building's full (i.e. coincident peak) load for at least one hour (which will typically meet the average load for two hours).

DC Generators. Allowing batteries to carry the load for an hour gives the generators enough time to turn on. Generators provide long-term continuity of electricity (after batteries have been discharged). In an effort to maintain compliance with the group's goals to minimize reliance on fossil fuels and reduce GHG emissions whenever possible, the generators will be fueled by green diesel. Green diesel is not the same as biodiesel; it is molecularly the same as regular, fossil fuel diesel.²⁵ Because it can be handled the same as diesel and because it has the same freezing point as diesel, modifications to the generator itself do not need to be made. While green diesel isn't widely available in New England at this time, it is being used in other parts of the U.S.: in California it is actually cheaper than regular diesel. Enough green diesel would be stored to meet estimated coincident loads for up to a 14-day grid outage, after which resupply is expected. The generators will primarily be used in an outage scenario.

While every building will have DC generators to maintain battery capacity and supply loads in prolonged outages, there is also a **secondary emergency generator** onsite that adds a layer of redundancy. In some facilities, there is already a preexisting generator that can be leveraged for this redundancy. Should one not already exist at a facility, we will install one. Regardless, these generators can be used to power critical loads in a building should the batteries and backup generators fail. These generators can also be powered by green diesel. They are not managed by the DCI. Instead, they need to be turned on and off manually or by whatever mechanism the building already employs. Should there be a mechanism for the preexisting generators to automatically turn on in an outage, this feature will need to be disabled.

²⁴ IEEE Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces, 6 April 2018. <https://standards.ieee.org/standard/1547-2018.html>

²⁵ "What is Renewable Diesel?" Diamond Green Diesel, Accessed 31 July 2019. <https://www.diamondgreendiesel.com/what-is-green-diesel/>

Table II: Tank Capacities

	Buckley Apts	Beth Israel Deaconess	Chelsea City Hall
Proposed Emergency Total Load kW	495	150	100
Additional Generator kW	250	75	50
Diesel Gal/hr @ Selected load	9.5	3.4	2.8
Gal of Biodiesel Needed at Selected Load	1,596	571	462
Total Cubic Ft. of Biodiesel	213	76	62
Single Cubic tank Dimensions (ft.)	5.98	4.24	3.95
Total Weight Diesel (lbs.)	11,332	4,056	3,280
Diesel Tons (net of tank weight)	5.7	2.0	1.6
Total Weight (lbs.) Using Biodiesel Density Factor	10,585	3,788	3,064
Biodiesel Tons (net of tank weight)	5.3	1.9	1.5
Proposed Battery storage kW	495	150	100
Existing (or Proposed) Generator kW	100	50	100
Current Summer Peak kW		239	126
Current Winter Peak kW		115	120
Original Emergency Panel Load	700	500	1,000
Current Peak (Winter or Summer)	Winter	Summer	Summer
Proposed Peak (Winter or Summer)	Winter	Summer	Winter
Current Heat Source	Electricity	Gas	Gas
Proposed Heat Source	Electricity	Gas	Electricity
Elevator Electrical Panel kW		30	

Revenue meters will be used when Eversource or ISO-NE call for export of power. More than one meter may be specified as utility interests and wholesale markets evolve. (For example, a special SMART

generation meter will be installed by the utility when the facility is qualified by DOER.) They can only be used in a radial or spot interconnection, not currently in an area network.

There are components that are included in our design but are not feasible or required for each building for varying reasons. These components include solar panels and CHP. Ideally, every building participating in the microgrid would have PV generating clean energy. Solar energy could be sold back to the grid. However, not every site is suitable for PV. Historical buildings, those without an appropriate amount of structural capacity, or those in the shade or that might have buildings built nearby that would cast shade on them are examples. When paired with batteries, PV helps further reduce emissions. In an outage, PV can further aid the design by recharging the batteries and potentially carrying a portion of the load during daylight hours.

The last component is the one that communicates with the DCIs at every participating facility: the **cloud-based software platform**. As previously mentioned, it maximizes revenues in blue sky scenarios and is not used in an outage. The cloud-based platform requires sophisticated mathematical tracking and calculation of optimum dispatching, based on a very large number of variables. They receive market, tariff, weather, grid operation and other data continuously in real time, and compute the optimum combination of resources (from multiple customers) at any moment that will maximize savings and revenues. These systems can work with various radio links but may be most easily deployed as a dedicated site on the internet. They send continuous telemetry signals to the smart inverters at each site, to control the operation of local switches. The platform is not a large physical installation and will likely be part of an existing data center maintained by the entity managing the microgrid. Examples of this type of technology include the NREL “REopt” software²⁶ that is publicly available and the muGrid Analytics “Redcloud” platform that is somewhat more rigorous.²⁷ Another such company is Stem Energy, which was formed 10 years ago and claims over 300 MWh of storage-based systems optimized with their AI platform.²⁸ Schneider Electric, GE, Enel X/ EnerNOC and others now offer optimization platforms for energy resource aggregation from multiple sites. One of the more recent examples comes from Autogrid, which is aggregating 10,000 DERs that are behind-the-meter (BTM) in order to participate in the wholesale market.²⁹ Several contractors who have developed proprietary platforms such as these have been interviewed. The specification of this element of the design is beyond the scope of this feasibility assessment, but it has been clearly demonstrated in practice.

Communications

Our microgrid provides reliable signals so that people can place calls, send texts, and use the internet via a satellite hotspot system that doesn’t rely on cell towers being operational. Each building that participates in the microgrid will have a satellite hotspot; it is not dependent on the grid or other wired communications, thus, it will be operational during power outages. An alternative to this approach-

²⁶ “REopt: Renewable Energy Integration & Optimization.” NREL, Department of Energy, 2020. <https://reopt.nrel.gov/>

²⁷ “Energy Optimization With Redcloud By muGrid Analytics.” muGrid Analytics, 2020. <http://mugrid.com/energy-optimization-redcloud-mugrid-analytics/>

²⁸ “The World’s Largest Energy Storage Network.” Stem, Inc., 2020. <https://www.stem.com/projects/>

²⁹ Wood, Elisa. “Here Comes the World’s Biggest Virtual Power Plant — And it’s Behind the Meter.” Microgrid Knowledge, 20 June 2019. <https://microgridknowledge.com/virtual-power-plant-japan-autogrid/>

should it not prove ideal for the community- is a microwave-link service offered by companies like Resilient Internet.³⁰

Figure 9 (below) illustrates the telecommunication and control infrastructure of the proposed distributed microgrid. Each facility has its own IT and telecommunication infrastructure and all are connected via wireless connections to a shared “cloud-based” logic platform.

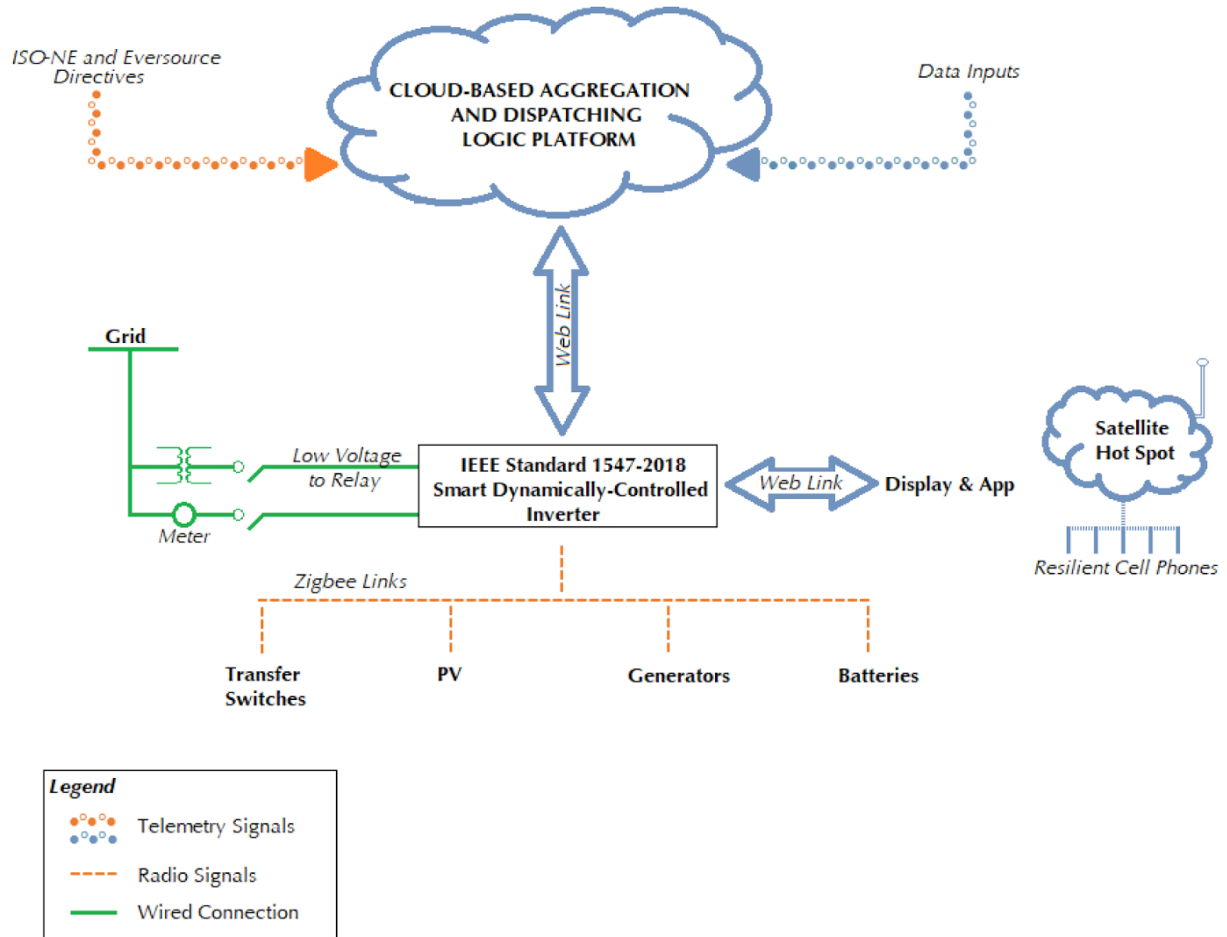


Figure 9: IT and Telecommunications Infrastructure

Facilities

DERs will be matched to the load (post energy efficiency improvements) of the property on which they are sited. Sizing of the local DERs is set equal to the coincident peak load in each facility (detailed in Appendix A Table iv. “Projected Maximum Coincident Peak Demand and DER Sizing”), which is presently expected to be close to a capacity optimally matched to wholesale market trading opportunity.

³⁰ Theodore, David. “Introducing the World’s First, Climate Resilient Internet.” *YouTube*. 5 July 2019. <https://www.youtube.com/watch?v=yhN9wXuxYrw&feature=youtu.be>

Following are preliminary data and energy-efficiency opportunities recorded during early “walk-through” visits. These will be confirmed and expanded when contractors are engaged.

Buckley Apartments

This apartment building is served via a single meter that records interval demand. It is electrically heated and converted to air-source heat pumps (ASHPs). The following data and energy-efficiency opportunities were recorded during an early visit.

- Current Summer Peak = 275kW from actual interval/billing data
- Current Winter Peak = 650kW from actual interval/billing data
- Current L&A (Base Load) = 187kW from actual interval/billing data (October)
- Proposed L&A = 187 kW x .9 = 168 kW (10% reduction due to EE)
- Cooling proposed = [275 (summer peak) – 187 (L&A) = 88kW]. Then 88kW * .8 = 70kW (20% reduction due to EE)
- Heating proposed = [650 (winter peak) – 187 (L&A) = 463kW]. Then 463kW * .7 = 325 kW (30% reduction due to ASHP/EE)

While the building is completely electrified, savings could potentially be realized by installing solar hot water heaters.

In terms of emergency preparedness, there is a preexisting 100 kW diesel generator that would be maintained for redundancy purposes. To make it more resilient, the Team would add 495 kW of battery storage, 250 kW of DC generators, 5 kW of PV and five bidirectional EV charging stations.

Beth Israel Deaconess HealthCare

This health-care facility has a single meter that records interval demand, and is gas heated.

- Current Summer Peak = 180 kW from actual interval/billing data
- Current Winter Peak = 167 kW from actual interval/billing data
- Current L&A (Base Load)= 75 kW from actual interval/billing data (November)
- Proposed L&A = 75 kW x .9 = 68 kW (10% reduction due to EE)
- Cooling proposed = [180 (summer peak) – 75 (L&A) = 105kW]. Then 110kW * .80 = 88kW (20% reduction due to EE)
- Heating proposed = [167 (winter peak) – 68 (L&A) = 99kW] for pumps, motors, etc. Then 99kW * .85 = 84 kW

The natural gas boiler would be replaced by air source heat pumps (ASHPs) and the gas-fired direct hot water would be replaced by solar hot water.

To maximize resilience for this critical facility, we would add a substantial 750 kW PV canopy in the parking lot and 150 kW of battery storage. The parking lot would also house 22 kW of bidirectional EV charging. We would also add a 75 kW DC generator and an additional backup generator of 50 kW that would be wired to serve emergency loads. The utility circuit serving Beth Israel is at 84% of capacity on peak, so adding DERs would help alleviate that congestion.

Chelsea City Hall

City Hall has a single meter that records interval demand, is gas heated, and is in the process of converting to ASHPs.

- Current Summer Peak = 115 kW from actual interval/billing data
- Current Winter Peak = 120 kW from actual interval/billing data
- Current L&A (Base Load)= 75 kW from actual interval/billing data (October)
- Proposed L&A = 75 kW x .9 = 68 kW (10% reduction due to EE)
- Cooling proposed = [115 (summer peak) – 75 (L&A) = 40kW]. Then 40kW * .80 = 32kW (20% reduction due to EE)
- Heating proposed = [120 (winter peak) – 75 (L&A) = 45kW]. Then 45kW * .7 = 32 kW (30% reduction due to ASHP/EE)

The existing natural gas boilers would be replaced by ASHPs. There are plans to replace the boilers at the facility in the next year. Due to the steep pitch of the roof, solar panels could not be placed discreetly on it, which means they would not be added given the building's historic landmark designation. Batteries (totalling 100 kW of storage) and a 50 kW DC generator can and will be added. The existing 100 kW generator will be retained. However, unlike the other buildings in the microgrid where the DERs can be sited outside or on the roof, the DERs here will need to be placed inside. This decision also relates to the historic landmark designation. The DERS will alleviate congestion on the 14 kV circuit serving City Hall that is 87% loaded.

Loads

Energy efficiency measures are the first order of business for each building that chooses to become part of the microgrid. This will create energy savings while reducing the building's load. While this is in line with the Team's aim to conserve energy and reduce emissions wherever possible, it makes the currently available data slightly less useful as it is notoriously difficult to estimate post-EE loads. With regards to post-EE loads, the Team has assumed (for purposes of modeling) a 20% reduction at all three buildings due to EE upgrades. At Buckley and City Hall, an increase in electric load is more than offset by decreased gas loads, as ASHPs are added.

In instances where interval data is available (Buckley and Beth Israel) accurate hourly load profiles of those buildings were produced (refer to Appendix A "Hourly Load Profiles"). For the other building (City Hall) a representative building hourly load was used. This data was pulled from Open EI,³¹ using a dataset from Baltimore as that was the city whose climate is most similar to that of Boston's.

All three buildings in Chelsea are master-metered, making the collection of load data quite straightforward.

³¹ Darghouth, Naim. "Baltimore, MD Commercial Simulated Load Profiles". Open EI, 16 September 2016, Accessed July 31, 2019.

<https://openei.org/datasets/dataset/simulated-load-profiles-17year-doe-commercial-reference-buildings/resource/288987f9-9eb1-4723-ac26-dbe44d843da9>

Table III: Tariffs at Studied Facilities

	Tariff
Buckley	Rate B7-NEMA LG General TOU
Beth Israel	Rate B7-NEMA LG General TOU
City Hall	Rate B2-Large General- Secondary (Prorated)

In the event of failure of the grid, the automatic transfer switches apply the inverter-based DERs to the total load at each site. The DERs are sized to assume the peak coincident load, thus ensuring building users can prosper-in-place without interruption.

1. In the further event of failure of any one DER (battery, generator, or solar), the DCI is programmed to draw necessary power from the others.
2. For *backup* redundancy, every facility will have an existing or new manually-operated emergency generator(s) connected to the usual critical loads. Its regular testing and maintenance will be built into the Operation and Maintenance (O&M) contract made part of each installation contract.

Capabilities of DERs and value to utility/grid operator

The DERs and other equipment that make up this microgrid are intended to ease the energy burden for the people and businesses that participate, while providing resilience and wellbeing in the form of reliable energy, water, and communications in the event of a greater grid outage. When considered in the aggregate, however, there are a number of benefits they can offer the utility/grid operator. There are also some considerations about which the utility might be concerned; these are also addressed in the design and use of the DERs. The following represent a large sample of such services and concerns, in no particular order.

Non-curtailment. Solar (when used) and wind (if used) are intermittent sources of power, meaning they do not produce a constant amount of power. For example, solar panels produce no energy at night; in the morning and late afternoon PV produces some energy; PV produces the most at midday. The amount of energy PV can produce also depends on cloud coverage. Similarly, wind is variable. Intermittency is a known concern for utilities. This has been compensated for in our design by the inclusion of battery storage. Batteries can ramp up and down to help maintain a smooth and steady source of power, based on how much the renewables are producing. In the event that the renewables are overproducing, curtailment isn't an issue as the excess energy can be used to charge the batteries. The cloud-based platform can further ensure that this is done in such a manner that the grid does not notice any sags or spikes by dispatching the batteries as necessary.

Ramping. The time it takes for an energy producer to generate energy is its ramp time. Ramp time is a concern for the grid operator because they need to make sure there is enough energy available at any

given moment to keep the grid up and running. Any energy shortage could require that an additional power plant be added to the mix; certain forms of energy or certain power plants can take a significant amount of time to get up and running. Additionally, less frequently-used power plants (peaker plants) may use dirtier forms of generation, like coal, which sacrifices environmental quality to satisfy peak electricity consumption times. Ramp time isn't an issue for batteries. They can instantly turn on and off to satisfy the grid's needs, be it during a grid interruption, fault, surge, or general soft restart. A *black start* scenario should not occur in our design as the cloud recognizes when the grid is down and signals each participating building in the microgrid to switch into island mode, seamlessly carrying the load. Additionally, batteries carrying load at the onset of an outage give the DC green diesel generators time to ramp up and produce enough energy to carry the building load through a prolonged outage.

Frequency and voltage regulation. This is a power quality issue as many important electronic and induction-drive loads are very sensitive to any deviation from 60.0 Hz in either direction. However, supply and demand changes on the grid can often cause this exact issue. Batteries in conjunction with smart inverters can help in this situation as well. Batteries are able to absorb energy (charging) as well as supply it (discharging), both instantaneously. Smart inverters can generate reliable sine waves within tight frequency and voltage limits that can be offered to the utility as regulation services. The DCIs can also control both phase and voltage of injected power, giving them the ability to supply reactive power on command whenever the utility or grid operator specifies. This Volt/VAR support aids with power quality as does the frequency regulation.³²

Demand response. This section could also be called load shedding, load shifting, grid load relief, or even locational balancing. In essence, there is value in being able to balance the energy supply on specific circuits, in shifting building loads at peak times, and in shedding loads at a moment's notice. This ability could help Eversource balance its distribution or preclude ISO-NE from having to call on peaker plants to fire up. By setting up signals from ISO-NE or Eversource to connect to the microgrid's cloud-based platform, the cloud can easily command each DCI to turn batteries off or on to shift and shed load when needed. This could even help avoid or postpone building new fossil fuel-reliant power plants or other utility infrastructure that might otherwise be necessary.³³ Lastly, for customers who pay demand charges, the DCIs in each building can switch loads over to battery power whenever the 15-minute demand at each meter exceeds a pre-set threshold or approaches the time of its historic peak. In this manner, demand charge expenses can be avoided or reduced.

Capacity markets, reserve markets, and energy arbitrage. This last grouping of features is an opportunity for the entity operating the microgrid and a benefit to the microgrid participants. With energy arbitrage,

³² The Federal Energy Regulatory Commission released a final rule removing barriers to energy storage resources from entering the electricity market, generating reliable revenue opportunities for batteries and other ancillary services.

Yeazel, Seth. "FERC Issues New Rule to Promote Electric Storage Resources, like Battery Technology". North Carolina Journal of Law and Technology, 19 February 2018.

<http://ncjolt.org/ferc-issues-new-rule-promote-electric-storage-resources-like-battery-technology/>

³³ This is precisely what has happened in California. In early 2018, the PUC ordered PG&E to pursue storage/non-fossil fuel options to replace 3 natural gas power plants.

Nemec, Richard. "California OKs PG&E Plan to Replace Gas-Fired Power Plants with Battery Storage." Natural Gas Intel, 19 November 2018.

<https://www.naturalgasintel.com/articles/116525-california-oks-pge-plan-to-replace-gas-fired-power-plants-with-battery-storage>

the cloud-based controller can monitor pricing information from the energy markets and opt to use the batteries when prices are high or charge up the batteries when prices are lower, ultimately saving the controlling entity and participants money. This can be conducted in 15-minute time slots when there are not greater needs, penalties or revenue options. The optimization side of the cloud platform can be programmed with this logic. Similarly, the DERs (in the aggregate) can participate in a number of ISO-NE energy (kWh) and capacity (kW) auctions. While they would be of benefit to the ISO when called upon, this mechanism would be leveraged primarily to generate revenues for the microgrid and benefits for the participants. Should ISO need the resources, a telemetry signal would be sent to the cloud platform, which would in turn control the DCIs at each building to complete the action necessary.

Other. There are evolving markets, protocols and regulations around features that would impact our microgrid. Since the design and implementation phases have not yet commenced, it is reasonable to assume that there could be additional revenue streams once the microgrid is up and running. The Team can speculate to some degree around these types of revenue streams, but is not depending on them for revenue at this time.

The provision of these services is expected to earn revenues commensurate with their value to the distribution and/or regional grid. Wholesale markets exist for most of the benefits (regional level), but Eversource has not yet begun to dispatch behind-the-meter (BTM) resources to benefit local circuits in the Boston area. Discussions with engineering and executive management representatives at Eversource continue, with a goal of assisting the utility's grid modernization and compliance with recent legislative and regulatory initiatives around BTM storage and renewables.

Resilience of Controls & DERs

The forces of nature that would typically pose the highest risk to our locations and facilities are high heat and flooding. We have incorporated safeguards against both in the design. Generators will be installed on the roof or on raised pads outside the buildings and are designed to operate in extreme weather. Batteries and inverters will be installed inside or in sheltered enclosures following National Electrical Manufacturers Association (NEMA) standards for outdoor use. Wiring, switches, and connections will be specified to be waterproof and resistant to all anticipated stresses. The controls are located in the local DCI for on-site switching and in the cloud-based platform for revenue optimization. The former are sited well above likely flood stage, in protected areas, and within weather- and tamper-proof enclosures; the communication among them has a wireless backup. The latter are accessed via the web, with satellite-link communication backup; however, they are not needed in emergencies.

Task 4: Commercial and Financial Feasibility

Our analysis finds a healthy range of scenarios in which our microgrid business model may achieve its mission-driven objectives in a financially self-sustaining manner. This chapter describes the overall shape of our business model.

Objectives

RUN-GJC is a mission-driven project team. The primary objective is to demonstrate a microgrid model that helps frontline, multi-racial working class communities prosper-in-place during extreme weather events or power outages, and to recover and remain in their homes and communities following those events. The microgrid's governing entity will be responsible for stewarding and allocating resources to support as many community members as possible, with particular attention to vulnerable community members that are unable to evacuate, and to organizations and institutions that provide crucial services and support to the community at-large in times of disruption (medical facilities, community shelters, retail businesses providing essential goods, etc.).

RUN-GJC's assessment of the commercial and financial feasibility of our model is not guided by an interest in profit maximization, but by the more conservative goal of financial sustainability. There are also several additional mission-based preferences and parameters that shape and/or limit the range of acceptable scenarios for commercial and financial viability. These are:

- To maximize the number of community residents, especially those most vulnerable, who can access the resilience benefits provided by the microgrids — whether through DERs installed in their homes, or at nearby community access points — for up to 14 days in an emergency. Although there is no geographic barrier to participation, our preference is to prioritize facilities that support vulnerable communities. Through the three facilities assessed, there are over 2,000 Chelsea residents that would benefit from reliable electricity.
- To provide opportunities for residents to save and build wealth, based on three principles:
 - Ensure that the residents and communities who are the intended primary beneficiaries of the microgrid do not contribute financially beyond making energy payments, which should be kept at a level matching or below what they are currently paying for energy
 - Ensure that workers on the project are paid a prevailing wage and can rely on safe working conditions
 - Ensure that the community is fairly compensated for the benefits the microgrid provides to other stakeholders in the community and energy system

Business Model

The business model is to sell clean energy, energy resilience, and capabilities based on the aggregated deployment of the distributed energy resources (DERs) of our microgrid. The microgrid entity generates some revenue through competitive participation in energy markets, and some through contracts and agreements that vary by stakeholder.

Normal business operations will be restricted to 'blue sky' times, because in times of emergency the DERs will be deployed to support the most vulnerable community members. During 'blue sky' times, the DERs will be combined and dispatched from moment to moment to maximize the revenue or savings they can generate.

Building owners, ISO-NE, Eversource, neighboring businesses and institutions are all expected to be customers. The primary 'customers' and the DER host facilities are one and the same, i.e. the DERs added for resilience and for revenue production are installed in the customers' own facilities — the buildings housing low-income residents and small businesses, municipal facilities, and nonprofit organizations (NPOs) that serve them. Direct customers of the microgrid services are noted under each item in the Revenue Streams section below.

Our model rests partially on well-established markets for the energy and other capabilities our technology can provide, and on the marketing advantages secured by the strong, trusted, local relationships our community-based team members have built over decades.

Revenue Streams

Our Team has identified 30 potential streams of savings and revenue based on the capacities of our microgrid model. 17 of them have been successfully monetized in other places. 13 provide demonstrable value, but have not been monetized in the past. Those 13 include benefits that impact the public at large, which in the future may be supported and compensated through public funding (similar to public funding streams for other public goods such as education, safety, and health). We hope to work with Eversource and the City to ensure our microgrid is fairly compensated for *all* the benefits we provide, not only those with precedent for monetization.

The multitude of options means there are multiple routes to financial viability. The value streams may be pursued in varying combinations, depending on moment-to-moment market conditions as well as longer term trends in markets and in the policy landscape. Because the revenue streams are not all additive at all times, the pursuit of revenue via these different avenues will rely on the optimization algorithms of our proposed cloud-based aggregation software. The software will be able to detect energy conditions as well as market conditions and determine the best way to deploy microgrid assets. Although the majority of the revenue streams have been operationalized before, they have not before been deployed in the combinations we imagine. But a similar model (a 'multiple-stacked application') has proved successful in Sterling, Massachusetts where its microgrid not only reduced utility costs, but also shaved demand charges by more than \$2,000 with a 2-hour battery discharge within its first month of implementation.³⁴

³⁴ Olinsky-Paul, Todd. "How One Small US Town Will Save Millions with a Microgrid". *Renewable Energy World* 20, no. 4 (5 July 2017).

Direct Benefits; Quantified Value Streams

The first 17 value streams are proven to be monetizable.

1. EE, Water & Demand Charge Savings
 - a. Customer: The savings will be shared with performance contract customers
 - b. Energy Efficiency description: Before microgrid construction begins, each participating building must be investigated for opportunities to reduce energy usage. This may include swapping out aged, obsolete, malfunctioning, or otherwise inefficient lighting and HVAC equipment; building envelope sealing/insulation; upgrading controls; improving boiler and chiller plants and their distribution systems; changing water fixtures; repairing leaks; installing cool roofs; upgrading existing appliances; and many other means of maintaining/improving comfort while reducing energy consumption. These actions will create numerous benefits for the consumer: they will (a) reduce customer costs, (b) increase building value, (c) improve the comfort, reliability, maintenance, health and safety of its beneficiaries, and (d) reduce environmental impacts.
 - c. Demand Reduction description: Part of the design process for energy efficiency includes upgrading controls. In facilities that pay a demand charge, the controls can be programmed to shed or postpone electric loads during peak hours. While this does not in itself reduce energy consumption, it does shift its timing away from hours when expensive (and often 'dirtier') power plants have to be run to meet peak grid demand. In the community microgrid design, this becomes one of the three key resources that can be accessed (dispatched) to reduce costs and earn revenues for the community (the other two being onsite generation such as solar and CHP, and storage using batteries).
 - d. Status: These savings will be realized after the entity operating the microgrid is in place; the Team has run successful ESCOs in the past, and has interviewed interested candidates
2. Lease-and-service of clean energy products
 - a. Customer: Municipal, institutional, and commercial building owners/managers in City
 - b. Description: All customers will have access to the same assets, but charges will occur on a sliding scale. Those under a certain income threshold (and potentially other determining criteria) will not incur charges.
 - c. Status: IBEW 103 and the National Electrical Contractors Association (NECA) will help identify & engage local lease/service contractors, and will train local residents in these services
3. Wholesale Market trading with ISO-NE (Capacity, energy, and regulation markets)
 - a. Customer: ISO-NE
 - b. Markets description: While the greater electrical grid is operating the ISO can pay the community microgrid for capacity, energy, and regulation benefits once they are enrolled in these markets. The ISO can view the microgrid as it does any other market participant. As of now, wholesale markets exist for most of the benefits (on the regional level specifically).
 - c. Status: Markets in flux; Team consults with and sits on ISO-NE committees

<https://www.renewableenergyworld.com/articles/print/volume-20/issue-4/features/microgrids/how-one-small-us-town-will-save-millions-with-a-microgrid.html>

4. Solar energy credits and SMART program revenues
 - a. Customer: Utility and trading exchange
 - b. Solar Massachusetts Renewable Target program (SMART) description: Initiated by the Massachusetts Department of Energy Resources, SMART is a long-term solar energy incentive program³⁵ set to promote cost-effective solar development in the Commonwealth. Teaming up with regional utility companies (Eversource, specifically) this particular incentive program rewards solar panel owners with varying compensation rates for each kWh of energy produced.
 - c. Status: Experienced solar contractors are being engaged with help of IBEW, NECA, their ECAP financing program, and other expert Team members; they will extract maximal revenues to offset installation costs
5. Carbon credits and other tradable commodities
 - a. Customer: Utility and trading exchange
 - b. Carbon credits description: In one form, carbon credits are tradable permits that allow the holder to emit one ton of carbon dioxide or greenhouse gas equivalent (methane, nitrous oxide, etc.). In an attempt to minimize and regulate greenhouse gas emissions, governments can limit the number permits given or auctioned to each holder while also incentivizing a decline in emissions by gradually lowering ceilings. Holders can then sell these credits on the market at prices set by supply and demand or use the credits for future projects. This revenue stream has been in practice (in one of its potential forms) by the Regional Greenhouse Gas Initiative (RGGI) for some years. Other forms of either compliance or voluntary credits are likely in the future.
 - c. Status: Team has approved carbon credits in VA, includes consultants advising exchanges
6. Energy Watchperson, continuous commissioning, and security service
 - a. Customer: Municipal, institutional, and commercial building owners/managers in City
 - b. Energy Watchperson(s) description: A trained staff member (neighborhood resident trainee) who periodically checks and tests equipment and performs maintenance as needed.
 - c. Status: To be offered after organization is in place. IBEW 103 and NECA will help identify & engage local contractors, and will train local residents in these services
7. Resilience premiums (avoidance of costs and revenues losses)
 - a. Customer: Municipal, institutional, and commercial building owners/managers in City
 - b. Resilience as a Service description: Resilience as a service will take the form of lease-and-service contracts — including an offer of preventive and actual maintenance services — where businesses, institutions, and government agencies neighboring the facilities will pay a recurring fee on a sliding scale in return for the guaranteed energy continuity provided by the batteries, generators, lighting, electric vehicles and chargers at each facility. Residents who cannot afford to buy into the lease-and-service contracts at these facilities will receive the same benefits at no cost.
 - c. Status: Value proposition has been drafted for ‘Resilience as a Service’ and preliminary interest attracted
8. Sale of heat, cooling, and refrigeration commodities from CHP or trigeneration; sale of resilient data transmission
 - a. Customer: Municipal, institutional, and commercial building owners/managers in City

³⁵ See Appendix E for a full discussion of Energy-Related Credits & Incentives Available

- b. Combined heat and power description: CHP is the concurrent production of both electricity and thermal energy (heating/cooling) from the same source of energy on site, replacing or supplementing electricity provided from a local utility and fuel burned in an on-site boiler or furnace. By recovering heat normally lost during the generation of electricity and power and funneling it into needed heating and cooling of the building, this process allows combined heat and power systems to operate at efficiency rates above 75%, a significant improvement over the typical efficiency rates of traditional separated power and thermal energy systems. In addition to increased energy efficiency and savings, combined heat and power can contribute to energy resilience for the consumer by adding a local source of power. (Note regarding CHP in the three initial facilities' assessments: The Team elected not to include CHP initially because of its marginal cost-effectiveness, difficulty in obtaining approvals and grid connection, and marginal contribution to resilience. However, future installation of CHP plants will be considered where a substantial year-round thermal load can be found.)
 - c. Status: To be offered after CHP/Trigen capacity is in place; Team has developed such plants with utilities and sold their commodities in past
- 9. Resilient charging services for EVs, cell phones, and other battery-powered electronics
 - a. Customer: Residents, businesses, nonprofits, municipal agencies
 - b. Electric vehicle (EV) batteries and charging stations description: during outages, beneficiaries can use charging services for electric vehicles, cell phones, and other battery-powered electronics that would otherwise be incapacitated
 - c. Status: To be offered after battery capacity is in place
- 10. Peak demand reductions, Volt/VAR support, soft restart, improved access to customers, other utility services
 - a. Customer: Utility
 - b. Grid attributes description: While the grid is operating, Eversource can purchase power and grid benefits from the neighborhood microgrid, namely via SMART and storage. The utility's costs are only to the extent that they engage with the microgrid to purchase the benefits of behind-the-meter storage. As of now, Eversource has not yet begun to dispatch behind-the-meter resources to benefit local circuits in Greater Boston. Discussions with engineering and executive management representatives at Eversource are continuing, with a goal of assessing the utility's grid modernization and compliance with recent legislative and regulatory initiatives around BTM storage and renewables.
 - c. Status: Eversource conversations are part of Team's regular process
- 11. Connectivity: uninterruptible cell phone and computer network service via resilient satellite hotspot
 - a. Customer: Individuals near our neighborhoods; commercial, institutional, government users
 - b. Communications description: Continuous phone and internet availability via resilient satellite hotspot
 - c. Status: To be offered when set up
- 12. Contribution/assessment from developers of new/upgraded properties, in consideration of permits etc.
 - a. Customer: Developers and City

- b. Description: Developers of new and renovated properties (in today’s vibrant real estate market) logically could be asked to contribute to their neighborhoods’ development of resilience as a condition of permits, approvals, and tax benefits. A model for this could be the Smart Utilities Policy for Article 80, that requires developers in Boston to create a “district energy microgrid” for developments over 1.5 million square feet if feasible.
 - c. Status: To be developed with City planners
- 13. Utility incentives, DSM budgets, other ratepayer- and taxpayer-funded subsidies
 - a. Customer: Government agencies, utilities, foundations; RGGI proceeds, etc.
 - b. Utility Incentives description: As a part of Massachusetts’ new and aggressive energy savings plan, utility companies such as Eversource will be offered the opportunity to take advantage of multi-factor performance incentive mechanisms (PIMs). These incentives will reward utility companies for achieving energy savings, pursuing demand benefits, and providing incentives to customers who rent, rather than own, their homes or apartments. The microgrid organization may offer assistance in meeting goals, in return for utility subsidization of EE and resilience costs.
 - c. Demand-side management (DSM) budgets description: DSM is the modification of consumer demand for energy through financial incentives and educational resources. These practices encourage consumers to consume less energy during the hours of peak demand and pursue a more conservative lifestyle when it comes to their energy needs. Utilities routinely adopt DSM incentives in their EE programs, which can be accessed by the contractors installing EE improvements. They therefore reduce installation costs.
 - d. Other ratepayer- and taxpayer-funded subsidies description: These subsidies can be in direct forms, such as cash grants, or indirect benefits such as tax breaks, insurance, and rebates. Applications to receive these subsidies will be available after implementation of the microgrid.
 - e. Status: Applications will follow development
- 14. RPS, CPS, storage certificates, EEPS resources purchased by utilities at less than ACP rates
 - a. Customer: Utilities
 - b. Renewable Portfolio Standard (RPS) description: The Massachusetts RPS is a regulation that requires energy supply companies to ensure a specific percentage of their energy resources come from renewable energy. Suppliers meet their annual RPS obligations by acquiring a sufficient quantity of RPS-qualified renewable energy certificates (RECs) that are created, traded, and tracked at the New England Power Pool (NEPOOL) Generation Information System (GIS). The community microgrid operator creates RPS certificates for each kWh of renewable power generated, specifically solar RECs that can be sold in the markets (although rules and utility relationships are complex).
 - c. Clean Peak Standard (CPS) description: This standard requires regional electric grids or utilities to use a certain percentage of clean energy sources in order to meet demands during peak periods. This will combat the spike in excessive greenhouse gas emissions as well as energy prices during times of high energy demand. The Massachusetts Department of Energy Resources (DOER) is in the process of developing a clean peak standard as initiated by the 2018 Act to Advance Clean Energy. As in the case of renewable energy credits, an Alternative Compliance Payment (ACP) may be adopted, which would set a ceiling on the value of peak-power reductions in market trading. The microgrid operator might then offer metered reductions into such markets.

- d. Storage certificates description: Many states with Renewable Portfolio Standards are reviewing the benefits of adding storage certificates into the tradeable pool of renewable energy certificates. In Massachusetts, these are built into the SMART program and separately metered. The Buckley Apartments with a 495kW storage capacity, the Beth Israel Deaconess Medical Center with a 150 kW storage capacity, and the Chelsea City Hall with a 100 kW storage capacity may be eligible to receive SMART payments. Since the total storage capacity available to the microgrid operator is the sum of all separate installations (aggregated by the cloud platform), participation in markets with minimum qualification standards is anticipated.
 - e. The Energy Efficiency Portfolio Standard (EEPS) description: EEPS sets a binding energy savings target that requires utility companies state-wide to reduce a specified percentage of energy consumption through investments in customer energy efficiency programs. Common programs include: rebates on energy efficiency appliances and installations, energy audits for homes and businesses, behavior change and customer education programs that seek to encourage conservation, direct installation of new energy efficient appliances and technologies, retrofit and maintenance of existing appliances and equipment, and appliance recycling programs that strive to remove outdated, inefficient devices from homes and businesses. These programs are funded by ratepayer system benefit charges approved by the Department of Public Utilities. (This program depends on legislative, regulatory, and utility planning developments.) These EEPS resources can be purchased by utilities at less than the ACP rates.
 - f. Status: Will follow evolving regulations
15. Payments to reduce insurance claims
- a. Customer: Casualty insurance carriers
 - b. Payments description: As climate change rapidly amplifies rates of flooding, hurricanes, and other extreme weather events, insurance claims have been reaching record breaking highs.³⁶ Consequently, casualty insurance companies prioritize serving buildings that can guarantee a lower risk of withdrawing claims under these scenarios. Our virtual microgrid network will significantly reduce risks for residents and can leverage a compensational agreement between building owners and the insurance agencies for the benefit of all parties.
 - c. Status: To be negotiated
16. Research and replication grants
- a. Customer: Foundations, government agencies
 - b. Grants description: Applications for research and replication grants will be available after implementation of the microgrid.
 - c. Status: Applications to be prepared by Team
17. Building analysis & circuit-level monitoring service
- a. Customer: Municipal, commercial, institutional building owners
 - b. Description: Sensors installed at each circuit can capture data at the electrical panel and transmit them to the cloud-based software to ensure uninterrupted power supply.

³⁶ Frank, Thomas. "Flood Insurance Program Increasingly Underwater as Payouts Shatter Records." *Scientific American*, 19 June 2019.
<https://www.scientificamerican.com/article/flood-insurance-program-increasingly-underwater-as-payouts-shatter-records>

- c. Status: Being marketed; will build into neighborhood organizations

Indirect Benefits: Additional (Non-Quantified) Value Streams

The following values are not quantified in the model because (a) they may be socialized, in the sense that no identifiable stakeholder can reasonably monetize them at this time or (b) they require future regulatory or legislative action to recognize, price, and assign responsibilities. Yet, we assert that these may be the most valuable of all the value streams.

18. Value of resilience, beyond the model's treatment of reduced insurance costs and increased property values (e.g., municipal bond rating improvements, monetized avoidance of lost revenues, lost records, repair costs, etc.)³⁷
19. Utility access to customers currently 'hidden' behind master meters, or otherwise unknown
20. Increased employment and economic development
21. Community networks and empowerment
22. Improved health from reduced pollution
23. Environmental benefits
24. Improved property values
25. New markets for utility services
26. Improved cybersecurity
27. Non-curtailment of intermittent (renewable) sources
28. Soft restart following grid interruption
29. Utility-Community relations improvement
30. Injecting power may require less T&D infrastructure accommodation when injected in smaller increments from the distributed sites of this non-contiguous design

Strength, Weaknesses, Opportunities, and Threats

Strengths

- We can rely on project team members with extensive experience with the technologies and markets to oversee microgrid operations. CESI has experience with program design, Synapse has experience in wholesale market trading, Cape Power Systems has experience with utility interfacing, and CESI/Peregrine have experience maximizing load controls.
- A key design element of our model that bolsters financial viability is that there is no strict boundary limiting the participation of community members and institutions. The scalable design enables us to grow and more easily achieve financial efficiencies of scale.
- Our Team has relationships with organized labor leadership that can help provide training, access to licensed electricians, contractor recruitment and financing.

³⁷ Two recent studies referencing the value of resilience are:

Chittum, A. & Relf, G. "Valuing Distributed Energy Resources: Combined Heat and Power and the Modern Grid." *American Council for an Energy-Efficient Economy*, April 2018.

<https://aceee.org/sites/default/files/valuing-der.pdf>

Anderson, K., Burman, K., Simpkins, T., Helson, E., Lisell, L., & Case, T. "New York Solar Smart DG Hub-Resilient Solar Project: Economic and Resiliency Impact of PV and Storage on New York Critical Infrastructure." *National Renewable Energy Laboratory*, June 2016.

<https://www.nrel.gov/docs/fy16osti/66617.pdf>

- Our Team has relationships with community members, small businesses, and local institutions that can facilitate customer acquisition and minimize transaction costs. Outreach has been facilitated by GreenRoots through their trusted relationships and reputation in the community. Our Team has found that many local stakeholders are highly interested in participating in our microgrid model, including city government; anchor institutions like hospitals, schools, and community centers; nonprofits; organized labor; developers; and residential property owners. Approximately two hundred potential community subscribers have been identified through GreenRoots' work in the neighborhood.
- Our Team's relationships with local stakeholders has helped facilitate site visits and acquire important data. Multi-metered buildings require contacting not just the property manager (who can furnish common area meter information) but each unit's resident. Asking strangers to hand over personal information is not easy; this work is aided and expedited by the trusted relationships GreenRoots has cultivated with residents over time. With facilitation by GreenRoots, each of the people responsible for energy monitoring at the two of three sites with interval meters granted the Team access to utility bills and signed an authorization form allowing Eversource to provide the Team with interval data. As the microgrid grows, this will not always be the case. Some multi-metered buildings will inevitably participate and bills will need to be collected by hand. This work will also be aided by GreenRoots familiarity with residents and residents feeling comfortable enough with GreenRoots to share their bills or sign over authorization for interval data access.
- Our model can pursue multiple revenue streams, which means we have multiple pathways to financial sustainability.
- The Team has extensive experience with microgrid technologies, including utility interconnection, ISO trading, cloud-based resource optimization, energy efficiency performance contracting, and clean-energy financing.

Weaknesses

- It will take time and resources to develop community leadership, business management skills, and technical competencies to provide meaningful oversight of microgrid operation.
- In order to pursue multiple revenue streams, the Team will have to develop and implement multiple marketing techniques.
- Although the model is scalable, it will be small when it starts out. This could make the project less attractive to some bidding contractors at the outset.
- The model is unique in its entirety, and complex, and can be difficult to explain or to grasp.
- The ownership model, and the governance and management entity for the microgrid will take time and resources to design and launch.

Opportunities

- Revenue generation has already been accomplished in each of the proposed markets by a number of private developers including EnPhase, Schneider, Ameresco, NRG, Siemens/Ruselectric, and several utilities. Our project team can tap the expertise of such established microgrid developers by inviting their participation in City-endorsed community microgrid expansion.
- There is a high level of interest in microgrid participation based on our Team's ongoing outreach and conversations with local stakeholders. Beyond the three facilities included in this assessment, there are nine other facilities that have signed letters of support for the project and are eager for the next phase of our work to begin.

- Vendors and contractors for each of the technologies have been identified, interviewed, and expressed interest.
- Our Team and project have secured strong political support from city officials.
- There is a surplus of available cash in the economy looking for investment opportunities.

Threats

- The properties where we hope to deploy microgrid assets include those in low-income neighborhoods where end-user load profiles are difficult to predict, and which are likely to change substantially following energy efficiency improvement.
- Economic modeling was challenging because interval data is not readily available for all buildings without Advanced Metering Infrastructure.
- In our commercial environment, key conditions (DER costs, tariffs, markets for attributes, and public policy) are volatile and subject to rapid change.
- Changes in the political landscape could affect local support for our project.
- Large utility plants may saturate wholesale markets and reduce the potency of our services.

Value Proposition for Stakeholders

Blue skies services and benefits will vary by stakeholder.

Community residents (both on and off the microgrid)

- Share savings (EE and solar) – potentially through the mechanism of the owner entity paying the utility bills, and then charging the users an amount less than their historical expenses
- Receive dividends from any profit
- Strengthened community networking and communications

Local businesses, organizations and institutions

- To nearby commercial establishments, we can lease clean-energy products with service contracts, which gives them the peace of mind of resilience in the case of grid interruption — they would make a monthly payment

Chelsea

- Jobs in energy efficiency, security, watchperson services (trained residents)
- Economic development in the participating neighborhoods

Massachusetts

- The microgrid will promote several Massachusetts state policy objectives:
 - Environmental justice, EJ (e.g., 2017 EOEPA Environmental Justice Policy³⁸); the microgrid project will provide economic, public health and resiliency benefits to EJ populations and will develop ways to replicate such successes for the benefit of additional EJ neighborhoods over time. For example, the policy looks to extend “energy benefits” in EJ communities with “access to funding, training, renewable or alternative energy, energy efficiency, or other beneficial resources disbursed by EEA, its agencies and its offices³⁹,”

³⁸ Environmental Justice Policy of the Executive Office of Energy and Environmental Affairs. Article 97 (31 January 2017) https://www.mass.gov/files/documents/2017/11/29/2017-environmental-justice-policy_0.pdf

³⁹ Ibid.

which are all topics that this microgrid project addresses. In addition, the proposed governance of the microgrid project provides residents with a real voice in decisions regarding energy source and use in both normal and emergency modes.

- Renewable and clean energy (e.g., RPS, Renewable Portfolio Standard and APS, Alternative Energy Portfolio Standard and related legislative and regulatory policies) through the addition of solar panels and battery storage on multiple facilities. The microgrid project will identify potential locations for solar PV at or near participating buildings and, more generally, are intended to increase the availability of clean energy to EJ populations. The team is studying potential opportunities for anaerobic digestion of food wastes, and the use of low-carbon fuels, but are not yet proposing their use for the purposes of this feasibility assessment. In addition, heat pumps and other ‘Renewable Thermal’ technologies will be assessed where feasible. Implementation of these energy and microgrid technologies and projects also promotes the Commonwealth’s economic development policies.
- Climate mitigation (e.g., Global Warming Solutions Act⁴⁰) by maximizing the reduction of carbon emissions in the neighborhood by leveraging solar energy, battery storage, and EV charging infrastructure. In this sense it also plays into the federal Clean Air Act⁴¹ as the clean energy and reduced number of combustion engines has impacts on public health.

Eversource

- The various DER capabilities will benefit Eversource in both blue and black sky conditions. The proposed cloud-based aggregation (combined dispatch) of large battery capacity will allow Eversource and ISO-NE to better balance intermittent power sources with grid demand by providing an instantaneous storage resource. Storage can smooth demand spikes, keep renewable sources generating when grid loads are low, and ramp up and down as these intermittent sources suddenly turn on and off. Furthermore, the battery/inverter capacities, which can be combined among all the participating facilities (via the cloud command), can be called on by Eversource following an outage or local fault to ease (ramp) the re-energizing of circuits. In normal mode (i.e. blue sky conditions), the smart inverters and their batteries offer Eversource additional ‘regulation’ services to sustain the grid’s standards. The battery source is ideally suited to sustaining voltage and frequency closely because of its ability to absorb or export energy instantaneously — a capability not matched by traditional generator sources.
- We can offer Eversource and ISO-NE benefits from our capacities to aggregate and coordinate dispatch of the DERs.
 - BTM storage capacity and distribution grid benefits
 - Massachusetts DPU’s Order 12-76-B mandates⁴²
- All new wiring would be behind meters and transfer switches (unlike conventional microgrids that use utility-owned distribution wiring and switching for island operation). No additional cost would be imposed on Eversource for the installed microgrid DERs and controls. The exception is when power should be exported in parallel mode, for either utility benefit or participation in

⁴⁰ An Act Establishing The Global Warming Solutions Act. c.298 (7 August 2008) <https://malegislature.gov/Laws/SessionLaws/Acts/2008/Chapter298>

⁴¹ Clean Air Act. 42 U.S.C. §7401 et seq. (1970) <https://www.epa.gov/laws-regulations/summary-clean-air-act>

⁴² Investigation by the Department of Public Utilities on its own Motion into Modernization of the Electric Grid. Department of Public Utilities of the Commonwealth of Massachusetts 12-76-B (12 June 2014) <https://fileservice.eea.comacloud.net/FileService.Api/file/FileRoom/9235208>

wholesale markets. Even in that case, the amount of power exported will be on the order of each customer's loads. The Team is meeting regularly with Eversource to plan such cases and ensure grid benefit.

ISO-NE

- The smart inverters and their batteries benefit ISO-NE similarly to how they benefit Eversource, as they offer additional capacity, energy, and 'regulation' services to sustain the grid's standards. The battery source is ideally suited to sustaining voltage and frequency closely because of its ability to absorb or export energy instantaneously—a capability not matched by traditional generator sources. Additionally, many benefits of distributed energy resources are of particular value to regional and/or local operators of the electric grid. The adoption of battery storage will put utilities in compliance with three out of the four mandates in the Mass DPU's Order 12-76-B. Storage is a grid modernization asset and could be eligible for rate recovery if accompanied by a quantifiable business case (see the State of Charge: Massachusetts Energy Storage Initiative report⁴³). Massachusetts State Law M.G.L. c.25 §21 Green Communities Act allows storage to serve as a peak demand savings tool.⁴⁴

Team and Stakeholder Roles and Responsibilities in Operation

To help ensure our Team's mission-driven objectives are maintained as priorities over the course of the lifecycle of the microgrid, we mean for the microgrid to be owned and operated by a municipal affiliate entity that is accountable first and foremost to those community residents that would be most reliant upon its support, and then accountable also to other key stakeholders. This owner entity would have ultimate authority and decision-making power.

The municipal affiliate-owned, community-run structure of microgrid leadership is an essential feature of the project. We envision that the microgrid would be run as a municipally-owned service in Chelsea, so the community representatives own and drive decisions regarding the microgrid. The board would be made up of community members with deep ties to their community, particularly working-class community members most impacted by climate change. The microgrid would not be aimed at maximizing corporate profits or amassing individual market share. The municipal affiliate structure would re-invest the profits back into the community. The municipal affiliate model would focus on equitably distributing benefits and profits, supporting long-term community work, and strengthening resident power and bonds between residents. Thus, the structure would be an effective method of ensuring that economic and climate resilience benefits from the microgrid go to those who need it the most.

⁴³ "Massachusetts Energy Storage Initiative Study." State of Charge, July 2017.

<https://www.mass.gov/files/2017-07/state-of-charge-report.pdf>

⁴⁴ Massachusetts State Law M.G.L c.25 §21 (2 July 2008)

<https://malegislature.gov/Laws/GeneralLaws/PartI/TitleII/Chapter25/Section21>

Table IV: Stakeholder Roles for Ongoing Microgrid Operations

Stakeholder	Role
Microgrid owners (municipal affiliate entity associated with GreenRoots)	The ownership entity will provide regular oversight over microgrid operation to ensure it is achieving the intended benefits, and that the contractors are meeting O&M specifications. It will be the primary point of contact for community members with questions or concerns. It will also engage in ongoing outreach to community residents interested in participating in the microgrid.
CABA	CABA will provide support and services for small businesses participating in the microgrid, and will engage in ongoing outreach to small businesses interested in participating.
Engineering Procurement and Construction (EPC) Contractors, Subcontractors, and Vendors	EPC contractors will provide O&M services and guarantee savings, revenues, and PPA prices. Vendors and subcontractors will provide service installations as needed.
RUN, CLU, IBEW	RUN, CLU, and IBEW will support and advise microgrid owners on matters relating to contractor O&M work and any other questions relating to the microgrid technology.
BlueHub	BlueHub will provide follow-up support on financing and can offer advice on replication.

Financing

The project team has identified several promising leads to secure the upfront capital needed to initiate installation of our microgrid. The Team has relationships that will help secure project financing/equity investment, and has a track record in raising and placing hundreds of millions of dollars in microgrid technologies. CESI and Peregrine have extensive experience in Energy Savings Performance Contracts (ESPC) and Property Assessed Clean Energy (PACE) financing. Team members CLU (via NECA's E-CAP) and BlueHub Capital bring other financing options to the project.

As one principal source of project financing, we are pursuing an agreement with the Energy Conservation and Performance Platform (E-CAP). E-CAP is a program of NECA in cooperation with IBEW, which has a track record of financing energy efficiency and DER projects similar to ours.⁴⁵ NECA is a contractor network partnering with the International Brotherhood of Electrical Workers (IBEW), a union with which RUN-GJC team members have a close working relationship. Working with NECA provides our Team an opportunity to pursue other objectives and advantages:

- The first opportunity is the ability to ensure that the people who help build and install the project are paid a prevailing, living wage.
- Second, with the cooperation of the IBEW Local 103 and the National Electrical Contractors Association Training Center in Dorchester, the installation, connection, starting, and servicing of generators can be handled by trainees with mentoring from their instructors. It is the Team's

⁴⁵ "NECA Energy Conservation and Performance Platform (E-CAP)." National Electrical Contractors Association, 2020. [https://necanet.org/joining-neca/member-benefits-services/tools-resources/neca-energy-conservation-and-performance-platform-\(e-cap\)](https://necanet.org/joining-neca/member-benefits-services/tools-resources/neca-energy-conservation-and-performance-platform-(e-cap))

hope that trainees for this work can be recruited from the neighborhood to help create local jobs with training provided, a model that proved successful in Northern Portland, Oregon. There, the Living Cully coalition invests in local residents through leadership development and job training that allows lower-income residents to contribute to positive change in their communities, while also building their own capacity to stay as revitalization occurs.⁴⁶ Their platform ensures low-income residents receive equitable access to the benefits of ecological restoration.

- We also expect to finance the project through the contractors and vendors we select to develop each installation.
- Lastly, pursuing this route allows portions of the work to be reimbursed out of the capital costs, financed by the IBEW/NECA Energy Conservation and Performance Platform (E-CAP). According to the E-CAP brochure, retrofit customers “do not need to borrow or invest money⁴⁷” and projects include performance guarantees, making their product and services appealing to the team.

Since this is a distributed microgrid with different groupings of assets in different facilities, the precise financing structure will vary among subscribers and cannot be predicted until the engineering design is completed, and plans and specs are developed for bid. The financing structures will depend on the EPC contractors who are engaged and the assets being installed.

The *likely* financing structures will include power purchase agreements (PPA) for solar power, batteries, and inverter installation. For energy efficiency improvements, we will likely use shared-savings agreements. For lease-and-service of clean-energy products to commercial customers, we are investigating vendor financing, franchising, and consignment arrangements. Security interests will be held by financiers, including vendors, unions, ESCOs, PPA contractors, and other investors, during the term of the debt. In some cases, investment tax credits and 179d tax credits will be applicable.

Foundations are interested in funding our model, including nontraditional funders who are aligned with our social mission and grassroots ownership model. Organizations like the Ujima Project and Boston Impact Initiative are especially active in the Boston area. In discussing the Boston Impact Initiative, Co-founder, Aaron Tanaka, said that, “Our focus has been to bring capital to communities that have been historically excluded from access, specifically focusing on entrepreneurs from Boston’s low-income communities of color. Boston Impact Initiative was our area’s first private, place-based impact fund and has helped model nimble and high impact investment strategies. This feels important as more foundations and endowments look to shift capital towards local investing. We see our role as finance activists, seeking to transform the local capital ecosystem by modeling new approaches, and working as local conveners and network builders.⁴⁸” While the upfront expenses involved with a project of this magnitude are not insignificant, we believe that the implications of a true community-led microgrid provide a compelling reason for both foundations and nontraditional organizations like Ujima to award grants and attractive financing to the Team and the entity that ultimately operates the microgrid.

Under the conditions of the real estate market today, we may be able to ask developers to contribute to neighborhood resilience as a condition of permits, approvals, and tax benefits.

⁴⁶ “Lideres Verdes”. Living Cully, 2020. <http://www.livingcully.org/programs/advocacy-and-leadership/>

⁴⁷ “NECA Energy Conservation”. NECA (see footnote 43)

⁴⁸ Dubb, Steve. “Interview of Aaron Tanaka.” Democracy Collaborative, November 2015. <https://community-wealth.org/content/aaron-tanaka>

Contractors, vendors, and suppliers

The selection of technology will be shaped by the design objective: to deploy a reliable combination of hardware and software that will minimize maintenance expenses and maximize performance and efficiency. The Team will give priority to union labor and contractors and to Massachusetts suppliers as it rolls out the program.

We have identified manufacturers, distributors, and/or contractors for all of the clean-energy assets to be deployed in the proposed microgrid (clean fuels, generators, solar DHW and PV, smart inverters, controls, satellite modems and wifi, EVs and chargers, and batteries). The Team has spoken with ten nationally-recognized suppliers and contractors in the technologies listed and have executed NDAs with some of them. None have been formalized as the Team needs consensus around who will ultimately be chosen to perform work on the project. The major challenge will probably be to attract competitive bids while the project is still small.

The municipal affiliate will issue RFPs to choose contractors and suppliers. The Team will select one or more EPC contractors for development and construction, and then an operations and management contract. For the project to succeed quickly and be widely-replicable, this entity should be values-aligned and close to the RUN-GJC Team. We want to be intentional about choosing our contractors in order to ensure high labor standards and other mission-driven objectives. While no commitments have been made yet, we have engaged a leading candidate (Nexamp) in developing cost estimates. They are a union EPC with close relationships with the IBEW-NECA partner, a leading solar PPA contractor, and a candidate for E-CAP financing. The general EPC contractor will engage contractors and suppliers, in collaboration with the Team. We have also received indicative quotes from prominent developers for storage, controls, and energy efficiency installations, further verifying the sustainability of this design.

Legal and regulatory needs and advisors

Since the DERs are distributed and sited to local loads, many of the potential issues of siting and environmental permitting are avoided. In cases of some large-building DC generators, the usual City, State, and industry standards and permissions will be followed. Solar panels and EV chargers will require permits from local authorities.

The Team has regulatory experts available through both Synapse Energy Economics and Peregrine Energy Group. Our project also enjoys a high level of local political support which can help smooth and expedite the installation phase. The Team is in continual contact with both City and utility representatives to ensure all issues are anticipated.

Table V: Stakeholder Roles for Microgrid Development and Construction

Entity	Development	Construction
Microgrid owners (entity associated with GreenRoots)	The ownership (municipal affiliate) entity, as it emerges, will be responsible for advocating for the microgrid project and articulating its value proposition. It will be the entity that secures financing, forms partnerships, oversees the development budget, procures and negotiates contracts with contractors and vendors.	The ownership entity will oversee contractors and hold them accountable to agreed-upon terms, acting as an owner’s agent (except for small businesses).
Lead neighborhood organization (GreenRoots)	GreenRoots, in collaboration with community members who would form the core of the municipal affiliate entity, will clarify the benefits and metrics of interest. GreenRoots will also recruit customers from the community and facilitate introductions between local stakeholders and the technical team.	GreenRoots will participate in approving the final technical design and budget, financing structure and terms, the selection of vendors and contractors, and the construction timeline.
CABA	CABA will interact with small businesses, conduct surveys, articulate the microgrid’s value proposition, and recruit small business customers.	CABA will serve as the owner’s agent for small business customers.
Engineering Procurement and Construction (EPC) Contractors	EPC contractors will conduct energy audits of facilities interested in participating in the microgrid. It will provide design recommendations, cost estimates, and forecast savings and revenue. Through the owner’s agents it will be accountable to owner interests.	EPC contractors will recommend vendors, get any necessary permits and approvals, and manage engineering, procurement, and construction.
Subcontractors and Vendors	Subcontractors and vendors will provide price quotes for assets and O&M services. They will develop a timeline/schedule and identify suppliers.	Subcontractors and vendors will deliver and install microgrid technologies, and they will provide any necessary documentation, materials, and training for operations.
RUN Technical Team	RUN will provide the master design for the microgrid and support and advise the ownership entity.	RUN will review EPC contractor work and commissioning.
CLU, IBEW, NECA	IBEW will advise on the electrical design. CLU will support the lead neighborhood organization and the formation of the ownership entity.	CLU, IBEW, and NECA will coordinate financing through NECA’s E-CAP. They will also advise in design and contractor/vendor selection.
BlueHub	BlueHub will provide advice and guidance on financing options.	BlueHub will continue to advise on financing matters as needed.

Development, Installation, Construction

Capital costs

We conducted our assessment assuming three specific facilities in Chelsea will participate in the initial stage of installation, including demand reduction, battery storage, engine generation, controls, solar where possible, as well as several stations for leasing and charging electric vehicles and satellite cell phones. The total capital cost for the three facilities is expected to range from \$6 million to \$8 million, depending on assumptions, as detailed in the Task 5 report.

In addition to equipment and installation costs, capital costs include initial marketing of concept to customers, conceptual engineering design, coordination of project development among participants, ESCOs, aggregators, lessors/lessees, and optimizing platform contract procurement. The model estimates these costs at approximately 5% of up-front installation costs per microgrid participant. Based on analysis using DER-CAM (detailed in the next chapter), we calculate an upfront investment of \$200,000 in working capital to initiate microgrid installation. This includes funding for one half-time equivalent staff for one year for the implementing organization as well as at least 90 days of receivables.

Start Up Costs

The start up costs include development, building audits, engineering systems and controls, coordination with stakeholders, Request for Proposal (RFP) development and bidding, project management, financing arrangements, and Measurement and Verification (M&V) protocols.

Selling, General, and Administrative Expenses (SG&A)

Selling, general and administrative expenses are the sum of all the expenses a company incurs, not including the cost of goods sold. These expenses include both the operating expenses — costs an organization must incur to keep the lights on and doors open — as well as the costs that are incurred while selling and distributing a product or service such as advertising costs. SG&A has not been assigned a value at this time.

Total Gross Margins Prior to SG&A Calculation

This is the final profit from known revenue streams, before subtracting SG&A (not including start up costs). The neighborhood organization will be set up in a way that permits sharing profits from operations among its participating members.

A pro forma projection of gross margins over time has been drafted by the Team as an example for consideration by potential investors. It is necessarily based on estimates of evolving markets, government and utility subsidies, and costs of major components. It is attached as Appendix G.

Profitability is determined for each of the revenue streams and its costs separately, depending on volume and many other variables. The net revenues are equivalent to gross margin or operating profit before allocation of SG&A expenses from the municipal affiliate. Each of the revenue streams, however, has been shown to operate profitably under appropriate deployment elsewhere, often by members of the technical Team or close colleagues. In the proposed business model, these revenue streams are mostly additive, and their costs are almost all independent of each other; their combination and relative

scales depend on local as well as regional market conditions at the time. They are not, however, simultaneously additive; their activation in real time depends on the cloud-based aggregation platform.

Task 5: Cost-Benefit Analysis

We have assessed the technical, commercial, and financial viability of the proposed design in general terms in the preceding chapters. Ensuring that the design's benefits will exceed its costs in specific buildings requires a quantification of many variables.

We therefore tested our business model with two approaches: 1) We tested multiple assumptions using the Distributed Energy Resources Customer Adoption Model⁴⁹ (DER-CAM); and 2) We acquired indicative quotes from prominent commercial developers/financiers who are interested in participating in the deployment of our model. We used the DER-CAM program to seek external validation of the technical and economic feasibility of the design for one of the facilities.

Methodology

Modeling software

DER-CAM is a decision support tool used to optimize the cost and/or emissions of a microgrid design. We selected this software to conduct a preliminary assessment of the proposed community microgrid, as recommended by the Massachusetts Clean Energy Center (CEC). This analysis was run using the most recent browser-enabled software: DER-CAM Web UI 5.9 Full. Previous modeling had been conducted using the Desktop version 5.8 Full.

While the updated version of DER-CAM provides new functionality, it was difficult to use given our hybrid multi-facility design model. Lawrence Berkeley National Laboratory (LBNL) recommended switching to DER-CAM's web-based interface after the updated desktop version could not run due to an unhandled exception error that was unfamiliar to the LBNL developers. LBNL eventually acknowledged that being a research institution, they "don't quite produce commercial-quality software," in reference to the bugs and server issues encountered. Additionally, methodological errors were identified. For example, the resilience input parameters for SAIDI and VOLL are constrained to values between 0 and 1, whereas they should have accepted any non-negative values in units of minutes and \$/kWh, respectively. Regardless, the Team made its best efforts to assess the Buckley Apartments using DER-CAM.

Modeling approach

Buckley was analyzed as a single node to represent the non-electrically contiguous (i.e. distributed) microgrid design. Using DER-CAM, we performed a cost optimization analysis for the property, first evaluating a "reference case" to obtain the annual energy costs and CO₂ emissions of the site prior to new investments, and then again for the various "investment cases" explored in this study.

DER-CAM projects may be created as a single-node or multi-node model. Using the multi-node configuration is unsuitable for the characteristics of the proposed microgrid for the following reasons:

⁴⁹ "Distributed Energy Resources - Customer Adoption Model (DER-CAM)." Microgrids at Berkeley Lab, *US Department of Energy*, 2019. <https://building-microgrid.lbl.gov/projects/der-cam>

1. If all three of the project's facilities are modeled under one multi-node project, DER-CAM's topography would only allow one utility connection node, with all loads and DERs arranged behind it. This would be inaccurate considering the facilities' geography and billing structure.
2. If one facility is modeled as a multi-node, the analysis would face the same weakness as using a single-node, which is that the DER-CAM model does not have information about or access to other facilities and their resources. Therefore, only one facility may be evaluated at a time (in other words, each facility requires its own run).
3. The most significant distinction between a single-node and multi-node project in DER-CAM is that the multi-node option requires specific information about electric, heat, and gas networks. According to DER-CAM's documentation, variables such as inadequate line capacities are likely causes of infeasibility. These multi-node inputs need a level of detail unavailable to us and are not crucial aspects of the design.

Ultimately, the single-node configuration is a better representation of the non-electrically contiguous microgrid design, but it does not account for the benefits of aggregation, which are described in more detail in the following section.

For all runs, solar data were obtained from DER-CAM's database for Logan International Airport. Wind data, hydro data, and ambient hourly temperatures are populated by default values because they are used to analyze technical features that are not included in the proposed microgrid design, such as wind generation and hydro generation.

We selected Buckley for this analysis because actual interval data was available for the site. DER-CAM organizes load data into hourly profiles for electricity-only, cooling, refrigeration, space-heating, water-heating, and natural gas-only end-uses. Buckley relies entirely on electricity and can therefore be modeled solely with an electricity-only load profile. LBNL had advised that all end-uses could be aggregated as electricity-only or natural gas-only, depending on the data available to us, although this was not applicable to Buckley.

We processed the hourly load profile to identify the number of week, weekend, and peak days. Peak days were defined as days when demand reached within 2 kW of the maximum value of the relevant month. The number of outage days were determined using the 2017 Eversource outage list. For each emergency day defined, a day was subtracted from the corresponding non-emergency day type. For example, if there were 2 outages on separate days by our definition in January, there were thus 2 emergency days and 29 non-emergency days.

Tariff rates were extracted from Eversource utility bills⁵⁰ and used as model inputs for electricity rates, monthly fees, and associated utility charges. The Eversource bills were given to RUN-GJC by the property manager (Chelsea Housing Authority) after GreenRoots facilitated the informational exchange.

Any pre-existing generators were defined. With all new microgrid investments disabled, the model was run at this point to obtain reference case values. The outputs of the reference for 'Total Annual Energy

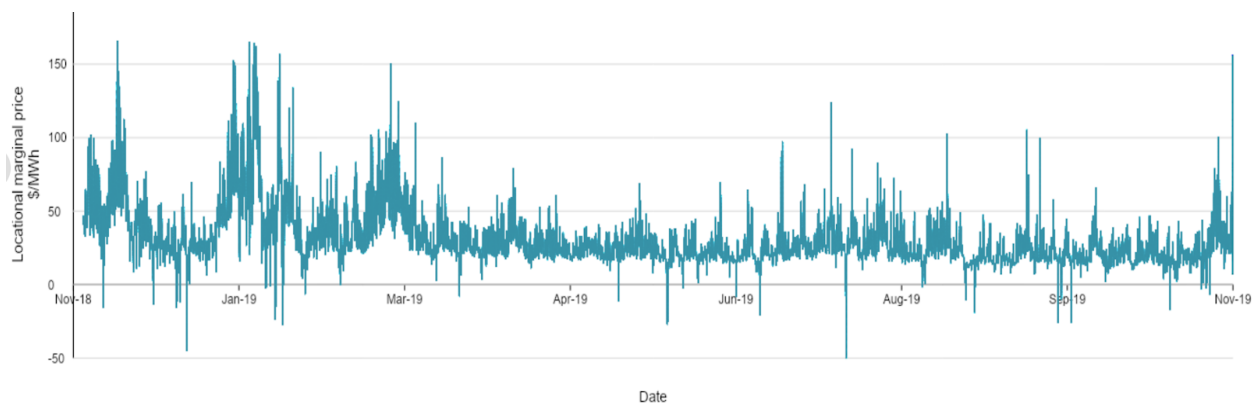
⁵⁰ As previously discussed, GreenRoots facilitated the collection of utility bills from the various property owners whose properties the Team analyzed for this study.

Cost' and 'Total Annual CO2 Emissions' were used as the BaseCaseCost and BaseCaseCO2 inputs in the investment case.

For the investment case, the constraints on DER investments were defined by the capacities discussed in Task 3. This included green-diesel generators, battery storage, EV storage, and PV generation. Outage days based on the 2017 Eversource outage list⁵¹ were input as scheduled outages to model real examples of outage scenarios with the proposed design. Power export options were also adjusted to enable net metering, renewable exports, and non-renewable exports.

ISO-NE markets were analyzed using recent historical data for ancillary services, including demand response and Locational Marginal Prices (LMPs) at local distribution nodes. The hourly price profiles to export electricity to the grid were obtained from ISO-NE pricing data for final real-time hourly LMPs.⁵² Demand response variables were determined using data from monthly demand-response threshold price summary reports to identify clearing prices for DR services.⁵³

Figure 10: Locational Marginal Prices (LMPs) in Boston from ISO-NE servers, 2019.



DER-CAM Results for Buckley

DER-CAM's investment case output determined a 12.40% increase in Total Annual Energy Costs and a 14.49% savings in Total Annual CO2 emissions (Appendix C, Table i.). The implication of this outcome is that the design is economically infeasible. The variables influencing infeasibility in this model are significantly impacted by the limitations mentioned above, including the design's ability to generate revenue and the value of resilience.

These results suggest the design does not have the capacity to export electricity or provide ancillary services, which are the only two branches of revenue identified by DER-CAM. By DER-CAM's configuration, the green generator, sized to 50% of the coincident load, is rarely expected to exceed the facility's load, making it unlikely to be available to export when the grid needs it. DER-CAM considers

⁵¹ "Eversource EMA Outage Accident Report 2017." Eversource, 2018.

<https://fileservice.eea.comacloud.net/FileService.Api/file/FileRoom/9163112>

⁵² ISO New England. *Pricing Reports: Final Real-Time Hourly LMPs*. Accessed December 16, 2019.

<https://iso-ne.com/isoexpress/web/reports/pricing/-/tree/lmps-rt-hourly-final>

⁵³ ISO New England. *Pricing Reports: Demand-Response Threshold Price Summary*. Accessed December 17, 2019.

<https://iso-ne.com/isoexpress/web/reports/pricing/-/tree/demand-response-threshold-price-summary>

relying on the green generator's full capacity to be economically favorable in both blue-sky and outage scenarios. We do not rely on the generator's full capacity, as the cost of electricity produced by the green generator is higher than the cost of grid purchase, even considering demand charges. The batteries are likewise never used in the DER-CAM model to export electricity or provide ancillary services.⁵⁴ This is a constraint determined by DER-CAM's conventional microgrid configuration, whereas in actuality the DERs could export their full capacity to the grid instead of serving behind-the-meter loads, due to the design's automatic transfer switch and revenue meter.

Aside from participating in wholesale markets, we assert that the generator or battery could, in practice, be used for demand response to reduce load at the facility. However, DER-CAM considers demand response as loads that can be shed, not as using DERs to reduce the net load.

Two outages were modeled (and are exhibited in Appendix C in Figures 1a-b), to depict winter and summer outage scenarios. In the event of an outage, battery dispatch and green generation are favored. If the maximum load curtailment has been reached, the green generators would be dispatched to support the load. In summer, the load profile rarely exceeds generator capacity, allowing the green generation to support the facility's full load in both blue-sky and outage scenarios. The risk of a run returning an infeasible result is especially sensitive to outage inputs, due to the cost of running the generators. For this analysis, the current price of biodiesel is estimated to be \$0.100/kWh, though as production increases, we expect the cost to decrease.

The appropriate approach to outage modeling is unclear, as DER-CAM allows inputs for "scheduled outages" and "unscheduled outages." Unscheduled outages are used to define the regular reliability of grid service in order to quantify the value of local, short-term reliability, whereas scheduled outages are intended to model medium to long term outages, allowing a better understanding of how resilient a microgrid is to events such as natural disasters.⁵⁵ The documentation suggests it is common to model one scheduled outage at a time, usually depicting a full-day or otherwise major blackout. Alternatively, unscheduled outages may be used to estimate the cost of minor outages over one year. Such information is available from the 2017 Eversource outage list. This data does not distinguish regular grid service outages from long term outage scenarios, which in turn can cause a misinterpretation of outage costs overall.

For the results presented in Appendix C, all outage data was input as unscheduled outages, overestimating the impact of severe outages on the facility. Consequently, DER-CAM's analysis of the cost to support such outages is inflated, incorrect, and returns an infeasible result. In previous runs depicting two unscheduled outages, with one outage per season, the output identified *positive* total savings for both energy cost and CO₂ emissions. This version of our DER-CAM analysis could not be

⁵⁴ Efforts to contact LBNL to understand the variables hindering this action went unanswered.

⁵⁵ Typically, a scheduled outage refers to intentionally taking generators offline for maintenance. DER-CAM section 7.2.1 defines Scheduled Outages as, "Hourly definition of the utility service availability during scheduled outages (emergency days). This value should be either 1 or 0 to indicate whether the utility connection is available...This table is generally used to define outage scenarios (e.g. full day outages) for resiliency modeling. To apply, add emergency day types to the NumberofDays table." Section 7.2.2 defines Unscheduled Outages as, "Hourly definition of expected utility service availability...This table is generally used to define the regular reliability of grid service in order to quantify the value of local, short-term reliability. To apply, no additional day-types (e.g. emergency days) are required."

"DER-CAM v5.9 Model Input Manual & Data Descriptions." Lawrence Berkeley National Lab, pp. 77-78.

recovered due to DER-CAM server issues which prevented any further DER-CAM runs to be completed under our time constraint.

The limitations of DER-CAM on the proposed design are the cause of this analysis' economically infeasible result. The model's inability to generate revenue and inaccurate outage scenario both damage the savings projections of this run. Resolving the latter would return an economically feasible output and analyzing the design without the constraints of a conventional microgrid analysis would prove the microgrid to be profitable.

Commercial Assessment

To get a commercial assessment of the level of investment monetizable from such combined sources, facility data have been shared with several prominent developers in three EPC categories (energy and water efficiency, solar and storage installation, and resource aggregation), with a request for indicative quotes. Team members have met with, or privately procured energy systems from, all of these developers in the past. Quantitative indicative quotes on elements of our design have been received from four. The resulting quotes appear to confirm both commercial interest and feasibility as the combination of prices, savings, and revenue sources quoted in each case have confirmed the cost-effectiveness of the Team's design. Quotes cannot be shared in this report because of Confidentiality or Nondisclosure Agreements.

Contractor Investment and Maintenance

EPC contractors will be needed for three categories of work:

- Energy efficiency (EE) and water efficiency improvements: providing expert identification, design, and installation of EE investment opportunities that will pay for themselves via future savings
- Solar and storage installation: optimizing the size, design and installation of PV panels, inverters, and batteries
- Aggregation of the resources (generation, storage, load management): designing, installing, and programming the cloud-based optimization platform and control interfaces for participation in grid-benefit markets

In all three cases, the design (and the model) assumes that an experienced contractor will invest in the installation of facility improvements. It may use its own capital and/or financing provided by the Team (from E-CAP or other low-cost sources), but in either case the investment will be commercially prudent — that is, the contractor will invest up to, but not beyond, the point at which its financial return requirements are met. Some contractors will bid on two or all three of these efforts. All contractors will be required to assume the risk of financial payback.

To protect their investment and secure the cash flow from savings and revenues, the contractors will execute an operating and maintenance (O&M) agreement with the Team (on behalf of the cohort of participating facilities). This benefits all parties by sustaining expert participation in the evolving markets and technologies. The Team will include clauses in the O&M agreement (as in the EPC agreement) to

codify the requirements and criteria defined by the neighborhood organization. The Team will provide oversight of the operations and maintenance obligations to ensure they are being met.

Building typologies and income ranges

Aggregation of many utility customers in a variety of building types is key to economic success as well as community satisfaction. Greater numbers reduce transaction costs, attract more and better bids, increase purchasing power, and qualify for better market participation at the wholesale and distribution levels. Including business, nonprofit organizations, and government customers along with the low-income neighborhood residents brings in participants who can afford to pay for benefits such as resilience, power quality, energy and maintenance savings, environmental stewardship, property value upgrades and public and customer relations.

The proposed design offers the same assets to all customer categories, on a sliding scale of lease-and-service charges. Low-income multifamily residents will experience resilience, savings, and participation in the networking and dividend program at no charge. Those who can pay more can participate based on what they can afford.

Benefits and Cost Discussion

The Team has concluded through the analysis in this report, despite the results from DER-CAM, that the microgrid will likely be able to meet all reasonable cost-effectiveness tests, under plausible assumptions for costs and revenues. The following discussion outlines how this is possible.

1. First, the microgrid can be economically feasible overall with a positive net present value (NPV) using optimistic or mid-range assumptions, considering costs & benefits to all parties. (See Appendix G.)
2. While an individual building (e.g., a low-income multifamily residence that pays no demand charges and has subsidized utility rates) may not generate sufficient net income to cover debt service or attract developer interest in itself, the goal is to craft an overall community project that would be self-sustaining in total. Eventually, creating a 'package' of multiple buildings could make the project size attractive enough for a developer to consider.
3. The community's leadership — in recruiting customers, maintaining political and Labor support, aggregating multiple facilities, marshalling substantial pro bono support, attracting low-cost financing and generating positive public interest — significantly reduces risks and transaction costs assumed by potential developers/contractors. This has generated interest in bidding among several large commercial contractors. It also makes the Team attractive to impact-investors.
4. The community can shift economic risks to contractors selected via an RFQ/RFP process. Using carefully-negotiated forms of power-purchase agreements (PPAs) and Energy Performance Contracts (EPCs), private capital can be engaged to meet public needs. (In simple terms, PPA developers offer to install solar/storage assets at no cost to their customers, in return for

monthly payments for the energy produced/stored. EPC developers offer to design and install EE improvements at no cost, in return for some form of shared savings, usually with a guarantee that savings will exceed debt service.)⁵⁶ The Team has received some indicative (non-binding) quotes for some buildings from prominent PPA and EPC developers of storage, controls, energy efficiency and solar projects. This is an important validation of the proposed design, because these developers invest only up to the level of diminishing returns.

5. The allocation or sharing of future benefits among the microgrid entity, the participating electricity users, and the companies that finance and construct the microgrid can yield sufficient margin to support the municipal affiliate entity in its role of managing the development, installation and operation of the microgrid and building ownership of the assets on behalf of the community, over time.
6. The microgrid can provide significant economic savings to participating residents and customers, mostly through lower energy and water use due to increased efficiency and load reductions as well as avoided equipment replacement costs. (These building improvements are normally installed at the same time as other microgrid resources and are expected to provide many of the annual net benefits.) The savings will be shared between contractors and the community (which will also receive dividends of some form to distribute the community's share of the other revenue streams). Also, in some scenarios, some customers in participating buildings may save additional money due to lower-cost electricity and/or heat from on-site solar and/or CHP.

⁵⁶ These are highly simplified summaries of very complex contracts. The Team has significant experience in negotiating their terms, however.

Task 6: Findings and Lessons Learned

Limitations of DER-CAM

While DER-CAM can approximate optimum wired-microgrid economics based on current tariffs and past consumption, it has disadvantages when evaluating the financial viability of *multiple* non-electrically-contiguous facilities as presented in our proposed microgrid.

DER-CAM's algorithm is constrained to a behind-the-meter DER asset configuration in a single-node analysis. Our microgrid design includes behind-the-meter resources that are connected not only to facility loads, but also directly to the grid via a new revenue-grade meter. Further, an automatic transfer switch allows control of dispatch to meet behind-the-meter loads or provide ancillary services (See Appendix A "One-Line Diagrams" subsection). DER-CAM's setup does not account for the use of these components and is therefore limited to the functionality of a conventional behind-the-meter DER configuration.

Our proposed design would allow the assets to maximize revenue streams by dispatching full capacity to the grid without dispatching any power to the facility. Conversely, under a conventional (DER-CAM) configuration, DERs can only provide ancillary services that are net of the facility's end load. Consequently, revenues from ancillary services as modeled in DER-CAM are artificially suppressed, and the resulting DER-CAM assessment loses annual energy savings and underestimates the economic feasibility of the microgrid.

Our proposed microgrid benefits from cloud-based aggregation logic, which combines the load-reduction and storage resources from all participating sites in response to wholesale market fluctuations and utility signals. Such aggregation logic and the resources it dispatches, often called 'virtual power plants,' offer frequency and voltage regulation, reactive power insertion, forward and near-term capacity, and demand response, for which active markets exist in ISO-NE. The non-electrically contiguous microgrid provides the flexibility required to implement a virtual power plant. The application of virtual power plants, which includes using cloud-based control, smart meters, and aggregated resources, may be comparable to the function of a conventional power station. This would require the combined capacity of multiple facilities to optimize the effectiveness of this new energy system.⁵⁷ Combining battery resources from many sites provides an ideal resource for such value streams because of their instantaneous response and capacity to either absorb or supply energy. In DER-CAM, each facility requires a separate single-node run, thus ignoring the economic benefits of optimizing via aggregation. With separate single-node models, the resources of all three facilities cannot be considered additively. The benefits from being able to do so are what allow the microgrid to participate in energy markets and make money from a whole new menu of revenue streams that would otherwise be unavailable, given that they may not otherwise meet market participation thresholds.⁵⁸

⁵⁷ Forbes, Alex. "Transform: Why Virtual Power Plants Are Becoming A Reality." General Electric, 7 June 2018. <https://www.ge.com/power/transform/article.transform.articles.2018.jun.virtual-power-plants-becoming-reality>

⁵⁸ "Forward Capacity Market." Sec. III.13., ISO-NE, 9 March 2018. https://www.iso-ne.com/static-assets/documents/regulatory/tariff/sect_3/mr1_sec_13_14.pdf

Many value streams that DER-CAM does not factor in, but which may be monetized as policies and markets evolve, are described in the Task 4 revenue streams section of this report. These include lease-and-service of clean energy products, solar energy credits and SMART program revenues, carbon credits and other tradable commodities, and utility incentives and other ratepayer and taxpayer-funded subsidies. Additionally, due to the inability to properly define the VOLL and SAIDI parameters and related inputs (see discussion in Task 5 Modeling Software section), DER-CAM's analysis of resilience assigns monetary value only to load curtailment. The result is an underestimated quantification of the microgrid's value of resilience. By neglecting the VOLL and SAIDI parameters, specifically, the model ignores the economic consequences of power interruption, of which the significance is well documented.⁵⁹ Furthermore, the economic analysis of resilience is susceptible to omitting the social implications of resilience, whereas the Team identifies the value of resilience, in addition to the national estimates discussed in Appendix F, as a social good.

A Parametric Assessment

Because of the limitations of DER-CAM and other publicly-available models, a multi-facility, multi-revenue parametric model originally built by CESI in 2013 was proposed for this feasibility assessment. The parametric model can compute cash flow and other financial results for a single building and also facilitate combining results from other facilities in the neighborhood. The parametric modeling would allow the Team to make projections of Base Case, Optimistic, and Pessimistic financial results by varying key assumptions. It lacks external validation, however, by recognized experts like those who developed the DER-CAM model, and so was withdrawn from the MA CEC-sponsored feasibility assessment. Nevertheless, given the limitations of DER-CAM, it is instructive to review the Team's takeaways from running a parametric assessment.

Although all significant cost categories are included and broken out in this model, the allocation of particular costs to particular revenue streams for summary tables is *necessarily* imperfect in any model. While operating costs can be associated uniquely with each revenue stream, capital costs have to be spread over all the streams. (The same DERs are required to produce demand cost reductions, solar/storage income, wholesale market revenues, marketable certificate sales, and resilience-as-a-service income.) The correct cost accounting treatment can be known only in retrospect.

A parametric model can compute results for a comprehensive set of existing and potential sources of subscriber savings and combined revenues. It cannot predict the sum of all these sources for all subscribers, however, because they are not all additive in real time. That function of aggregation and optimized dispatching is performed by the cloud-based software platform, which sends signals to the on-site controllers⁶⁰ in each subscriber's building.

⁵⁹ Schröder, T. & Kuckshinrichs, W. "Value of Lost Load: An Efficient Economic Indicator for Power Supply Security? A Literature Review." *Frontiers in Energy Research*, Vol. 3, 24 December 2015. <https://www.frontiersin.org/articles/10.3389/fenrg.2015.00055/full>

⁶⁰ Presently assumed built into the 'smart inverters,' but potentially involving other control logic distribution, as new suppliers enter the field.

(Running the parametric model outside the scope of this contract demonstrated that, in concert, our three buildings can provide a positive return on investment and are economically sustainable over time. Appendix G summarizes some of the common financial ratios for Base, Optimistic, and Pessimistic assumptions.)

The Team acknowledges the importance of using an externally validated program like DER-CAM to test our assumptions. Despite the disappointing results from analyzing one building at a time in DER-CAM, the Team feels comfortable moving forward with the project. As described in the Task 5 cost benefit analysis, the chosen contractors will make investments in building improvements and revenue generation only up to the point of diminishing returns. It is because we received favorable quotes from commercial interests, combined with the Team's dedication to the project, that we maintain an optimistic outlook for this work.

Our Design, Community-Based Approach, and Development

GreenRoots has canvassed hundreds of residents and organizations to determine the values that a community microgrid should deliver and the criteria for its design and builders — all based on the RUN-GJC Team's commitment to energy democracy and neighborhood leadership.

These findings set some high standards:

- resilience of the full load in each participating building, not just “emergency” circuits;
- ability of any facility to join, not just those that could be connected together (thus no “borders” to the community microgrid);
- starting with efficiency improvements that will reduce participant costs;
- minimization of fossil fuel use;
- no charge to participants in excess of their savings;
- no requirement for utility wiring or control over microgrid operations except for dispatching of purchased resources;
- availability of back-up cell phone service and charging in emergencies;
- community ownership of electric vehicles and chargers; and
- training and employment of neighborhood residents in clean-energy installations and service.

We have found that these standards can be met cost-effectively, with benefits to the municipality, the utility, and society at large, as well as to the participating residents and their neighborhood. Furthermore, the work completed to date has helped the Team consider what actions would support the project moving forward. These actions are enumerated and discussed below.

The grassroots driven and multi-stakeholder approach of our model brings key benefits and advantages and demands careful attention to engagement and communication.

The user perspective is as important as engineering judgment in designing a microgrid. In addition to the energy democracy principle, this is a matter of defining and meeting objectives most cost-effectively. Multiple viewpoints strengthen perception. Residents and laypersons are fully capable of grasping — and improving — complex ideas that have legitimate benefit.

To support meaningful discussion across all stakeholders, we need to create the proper materials. Complexities of the microgrid design have to be translated into terms understandable to all stakeholders, of whom the technical designers are a small sub-set. This includes technical terminology as well as translating documents into the language of choice in the community (Spanish in the case of Chelsea). Repetition, iteration, and multiple discussions are often necessary. A single document, however eloquent and accurate, cannot be expected to carry the full message. Graphics strengthen text.

Conversations on microgrids like the ones that GreenRoots has hosted during their community meetings are a perfect opportunity to not only educate residents about the details of the microgrid project, but also inform them about the City's emergency plan and what to do in the case of an environmental disaster. As Chelsea works to implement the microgrid, community leadership on the project will ensure that outreach and conversations continue in an effective and appropriate manner.

Future success of a distributed community microgrid depends on organized community support for its marketing strength, efficient management, and design advice. GreenRoots has demonstrated a broad base of support among residents, small businesses, City managers, and local institutions. They have participated regularly in Team meetings, advised frequently on design elements, garnered political support, conducted impressive community member surveys, and organized for the next step of project development. Their commitment is firmly demonstrated in the many hours of uncompensated time invested in this project.

Recommended action:

1. Support GreenRoots staffing

Our community-based approach provides significant marketing and recruitment advantages.

Both low-income participants, for whom resilience may be free of charge, and commercial customers can be reached more readily by trusted community leaders endorsed by the City than by commercial sales practices. This expectation has been confirmed by both the results of surveys by Team members and our identification of hundreds of energy consumers who rank resilience high among priorities but have rarely (or never) been contacted by utilities or credible contractors.

Recommended action:

2. Test the recruitment capacity of GreenRoots, who has surveyed hundreds of residents in the awardee community. Confirm their marketing advantage by supporting their respective staffs as they convert expressions of interest into customer commitments to move forward with energy efficiency and microgrid-related installations. (Such commitments will, of course, be conditioned on acceptable contractor proposals.)

Key characteristics of our community lend it well to our microgrid model, yet other characteristics of our community may pose a challenge.

Chelsea is an ideal site for this microgrid project since it captures common characteristics of EJ communities (low-income, communities of color and residents who experience language isolation). Chelsea models a project in an immigrant city that plays a key regional role across a variety of industries. Across the City, this project will produce key insights into how different pressures, such as environmental

and industrial burdens, affect the development and execution of similar projects in EJ communities more generally.

The details of governance and corporate structure require further investigation and decisions by the proposing team, especially its community members and city stakeholders. Unlike conventional microgrids developed by commercial or utility interests, the proposed model will require some seed capital/grants to support start-up activities.

Recommended actions:

3. Support a pilot project in the community, in cooperation with the City.
4. Identify community leaders in other Massachusetts cities with comparable neighborhood, Labor, utility, and political support, who could mount a similar program. An RFQ is recommended to accomplish this. Consider funding feasibility assessments similar to those now concluding, making use of their findings and using the Technical Consultant to assist their development.

Our mission-driven objectives and relationship-driven approach have helped us cultivate strong local political support which will aid us in both development and operations.

Due to extensive outreach efforts, the Team has cultivated local political support for this project. The microgrid's objectives, operation, and selection of community developers has been discussed in detail with City leadership. The Chelsea City Manager has endorsed the program, participated in Team meetings, approved the selection of community organizations, and named representatives to work with the Team on next steps.

Recommended actions:

5. Engage the City appointees in action items above to demonstrate continued political support and ensure municipal objectives are met.
6. In Chelsea, where the microgrid development organization is intended to be a municipal affiliate, finish the design of that organization's structure and governance. Obtain City Manager and City Council approval and complete the appointment and election of Board members, including community representatives.

Our model is unique and will require creating a new type of entity to oversee development and eventually ownership responsibilities.

The RUN-GJC Team has been effective in developing a technically and economically feasible design and securing support from all essential stakeholders (municipal, utility, Labor, community, contractor representatives, customers, CEC). The next steps will require a focused organization with the legal capacity to make commitments, hire staff, issue contracts, raise funds and spend them, handle accounting and financing, and provide appropriate liability protections. Candidate organizations have been identified but no legal commitments have been made yet.

Recommended actions:

7. Secure all necessary agreements, complete the design of the municipal affiliate, record governance and management structures with appropriate authorities, prepare a staffing and management plan, and otherwise complete a business plan to guide the project forward.
8. When all approvals are in place, take the legal steps to establish the organization and initiate operations.

Our model is minimally disruptive to local utility infrastructure and can even provide benefits to the local utility company.

With all new wiring behind meters and behind transfer switches, interconnection with the grid is unchanged. Care was taken to build in protections against any unintentional power export to the grid or apparent fault currents. Power export is controlled by a utility-activated switch and revenue meter. The wiring diagrams and operating protocols were reviewed with Eversource engineers in three meetings, several phone calls, and exchange of documents. The Team has found the Eversource engineers to be cooperative and helpful, and they have raised no objections to the design once it was fully described. At the management level, the Team has suggested to their Chief Customer Officer (CCO) that Eversource could take advantage of a growing deployment of distributed BTM resources under their new three-year EE Plan which includes storage. She expressed an interest in exploring that possibility. This arrangement could have some advantages over participation in ISO-NE wholesale markets if equivalent value could be reaped by the neighborhoods involved.

Recommended action:

9. Engage Eversource and others, possibly CEC, to support the pilot project in Chelsea.

Collecting energy use data for buildings for accurate financial modeling is challenging, likely more challenging than for campus-based microgrid models, but our relationship-driven approach mitigates this challenge somewhat.

One of the challenges of this project was getting access to *actual* energy consumption. This was more of an issue in multi-metered buildings. A second layer to the data issue was the fact that many buildings do not have Advanced Meter Infrastructure (AMI) and thus interval data is not available. Both are significant challenges when trying to determine accurate load profiles.

The Team tried a variety of approaches in an attempt to get as much actual data as possible to inform load profiles. While Chelsea did not have any multi-metered buildings in the feasibility study, it is inevitable that multi-metered buildings will aim to join the community microgrid. When those buildings join, the Team will look to collect utility bills from tenants using the same method that partners CPA employed when facing the same issue. That method is to post signs, send emails, and schedule phone (robo) calls with help from property managers asking tenants to drop off copies of their bills at an easy-to-get-to location. While this tactic will result in some bills being collected, and while the bills show a year's worth of monthly consumption data, they do not display interval data.

For buildings that did have time-of-use meters, there were still some hurdles that needed to be cleared in order to gain access to the data. The steps of that process were to 1) determine which sites have the TOU meters, 2) fill out an Eversource EPO (Energy Profiler Online) Service Agreement, 3) send the prepared agreement to GreenRoots for them to have the appropriate person at the facility fill out the form with the meter number(s) and authorization signature 4) submit the signed form to Eversource. Once Eversource granted access to the data, it was available for just 30 days. Furthermore, a one-time request had a \$50 fee for each meter in question and an annual subscription to the data cost over \$160.

When interval data were not available, the Team had to use interval data from a similar building type. From the source the Team used, the buildings in the most similar climate to Boston's were from

Baltimore.⁶¹ Boston's and Baltimore's climates are fairly different. Also, the buildings available could vary significantly from the buildings we were trying to model.

This will be an issue for microgrid development until AMI is readily available. The Team would support regulations that favor upgrading meters to AMI. Once buildings have AMI, it will significantly help the Team model energy more accurately and DERs can be better sized for the building's needs.

Recommended action:

10. Support policy that mandates an equitable roll out of AMI in Massachusetts. For example, communities with MVP or EJ designation could qualify for free AMI and installation at municipal buildings whereas commercial and industrial customers would pay out of pocket. The utility should also contribute to the roll out to at least subsidize the expense.

Our model is unique and merits publicity and replication across the country.

The interest of media outlets, educational and nonprofit organizations in this novel microgrid design has been demonstrated by various inquiries and interviews. The design, which is unusual and relatively complex, has been challenging to communicate. It is important to be transparent and understandable when communicating with the public. A broad public understanding will also help promote replication elsewhere. Therefore, the Team wishes to work closely with CEC in future public education and promotion efforts.

Recommended action:

11. Develop a public education plan in which CEC and the Team can effectively cooperate, recognizing the constraints and advantages of both public and private constructs.

We are confident our microgrid design is technically sound and cost-effective, but the *development* process will be a crucial time to work with contractors to continue to specify and refine details.

The proposed design has been subjected to expert review by a number of specialists in the technologies involved, including the CEC, a past Director of System Planning for Eversource, and several other technical colleagues of the Team including some potential contractors. This has yielded several improvements and clarifications as well as overall verification. The Team is confident that the design presented in reports to CEC is technically sound and cost-effective at the conceptual level. Many design details remain to be filled in, however, at the level of equipment specification, especially for batteries, inverters, and controls, since all of these technologies are rapidly evolving.

A competitive bidding process will support this detailing in general, but special attention to the controls and metering architecture is warranted. In the proposed design, control is distributed among a cloud-based aggregation/optimization platform, 'smart' dynamically-controlled inverters, and an array of transfer switches and metering arrangements. (Metering of power flow and integrated energy among the loads, solar, storage, generators, and grid can actually be achieved electronically at any reasonable degree of accuracy, but in Massachusetts the utilities' physical meters are still required.) In the proposed design concept, the Team has placed much of this 'microgrid controller' logic at the inverter level, receiving dispatch signals from the cloud-based optimization platform; however, other distributions of the logic functions are possible and may be found more cost-effective.

⁶¹ Darghouth. "Simulated load profiles." See note 29.

The technologies, industry standards, codes, suppliers, potential revenues, and costs of all the key components of a microgrid are evolving rapidly and require a flexible, dynamic approach to component selection, placement, sizing, and interconnection. For every element of a microgrid, there are contractors, suppliers, and installers who have to make a living at it. Their experience is both informative and potentially limiting. They have essential lessons to teach, but also have adopted repeatable practices that serve their needs without necessarily making them open to new approaches. As implementation proceeds, the community-based developers of the proposed microgrid will formulate RFQs to identify those contractors most likely to meet neighborhood criteria as well as long-term design objectives.

Recommended action:

12. In cooperation with potential bidders, define the job content and skill needs of workers who could be hired to install and maintain elements of the microgrid. Work with the training facility to round out curricula and practicum content and set up certification processes.

Collaborating with our labor partners in development can support not only our good jobs and workforce development objectives but also open access to a cost-effective source of financing.

The Team has visited the NECA-IBEW training facility in Dorchester and discussed with them the need for trained workers in the several trades involved in a neighborhood-based distributed microgrid construction, operation, and maintenance. They have installed solar panels, batteries, and controls on site to support training and development at their facility. The Team finds that this will be an effective means of securing employment for neighborhood residents. The NECA-IBEW partnership also supports the E-CAP project financing platform, which the Team believes will be a cost-effective source of project financing in design and construction.

Recommended action:

13. Establish a process for financing microgrid installations using the E-CAP program.

Prominent vendors and developers have expressed interest in participating, and validated the likely penetration of new markets.

Preliminary discussions have been held with numerous potential bidders in the key categories of ESCOs, optimization platform vendors, solar and battery EPCs, financiers, and anaerobic digesters. (Mutual NDAs have been signed with several, so names are not listed here.) This effort was conducted to identify potential contractors and to judge the recommended design details against the practices of established contractors in commercial markets. The results of these discussions are encouraging on both fronts. The key design features were presented to these expert practitioners so that their feedback could improve the Team's understanding of operating details and strengthen the content of the planned RFQs.

Recommended action:

14. Fill out the list of experienced bidders in each of the technology categories discussed above, using criteria such as demonstrated experience, endorsements of customers, staff capabilities, commitment to community support and fair wages, and capacity to incorporate technical advances in their fields.

The number and quality of bids will depend on the size of the potential investment.

Our distributed design, unlimited addition of participating buildings, active municipal support, grassroots recruitment, and minimization of transaction costs has proven attractive to potential bidders. Although the CEC feasibility assessment has been focused on three buildings, many more have expressed interest in participating. The assets required are in three categories: (1) energy and water efficiency retrofits and replacements (HVAC, lighting, controls, plumbing and electrical components); (2) solar plus battery storage installations; and (3) electrification of local transportation (EVs, grid-connected 2-way chargers, large mobile battery vans).

An order-of-magnitude estimate of the investment potential can be made by (a) extrapolating from the installations proposed for these buildings, (b) running online models like Mapdwell or Google Project Sunroof and backing into complementary storage and EE investment, and (c) estimating market penetrations. This produces estimates in the range of \$25 to \$75 million, over a five-year marketing window.

Additional investment opportunities are likely as the number of participants grows. These include CHP, fuel cell applications, geothermal and river-water heat pumps, and anaerobic digesters to produce indigenous energy sources (methane). In the long run, merging the distributed neighborhood microgrid with City plans for distributed resources is also likely.

Recommended action:

15. Issue RFQs from the municipal affiliate, with City and CEC endorsement, to assess interest, potential, and commitments in the industry. Include a description of the proposed design and invite further critique in the respondents' approach. From this process combined with the market survey in Recommendation 2 above, select a smaller number of candidate vendors to discuss the content of RFPs for design, procurement, installation, commissioning, operation, maintenance, and metrics.

A Comment on Insurance

No model exists for quantifying the value of microgrid-related resilience in business or property insurance premiums, but there is some potential for such a model to be implemented in the future.

When we initially started exploring revenue streams for the microgrid in Chelsea, we were optimistic we could secure a revenue stream through decreasing insurance payments either for business interruption (BI) insurance or property insurance. We reasoned that because the microgrid would prevent damage caused during an outage like lost produce related to refrigeration or critical systems, mitigating this risk would impact the insurance payments paid each month. These savings, much like energy efficiency savings, could be used as a revenue stream to help pay for the project.

We spoke with microgrid developers, representatives from insurance companies, national labs and NYSERDA to explore what others have done around microgrids and insurance. Ultimately we found that there were no microgrids or insurance companies that had impacts on BI insurance or property insurance premiums. There were a few themes from these conversations that we wanted to note for the public.

Of the half dozen microgrid developers and technology providers we spoke with, most said that microgrids should impact insurance premiums, but that they hadn't built a microgrid yet or heard of an established microgrid that had successfully changed insurance payments. When speaking with representatives from national labs and NYSERDA there was equal interest in the potential for microgrids to decrease insurance payments, but that there was no research they could point to this being done or the theoretical limitations. The most complete article we could find in the public domain was published by NYSERDA titled "How Reliable is Your Microgrid?"⁶² This article's conclusion was that there are currently no insurers that will consider microgrids in their payments.

In speaking with insurance companies, we found a similar conclusion. The rationale put forward was two-fold. First, because microgrids are not standardized products, like a sprinkler system, for example, reliability from system to system varies dramatically. Many microgrid installations are a grouping of various distributed energy resources like solar, energy storage, and combined heat and power fossil-based generation that come from different manufacturers and can at times have additional challenges in being coordinated in a microgrid. Because there is no standard product for microgrids currently, implementing an insurance change because of one being installed is very difficult. The actuarial work to determine the change in premium would not justify the number of microgrid varieties. This does point to the possibility of standardized microgrid solutions that have been deployed in large numbers being able to impact insurance rates in the future.

Second, while microgrids mitigate one type of risk — loss of electricity — they do not fundamentally alter the risk profile of the building or business and therefore do not justify a change in premiums. Boilers can still explode, chilling units can break down and a whole number of other hardware problems can occur that can put the business or build at risk. We found this rationale less compelling because of the impact that lightning rods or a central alarm system can have on insurance payments.

We are still exploring whether uninterruptible power supplies (UPS) or diesel generators at critical facilities or data centers impact the insurance premium for these businesses. If we find that these systems do decrease insurance premiums, we are optimistic we can learn lessons of how these similar technologies were able to shift the insurance industry and apply those lessons for the benefit of our community microgrid.

While we do not expect to gain a consistent revenue stream from decreased insurance payments, we are optimistic future microgrid developers and owners will be able to and in doing so be able to put a value on resilience.

Conclusion

Our community is on the front lines of a multi-faceted crisis: economic, environmental/ climate and public health crisis. We are trapped within an inequitable political economy — driven by a corporate

⁶² Jones, Richard B. "How Reliable is your Microgrid?" Public Utilities Fortnightly, 27-36, 29 July 2015. <https://www.nyserdera.ny.gov/-/media/Files/Publications/Research/Electic-Power-Delivery/How-Reliable-Is-Your-Microgrid.pdf>

agenda of privatization, deregulation, and austerity — that has caused and is exacerbated by climate change.

Successful implementation of a community-led microgrid allows residents to control their narrative, showing that traditional experts (elected officials and scientists) are not the only people qualified to be decision-makers in the energy sector. Instead, local residents in Chelsea can be lifted up as the experts on their own communities, capable of planning and implementing local solutions to their own problems alongside government officials and other experts. Those most impacted by the climate crisis have to be at the forefront driving the solutions.

The neighborhoods and areas surrounding the microgrid sites will enjoy a healthier environment from both microgrid use itself and the green influence of the project on the community. Using the microgrid will also be a significant step towards reducing an area's greenhouse gas emissions.

We have developed strong links within a broad ecosystem of actors working towards similar ends, some of which will likely extend into longer-term partnerships as we expand this network of community-based microgrids. Our technical team has led relations with the engineering team at Eversource, as well as with market-leading companies such as Nexamp and other prominent developers. We also have secured advisory relationships with former senior energy officials within the state government, and several consultants with expert knowledge of the state-of-the-art technology in the microgrid sphere. In addition, we have strong relationships with organized labor, which has led us to responsible contractors affiliated with unions, such as Nexamp, as well as potent labor-affiliated financing streams via the National Electrical Contractors Association.

We are confident that, despite market fluctuations and the difficulty of predicting certain variables, the strength and financial viability of our model can be proven in practice, as we have developed a robust revenue stream to undergird our investments. These revenues draw from a broad set of sources, including subscribing building owners or host facilities and their tenants; ISO-NE, which has active markets for capacity, energy, and regulation services; potentially state-run exchanges for carbon trading; Renewable/Alternative Portfolio Standard certificates for energy produced by qualifying sources; nearby businesses, residences, and institutions who will pay for guaranteed resilience and related services; and solar or storage incentive pools, such as the SMART program currently undergoing revision.

The large amount of community outreach already conducted and resulting community buy-in demonstrates strong and extensive support for this project. Feedback from residents on the microgrid project has been overwhelmingly positive. Conversations and survey results from residents have shown full support for a microgrid in Chelsea. While all partners remain committed to continuing to solicit feedback from community members as we move forward, the support so far is a promising positive indicator for the project.

There are many benefits both to the utility companies and to the state with the implementation of our proposed microgrid. Utility companies typically have expressed hesitation with regard to DERs and microgrids for various reasons. However, microgrids also can provide benefits to them in many ways. For instance, distributed resources allow for deferment of large investments in infrastructure for peak loads, which our virtual microgrid can help mitigate. The storage component of our system allows for the smooth introduction into the macrogrid of intermittent renewables. Small suppliers can help regulate the power frequency of the macrogrid in line with system protocols, keeping it stable for large-scale use. In the event of a grid outage, small systems can also assist in 'blackstart' or re-energizing of critical transmission systems without the need for external power supply.

Additionally, Massachusetts is mandated by law to meet stringent emissions reduction targets, and the state already has lost in legal cases demanding it comply with requirements codified in statutes like the Global Warming Solutions Act (GWSA) and the Green Communities Act. Additionally, these targets are being strengthened and goals are being raised through the Commonwealth's GWSA Implementation Advisory Committee and its working groups such as the Climate Justice Working Group. Under this increasing pressure, the state government is searching for ways to meet these goals, and we believe our model can assist in achieving them. As well, we can assist in meeting environmental justice standards, some of which are likely to be passed this session, and all of which are already generally accepted as essential to a just energy policy framework.

Though we see this project as being controlled by the local community and primarily benefiting local participants, we recognize that there are other key stakeholders in their success. Among them is the City of Chelsea, which stands to share in the pride of hosting among the first energy resilience projects of their kind. The local utility, Eversource Energy, is also a major stakeholder, and can share the benefits and provide some of the engineering support and hardware infrastructure for the projects. The grid operator likewise is a remote but significant beneficiary and enabler of this model, and may well come to regard it as prefiguring future distributed energy systems. Other stakeholders will continue to emerge as these kinds of systems proliferate in coming years, the common thread being the many novel benefits, interdependent relationships and infrastructure evolutions that they enable.

We see these social, community, and economic benefits as integral to the strength of our cost-benefit analysis. We think of residents as members of the controlling entity, entitled to a share of the various forms of resilience our microgrid provides. These include energy reliability of course, as well as water and energy cost reductions, access to shared electric transportation and dependable communications systems, ongoing rights to participate in project decision-making and support from the controlling entity, and eventually dividends from the collective investment.

Equitable energy distribution and energy democracy can only happen with true investments in energy systems; ones that reflect the principles of a just transition and the green economy we are all working towards, as well as ensuring inclusion and transparent community practices. We have learned through our modeling that it is not enough to only impose clean energy systems over our old systems — the communities must be included. For far too long, our energy systems have profited off of an unequal and antiquated market-based, fossil fuel-based economy.

Grid modernization is imperative for our future energy usage. As our model is decentralized, this is necessary in moving towards deploying new infrastructure for a carbon-free future. We must change the rules for how our energy system is governed, which includes modernization to create capacity for the needed clean energy storage.

Our microgrid will increase resilience in ways that are not easily quantified, and which should be treated as public goods that merit public funding and support.

Aside from insurance considerations, there are many other values of resilience that are difficult to monetize in today's economic and political system. These are detailed in the Task 4 section of this report under the heading "Indirect Benefits; Additional (Non-Quantified) Value Streams." Thirteen such value streams are listed, including avoidance of future losses, employment, health, community benefits, utility benefits, municipal benefits, property values and new markets.

Ultimately the value of resilience cannot be pinned down because it includes so many socialized and non-quantifiable elements. Many attempts can be found in the literature, and several are reviewed in the Appendix F, Table i, which computes values from four of the prominent references, showing the wide divergence in methodology.

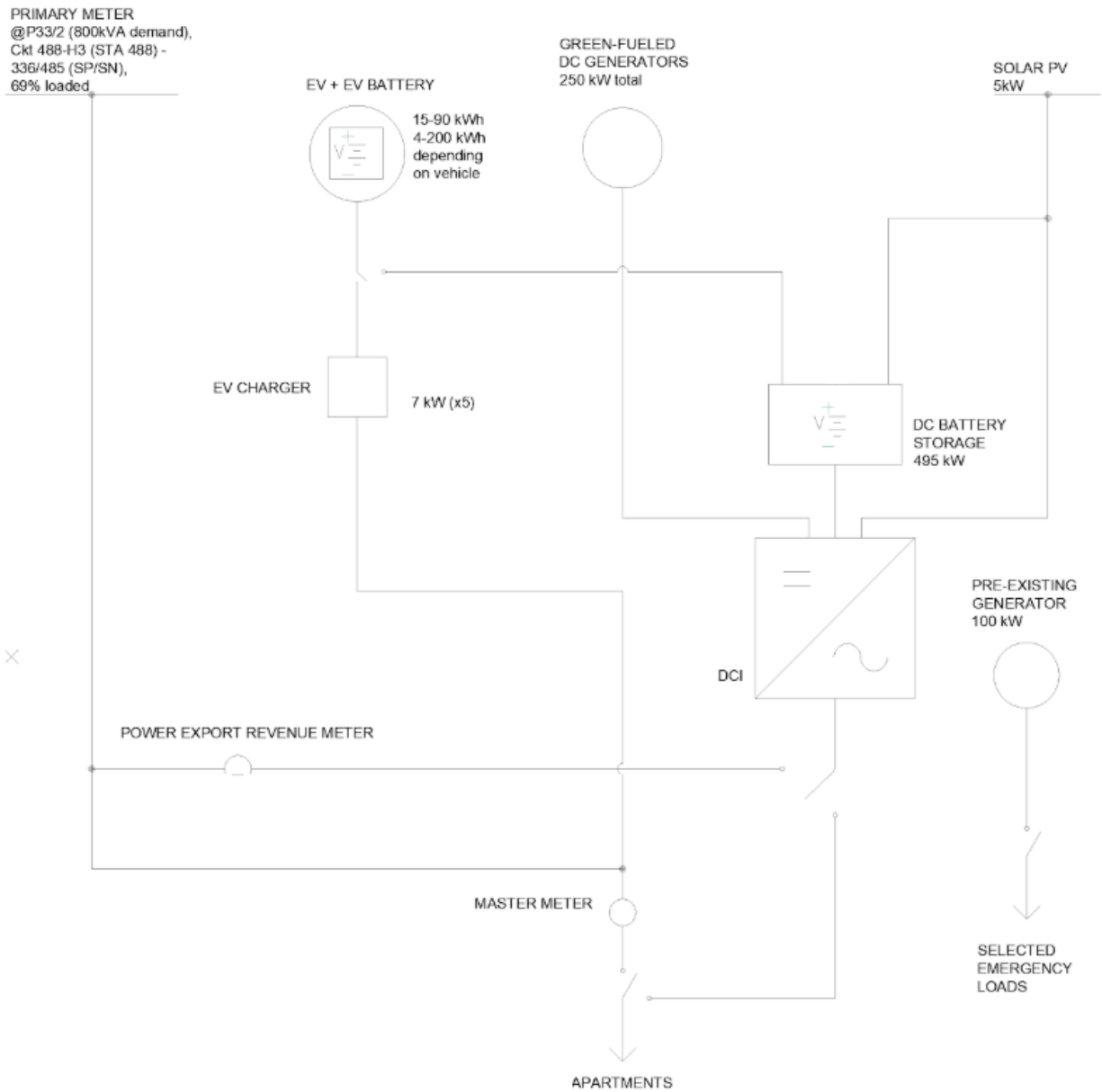
A lesson from all this is that resilience has value far exceeding the economic streams that can be monetized for investment, at least in today's system of markets, insurance, and governance. It is a public benefit rather like universal public education, national defense, or social security, but the political will to fund it has not yet been found.

Appendices

Appendix A: One-line Drawings, Equipment Layout Diagrams & Load Profiles

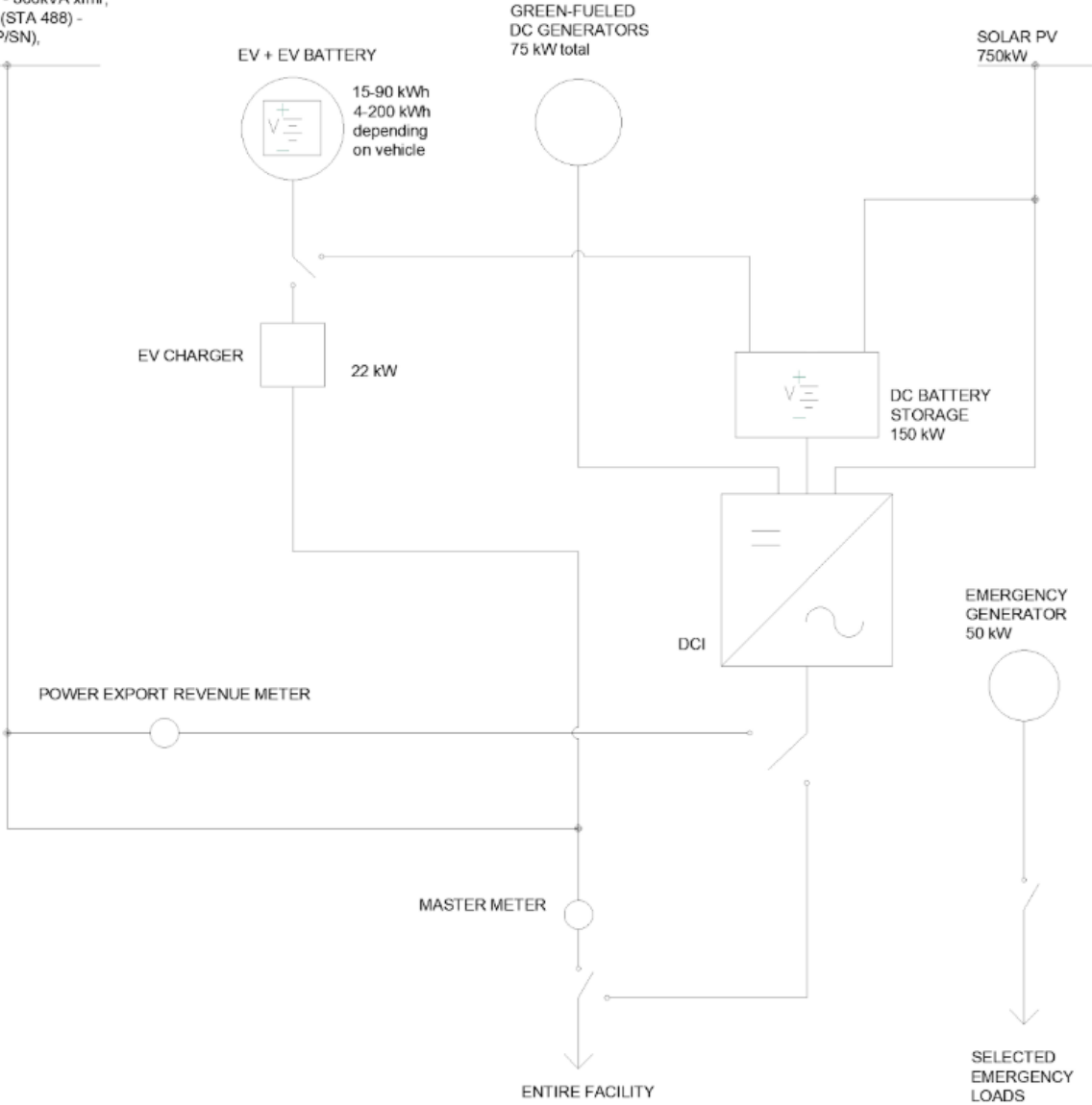
One-line Drawings

Buckley Apartments



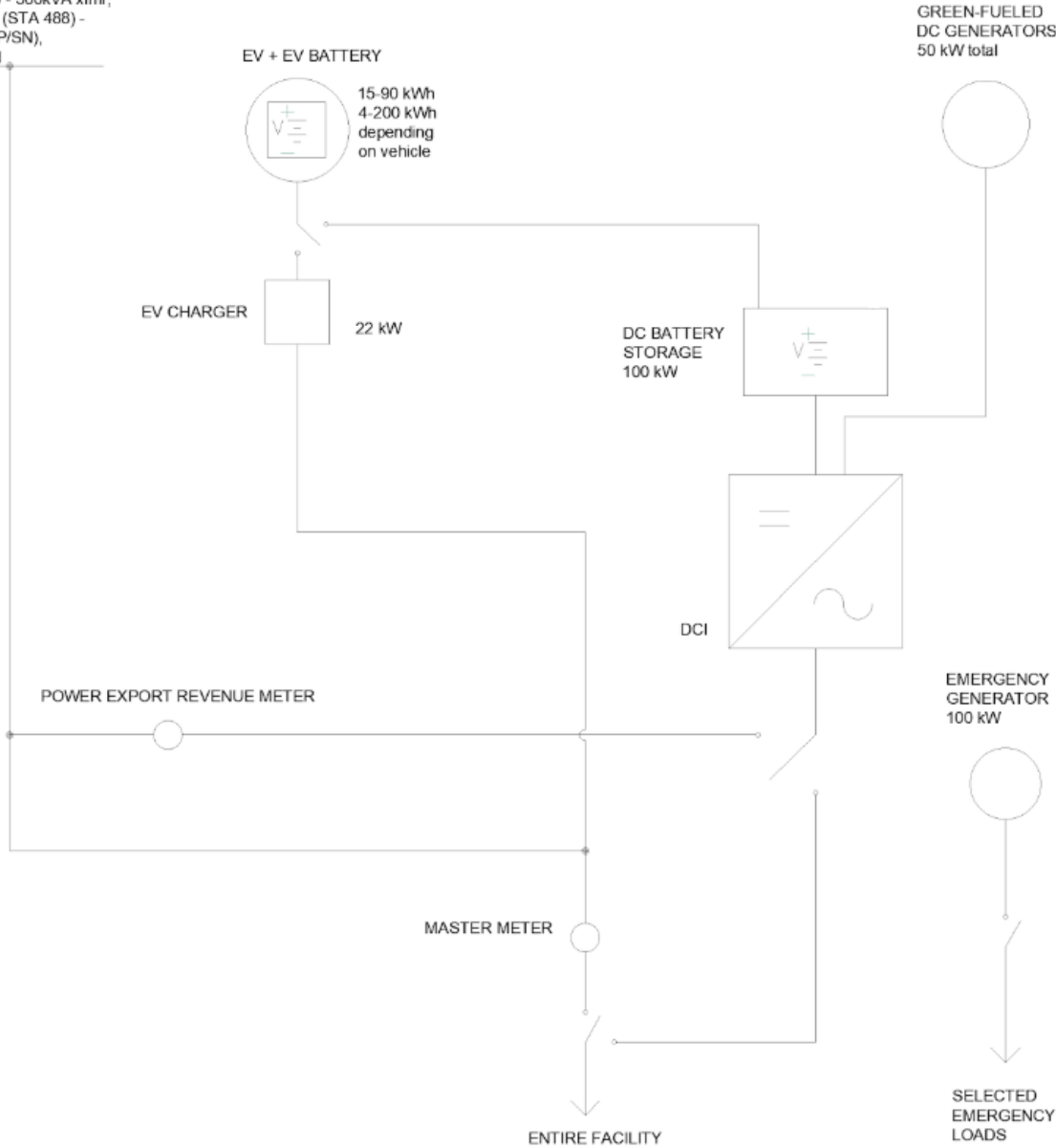
Beth Israel Deaconess Medical Center

PMH 13323 - 300kVA xfmr,
 Ckt 488-H7 (STA 488) -
 410/485 (SP/SN),
 84% loaded



Chelsea City Hall

PMH 13323 - 300kVA xfmr,
 Ckt 488-H7 (STA 488) -
 425/485 (SP/SN),
 87% loaded



Equipment Layout Diagrams

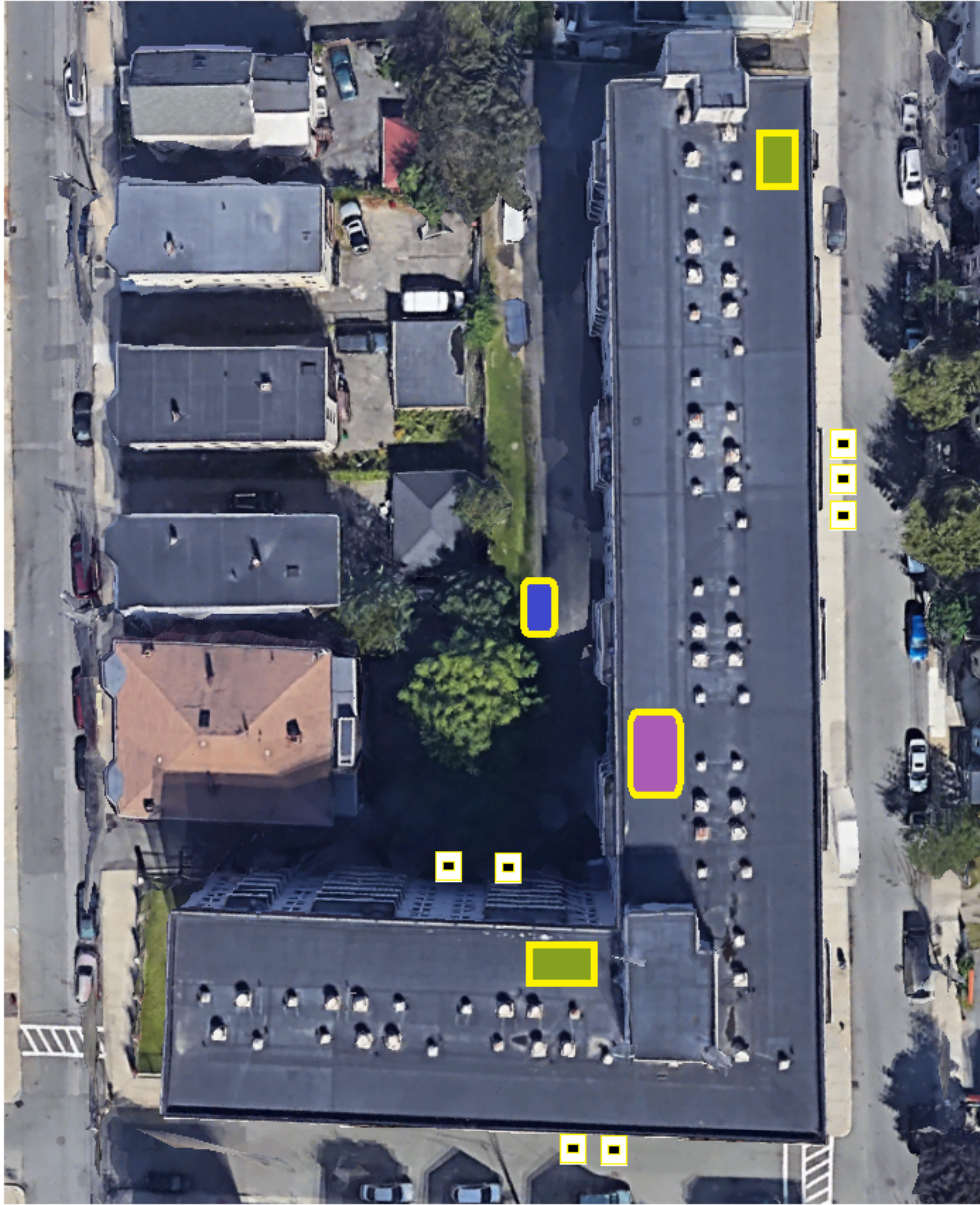
Equipment Layout: Buckley Apartments

Additions to Buckley include five bidirectional EV charging stations, 500 kW of batteries- broken into two banks of 250 kW each, a microgrid controller, and a 250 kW generator. There is already an existing 100 kW generator (shown in the first photo below). The batteries can be broken into two banks of 250 kW; they include inverters.



Example of where bidirectional EV charging stations can be placed:





Batteries

 A photograph of a large, grey, rectangular battery unit. To its right is a green rectangle with a yellow border, which corresponds to the marker on the building's roof.

Bidirectional EV Charger

 A photograph of a bidirectional EV charger. To its right is a small yellow square with a black center, which corresponds to the markers on the building's roof.

Back up Generator

Emergency Generator

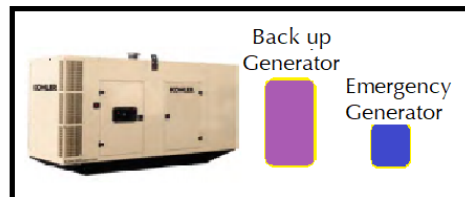
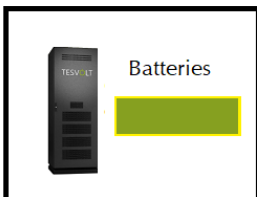
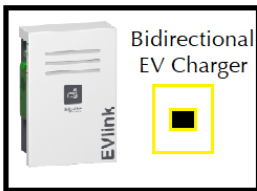
 A photograph of a large, tan, industrial backup generator. To its right are two colored rectangles: a purple one and a blue one, both with yellow borders, which correspond to the markers on the building's roof.

Microgrid Controller will be located indoors in utility closet.

 A photograph of a microgrid controller unit, which is a tall, grey cabinet with a screen and buttons.

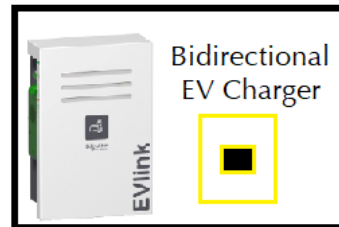
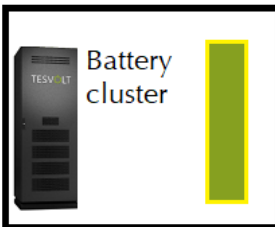
Equipment Layout: Beth Israel Deaconess Medical Center

Additions to Beth Israel include 150 kW of battery storage, a microgrid controller, 75 kW DC biodiesel generator, 50 kW emergency generator, 750 kW of PV, and 22 kW of bidirectional EV charging. As context, Beth Israel is the building in the upper left of this image. The other building pictured is a Walgreens; to their north is a creek.



Equipment Layout: Chelsea City Hall

There are not many adjustments that can be done to the exterior of City Hall. Most of the proposed new DERs (microgrid controller, batteries, and inverters) will be housed within the building. The new generator can go on the roof of the small facility at 45 Washington Ave. that houses the Emergency Operations Center. The bidirectional EV charger will of course be housed in the parking lot adjacent to the main building.





Load Profiles

Appendix A, Table i.

Buckley Apartments: Loads by Facility and How Served		
Facility	Apartments	Common Area
Heating Generation	Owner- electricity- electric baseboard	Owner- electricity- electric baseboard
Heating Transmission	NA	NA
Heating Distribution	Owner- electricity- electric baseboard	Owner- electricity- electric baseboard
Cooling Generation	Owner- electricity- window AC	Owner- electricity- window AC?
Cooling Transmission	NA	NA
Cooling Distribution	Owner- electricity- window AC	Owner- electricity- window AC?
Heating/ Cooling Generation		
Heating/ Cooling Transmission		
Heating/ Cooling Distribution		
Domestic Hot Water	Owner- electricity- electric DHW tanks	Owner- electricity- electric DHW tanks
Elevator	Owner- electricity- cable	Owner- electricity- cable
Lights & Appliances	Owner- electricity- lights & appliances	Owner- electricity- lights & other
Energy Management System	Thermostats	Thermostats
Emergency Generator	No	100 kW
Emergency Generator Serves		emergency lights, fire alarm & elevator

Appendix A, Table ii.

Beth Israel Deaconess Medical Center: Loads by Facility and How Served		
Facility	Offices	Common Area
Heating Generation	Owner- gas- boiler	Owner- gas- boiler
Heating Transmission	Owner- electricity- pumps	Owner- electricity- pumps
Heating Distribution	Owner- electricity- AHU	Owner- electricity- AHU
Cooling Generation	Owner- electricity- condenser	Owner- electricity- condenser
Cooling Transmission	Owner- electricity- pumps	Owner- electricity- pumps
Cooling Distribution	Owner- electricity- AHU	Owner- electricity- AHU
Heating/ Cooling Generation		
Heating/ Cooling Transmission		
Heating/ Cooling Distribution		
Domestic Hot Water	Owner- gas- atmospheric gas DHW tank	Owner- gas- atmospheric gas DHW tank
Elevator	Owner- electricity- hydraulic	Owner- electricity- hydraulic
Lights & Appliances	Owner- electricity- lights & other	Owner- electricity- lights & other
Energy Management System	Thermostats	Thermostats
Emergency Generator	No	No
Emergency Generator Serves		

Appendix A, Table iii.

City Hall: Loads by Facility and How Served			
Facility	Offices (most)	Offices (a few)	Common Area
Heating Generation	Owner- gas- boiler		Owner- gas- boiler
Heating Transmission	Owner- electricity- pumps		Owner- electricity- pumps
Heating Distribution	Owner- cast iron radiators- forced hot water		Owner- cast iron radiators- forced hot water
Cooling Generation	Owner- electricity- window AC		Owner- electricity- window AC
Cooling Transmission	NA		NA
Cooling Distribution	Owner- electricity- window AC		Owner- electricity- window AC
Heating/ Cooling Generation		Owner- electricity- heat pump	
Heating/ Cooling Transmission		NA	
Heating/ Cooling Distribution		Owner- electricity- heat pump	
Domestic Hot Water	Owner- gas- atmospheric gas DHW tank?	Owner- gas- atmospheric gas DHW tank?	Owner- gas- atmospheric gas DHW tank?
Elevator	Owner- electricity- hydraulic?	Owner- electricity- hydraulic?	Owner- electricity- hydraulic?
Lights & Appliances	Owner- electricity- lights & other	Owner- electricity- lights & other	Owner- electricity- lights & other
Energy Management System	Thermostats	Thermostats	Thermostats
Emergency Generator	No	No	100 kW
Emergency Generator Serves			Emergency lights, fire alarm & elevator

Appendix A, Table iv.

Projected Maximum Coincident Peak Demand and DER Sizing			
	Buckley Apts	Beth Israel Deaconess	Chelsea City Hall
Proposed Emergency Total Load kW	495	150	100
Additional Generator kW	250	75	50
Proposed Battery Rating kW	495	150	100
Proposed Battery Storage Capacity kWh	495	150	100
Existing (or Proposed) Emergency Generator kW	100	50	100
Current Summer Peak kW	275	180	126
Current Winter Peak kW	650	167	120
Proposed PV kW	5	750	0
Current Peak (Winter or Summer)	Winter	Summer	Summer
Proposed Peak (Winter or Summer)	Winter	Summer	Winter
Current Heat Source	Electricity	Gas	Gas
Proposed Heat Source	Electricity	Gas	Electricity
Elevator Electrical Panel kW		30	
Lights & Appliances (L&A) Electrical Panel(s) kW	168	68	68
Estimated Cooling Peak kW	70	88	32
Estimating Heating Peak kW	325	84	32
EV Charging kW	7 (x5)	22	22

Appendix A, Table v.

	Battery Capacity	Daily Generator Production
Buckley Apts.	495 kW	5,940 kWh
Beth Israel Deaconess	150 kW	1,800 kWh
City Hall	100 kW	1,200 kWh

Appendix A, Table vi.

Chelsea Description of DERs Installed in Microgrid Customers' Facilities ⁶³			
	Buckley Apts.	Beth Israel	Chelsea City Hall
Green Generators			
Energy/Fuel Source	Green diesel ⁶⁴	Green diesel	Green diesel
Nameplate Capacity (kW)	250	75	50
Normal Annual MWh	Platform ⁶⁵	Platform	Platform
Average MWh/ Day During Outage	4.63	1.94	0.36
Fuel Consumption MMBtu/MWh	11.37	11.37	11.37
Gallons Stored On Site	1,596	571	11.37
Batteries			
Energy/Fuel Source	N/A	N/A	N/A
Nameplate Capacity (kW)	495	150	405
Normal Annual MWh	Platform	Platform	Platform
Average MWh/ Day During Outage	Same as generators*	Same as generators*	Same as generators*
Fuel Consumption MMBtu/MWh	N/A	N/A	N/A
Gallons Stored On Site	N/A	N/A	N/A

⁶³ Most outages will be shorter than the batteries' capacity in MWh. In prolonged outages, the DC generator will be switched on to feed the load. A "*" in this row denotes that the footnote applies to that facility.

⁶⁴ Diamond Green Diesel. 2019. "What is Renewable Diesel?" Accessed July 31, 2019. www.diamondgreendiesel.com/what-is-green-diesel

⁶⁵ I.e. as determined by the cloud-based optimization platform.

Solar			
Energy/Fuel Source	N/A	N/A	N/A
Nameplate Capacity (kW)	5	750	0
Normal Annual MWh	6.5	975	0
Average MWh/ Day During Outage	0.02	2.67	N/A
Fuel Consumption MMBtu/MWh	N/A	N/A	N/A
Gallons Stored On Site	N/A	N/A	N/A
CHP			
Energy/Fuel Source	Green diesel	Green diesel	Green diesel
Nameplate Capacity (kW)	0	0	0
Normal Annual MWh	0	0	0
Average MWh/ Day During Outage	N/A	N/A	N/A
Fuel Consumption MMBtu/MWh	0	0	0
Gallons Stored On Site	0	0	0

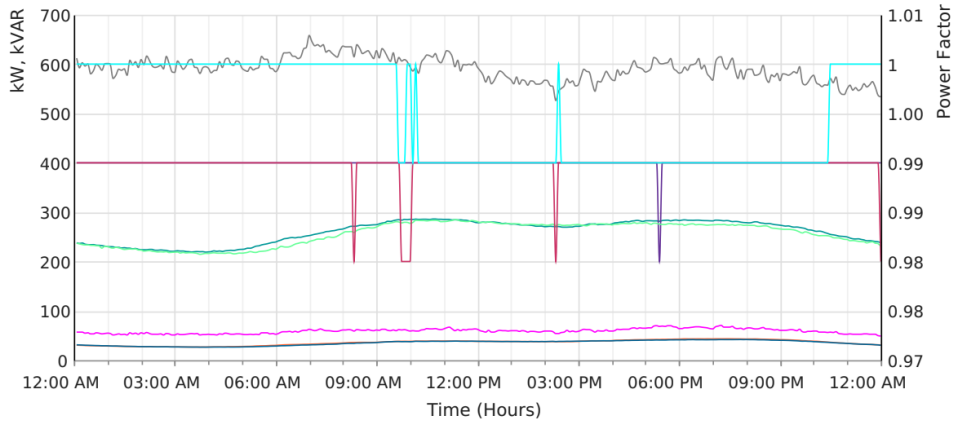
Hourly Load Profiles

On sites where interval load data is unavailable (City Hall), the hourly load profile is estimated based on OpenEI's simulated load profiles for DOE commercial reference buildings. This data set consists of 30 minute intervals from 1997 to 2014 for several types of commercial buildings. Residential sites are analyzed using OpenEI's data set for Midrise Apartments, and municipal sites are analyzed using the data for a Medium Office. For each year from 2011 to 2014, the winter and summer peaks are extracted, as well as average load profiles of the winter and summer seasons.

For each site, the number of units and area are available for apartments, offices, and common areas. These values are compared with the buildings used to model the OpenEI data set in order to determine a proportion between the site loads and the model loads, and the data set is scaled accordingly.

Average Profiles

Profile for Account: 26173121000

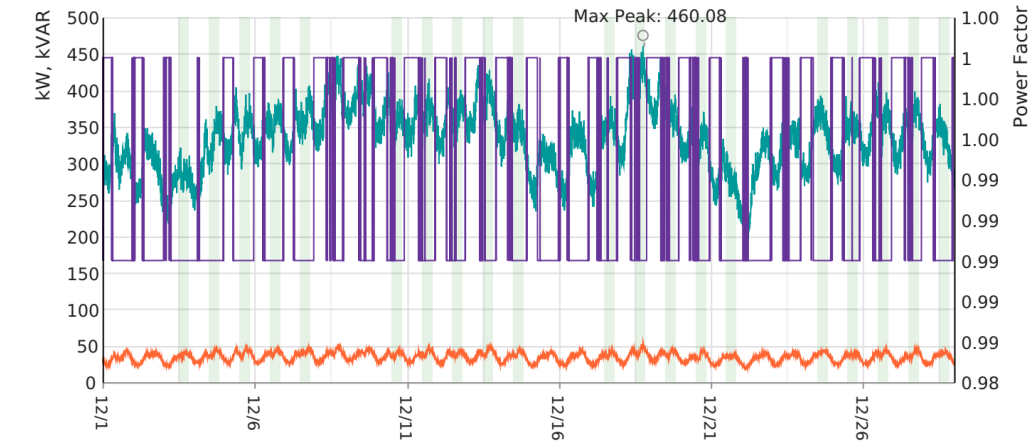


- 26173121000 CHELSEA HSG AUTH (kW) - Average Weekday
- 26173121000 CHELSEA HSG AUTH (kVAR) - Average Weekday
- 26173121000 CHELSEA HSG AUTH (Power Factor) - Average Weekday
- 26173121000 CHELSEA HSG AUTH (kW) - Average Weekend
- 26173121000 CHELSEA HSG AUTH (kVAR) - Average Weekend
- 26173121000 CHELSEA HSG AUTH (Power Factor) - Average Weekend
- 26173121000 CHELSEA HSG AUTH (kW) - Peak Day 01/07/2018 07:00
- 26173121000 CHELSEA HSG AUTH (kVAR) - Peak Day 01/07/2018 07:00
- 26173121000 CHELSEA HSG AUTH (Power Factor) - Peak Day 01/07/2018 07:00

Thursday, December 28, 2017 through Friday, December 28, 2018

Load Profile

Profile



■ 26173121000 CHELSEA HSG AUTH (kW)
■ 26173121000 CHELSEA HSG AUTH (kVAR)
■ 26173121000 CHELSEA HSG AUTH (Power Factor)

Saturday, December 1, 2018 through Friday, December 28, 2018

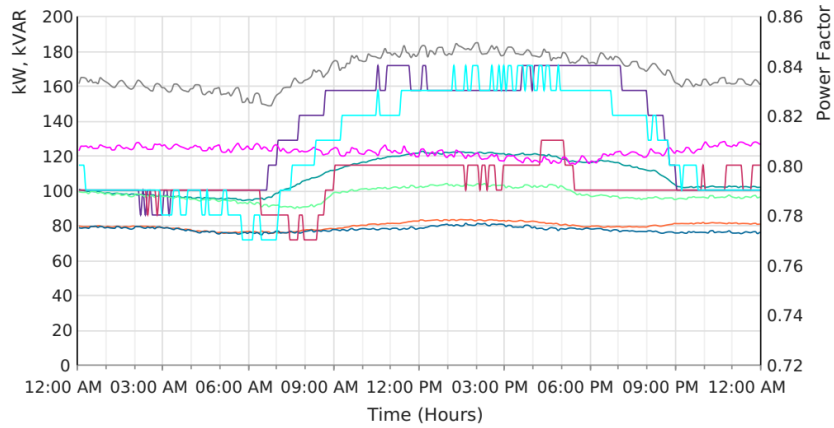
@Schneider Electric

Beth Israel



Average Profiles

Profile for Account: 26115241007

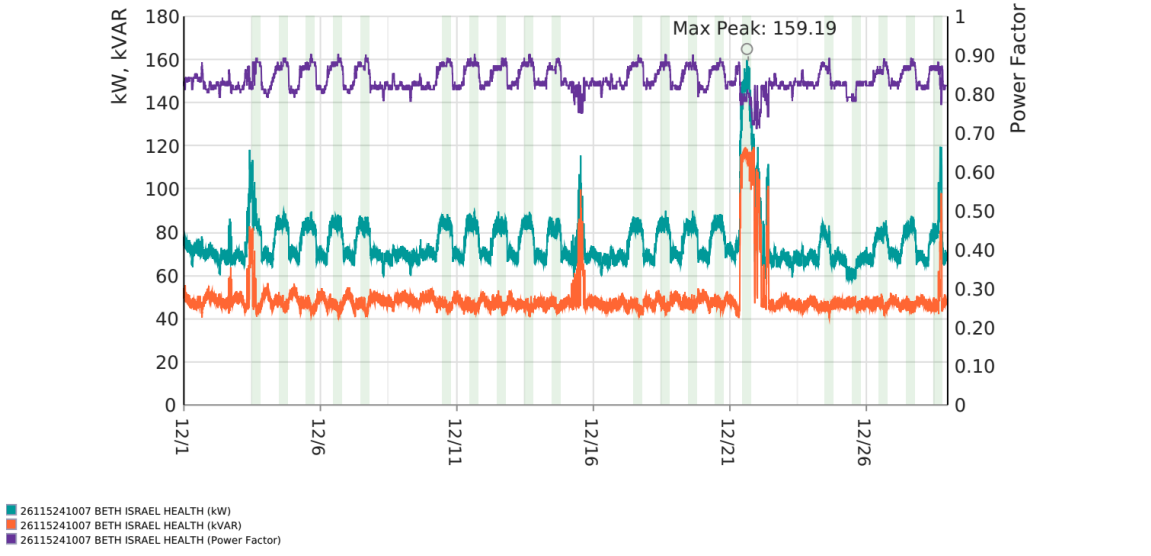


Thursday, December 28, 2017 through Friday, December 28, 2018

@Schneider Electric

Load Profile

Profile

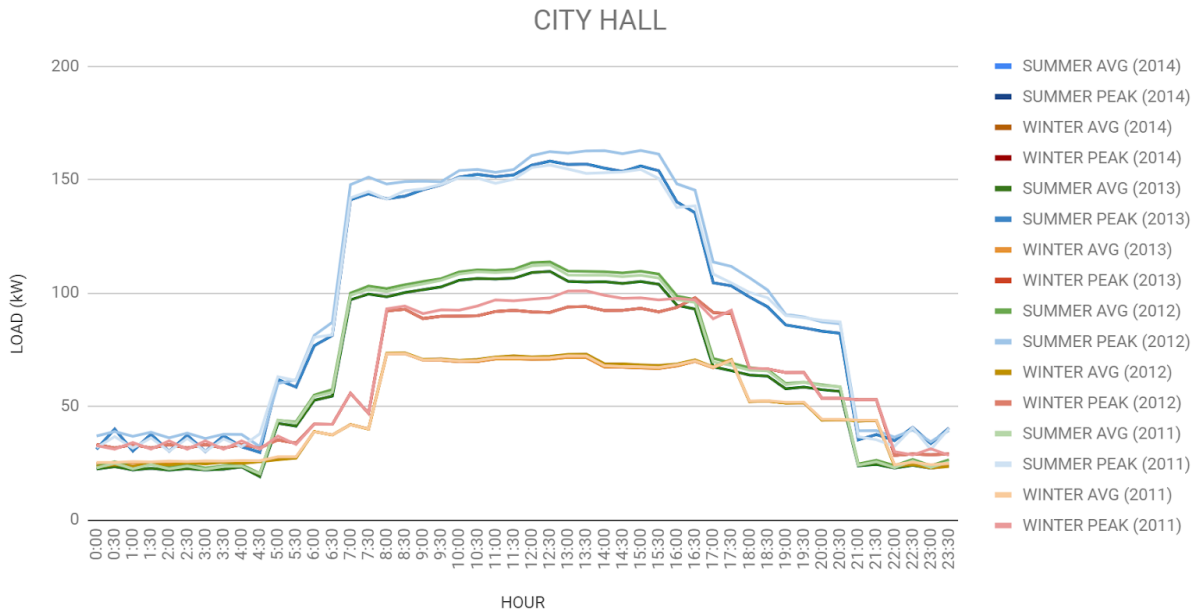


Saturday, December 1, 2018 through Friday, December 28, 2018

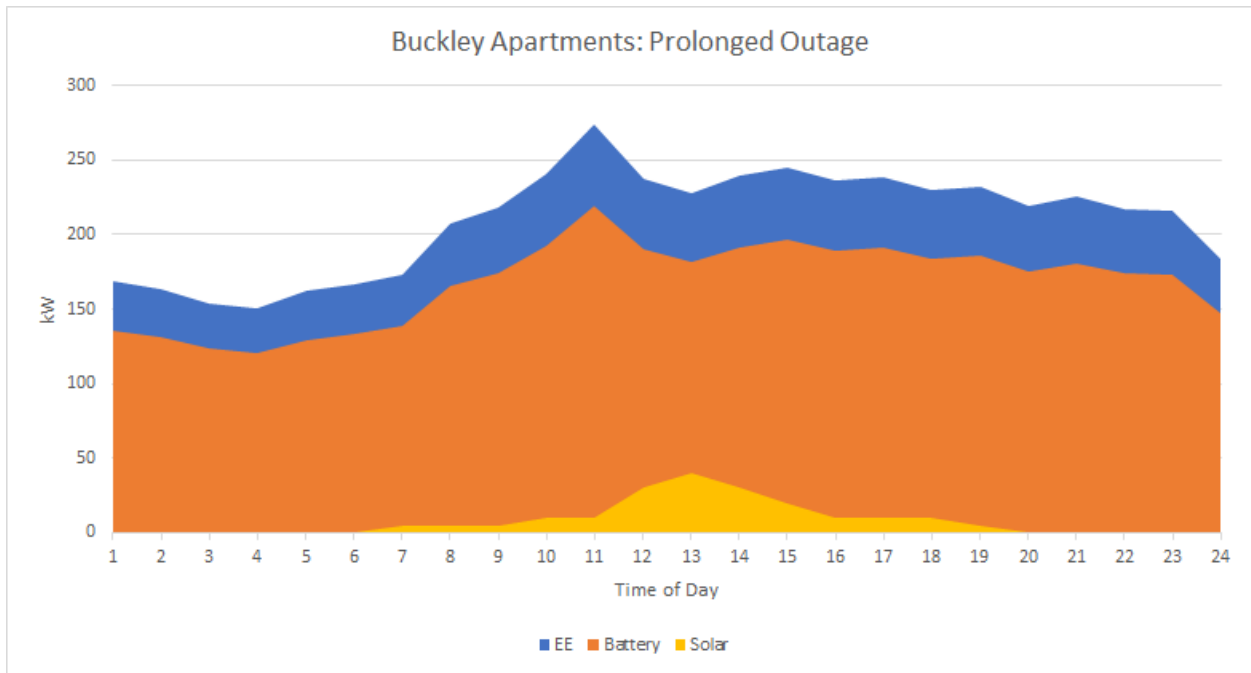
@Schneider Electric

Appendix A, Table vii.

City Hall		
MAX PEAK (kW)		
	WINTER	SUMMER
2011	156.3356182	100.8759096
2012	162.7837933	99.77171799
2013	158.1369182	97.87950255
2014	143.7659699	98.38659919
1997-2014	169.7405558	106.7778678



Appendix B: Stacked Area Plot



Dark blue shows impact of EE on the baseline load (EE is "always on"). For simplicity, an average 20% saving is assumed. The actual impact will vary from hour to hour and day to day, depending on the measures installed, weather, facility occupancy and operation, time of day, and other factors.

Yellow shows the contribution of solar energy on an average day in Boston. (The solar contribution is magnified by a factor of 10 to make its impact visible.) This example is based on experience elsewhere; the actual impact profile will depend on weather variations. Solar will always be chosen first (by the smart inverter) to feed the load.

The remaining area (orange) would be supplied by the batteries (supplemented by solar) in a prolonged outage until depleted, at which point the DC generator⁶⁶ will fire to serve load.⁶⁷ This is the same as the power supplied by the grid in normal operation, since the proposed strategy is to supply the full facility load in emergencies.

We used real interval data for a sample one-day load at one of the initial facilities (Buckley). The initial EE improvements reduce the peak load profile. Then the contribution of solar supplies what load it can, and the batteries assume the rest.

⁶⁶ We chose a DC generator because an AC alternator is too noisy both acoustically and electronically.

⁶⁷ The battery always supplies the load (via the inverter). There are lots of ways to do this; we can deploy our battery banks in several modules around the facility. So for example, we can set up two banks, each with a rating equal to the peak coincident load at the facility) but only a half-hour discharge duration. Then when the first is discharged, we switch over to the second. There are other ways to do this, which the contractors can optimize when they bid.

It's interesting to note that the battery's area on the plot is exactly the same as the grid's contribution in normal times, so the "emergency" and "normal" plots are identical. This is due to our special design which guarantees all subscribers can prosper-in-place and have power equivalent to that of more affluent customers: the battery (then generator) simply picks up the peak coincident load if the grid fails, and maintains it for the duration of a prolonged outage.

We plan to market this service also to paying customers (commercial, residential, and public) surrounding the chosen neighborhood, in the form of "resilience as a service" via lease-and-service of clean energy assets. We'll charge on a sliding scale, treating subscribers in all income classes the same except for the monthly fee (zero to full reimbursement).

The plot is of course only an example, since both loads and supply opportunities vary so widely, but its format and design concept will not change. New interval load data and supply parameters can be entered to produce new plots for any scenario.

Appendix C: DER-CAM Results for Buckley

Appendix C, Table i.

Summary Table

	Optimized Value	Reference Value	Total Savings (%)
Total Annual Energy Costs (k\$)	136	121	-12.70
Total Annual CO2 emissions (metric tons)	697	815	14.49

Figure 1a. Winter Hourly Load Profile for a 10-Hour Outage (Outage from 1 pm to 11 pm)

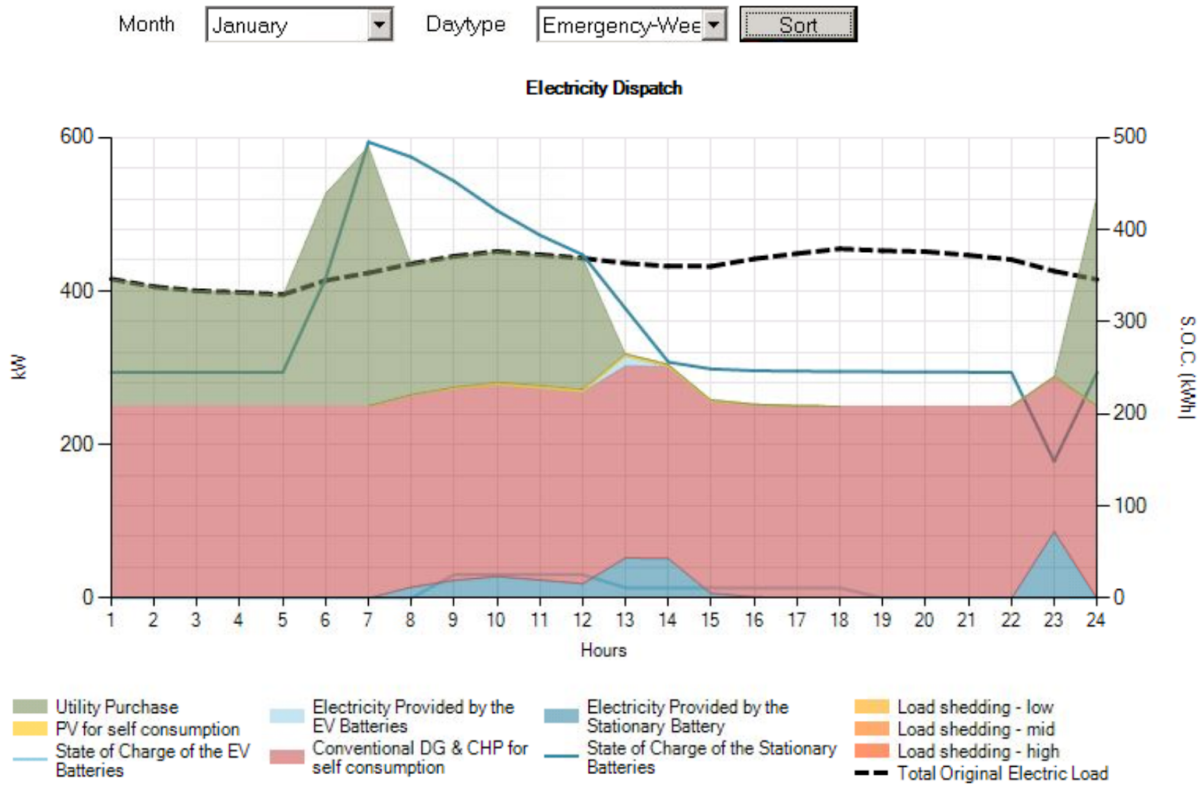
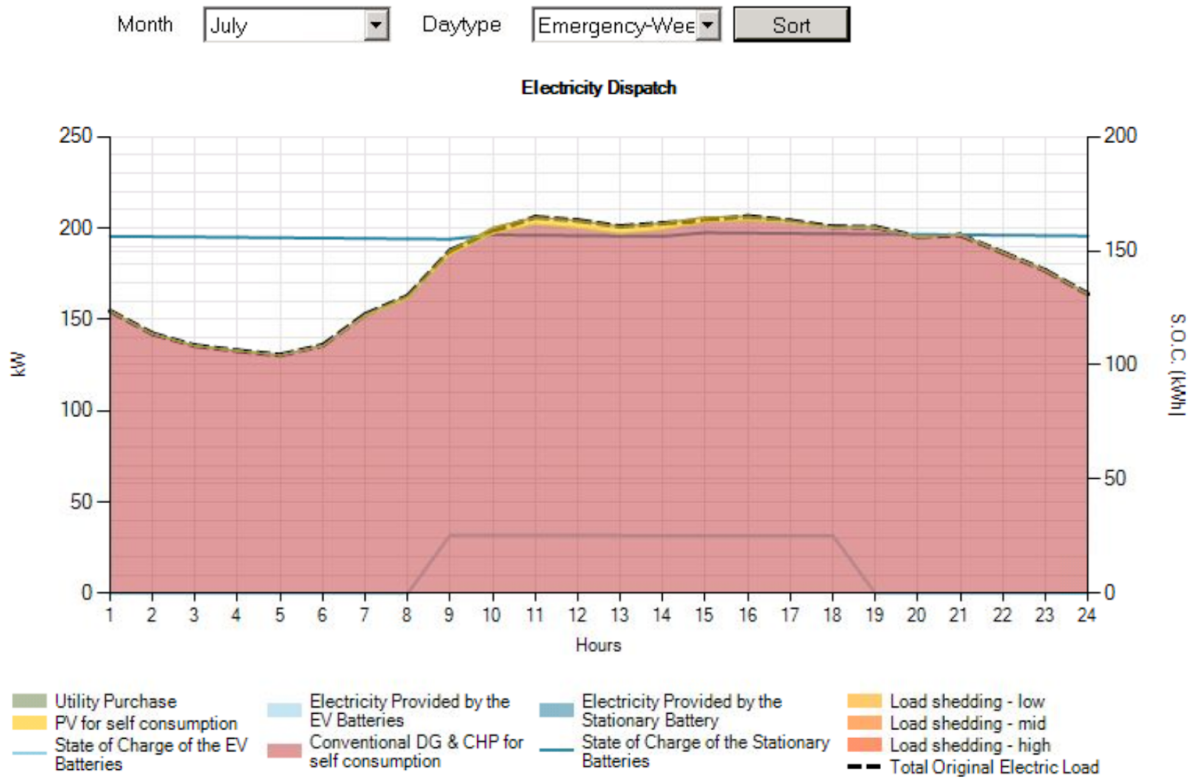
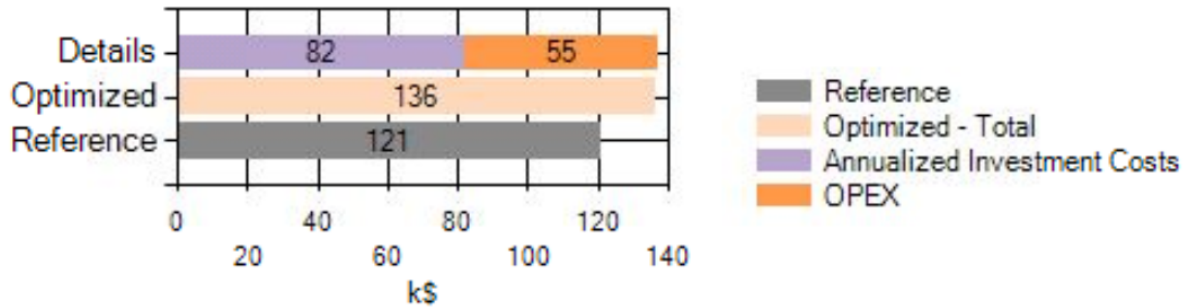


Figure 1b. Summer Hourly Load Profile of a 5-Hour Outage (Outage from 9 am to 1 pm)

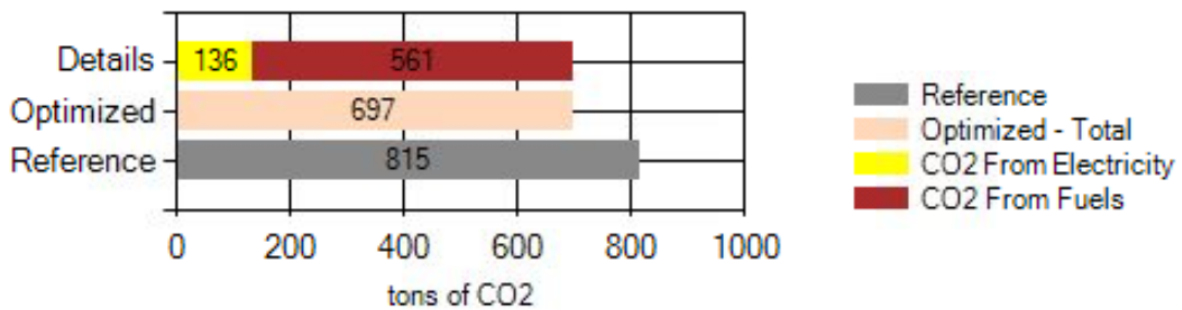


Buckley Charts Summary

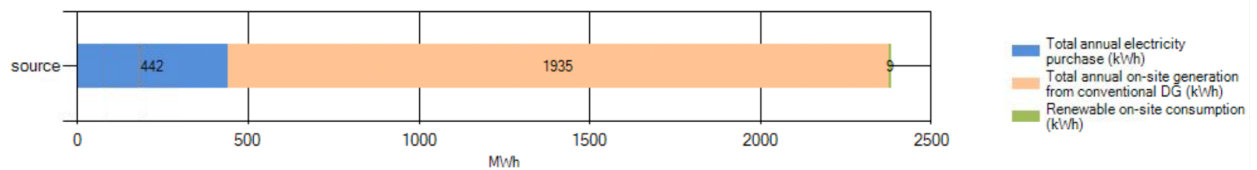
Total Annual Energy Costs



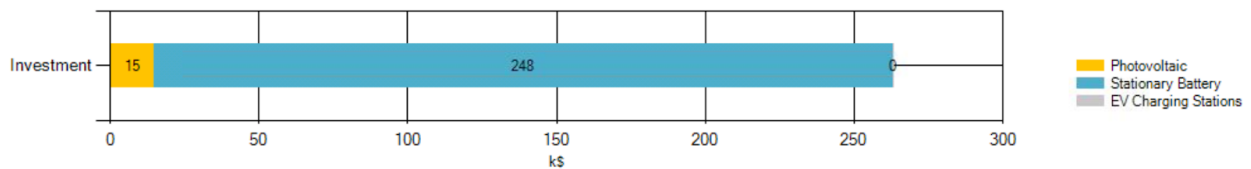
Annual CO₂ Emissions



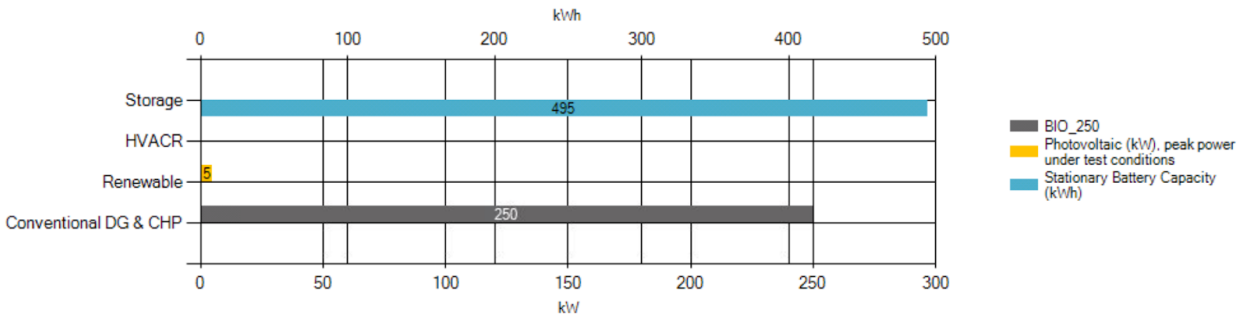
Total Electricity by Source



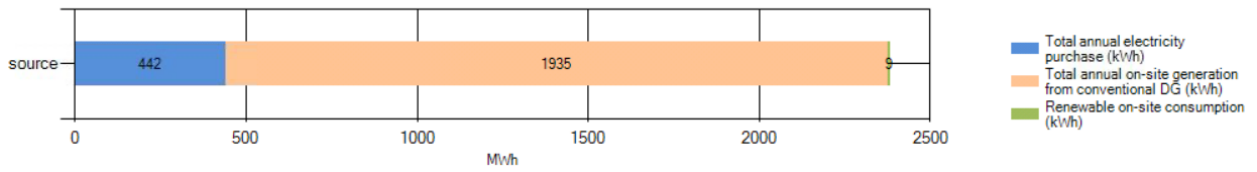
Total DER Capital Costs



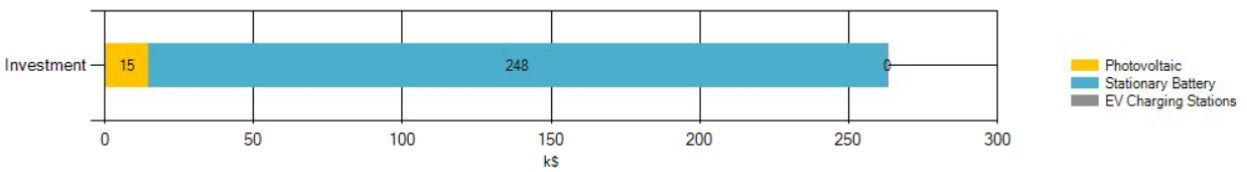
New DER Capacities



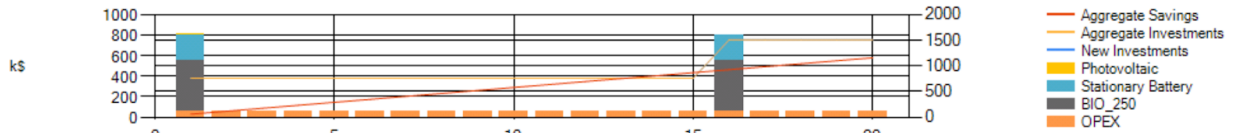
Total Electricity by Source



Total DER Capital Costs



Yearly Investment



Costs Summary

Total Annual Energy Costs	k\$	136
Total DER CAPEX	k\$	263
Annualized DER Costs	k\$	82
Total Annual OPEX	k\$	55
OPEX - Electricity	k\$	29
OPEX - Fuel	k\$	0
OPEX - O&M	k\$	26
Total Revenue	k\$	0
Revenue - Electricity Export	k\$	0
Revenue - Ancillary Services	k\$	0

Energy Summary

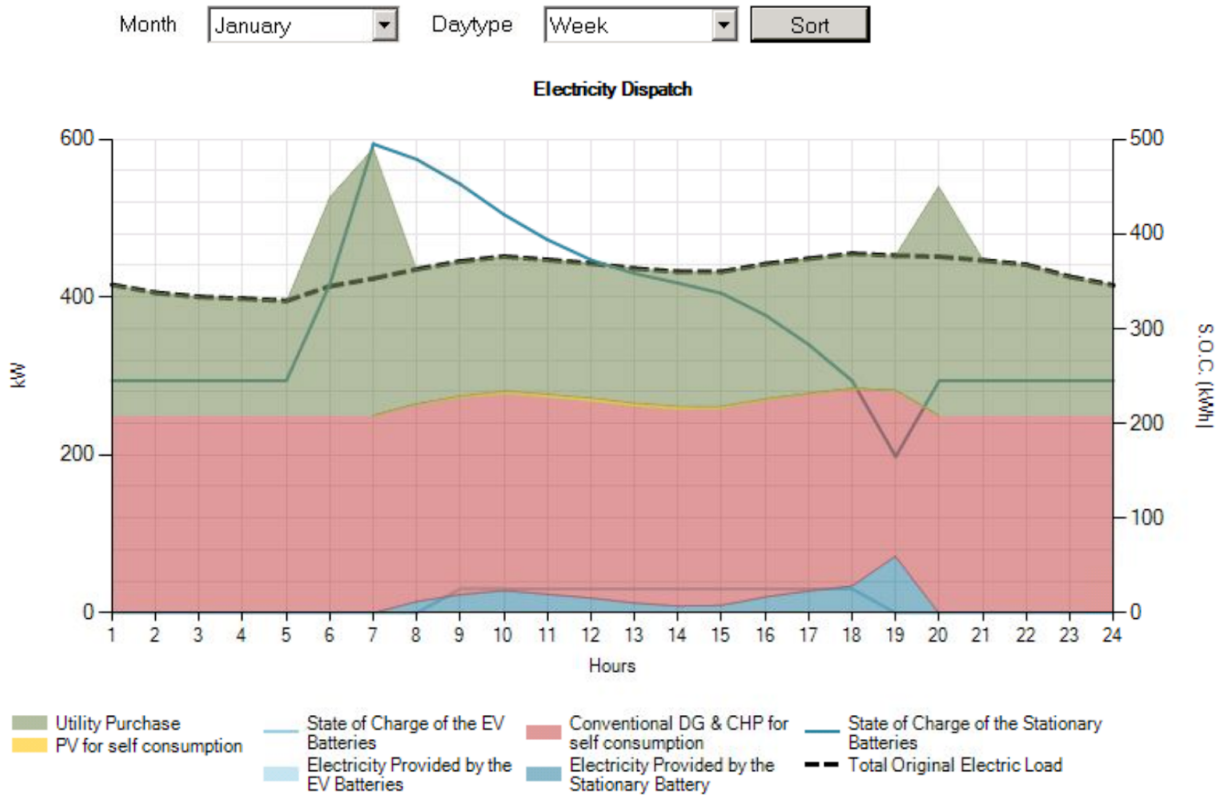
Electricity Consumption	MWh	2399
Fuel Consumption	MWh	7412
Onsite Renewable Gen.	MWh	9
Onsite Non-Renewable Gen.	MWh	1935
Total Electricity Sales	MWh	0

CO2 Summary

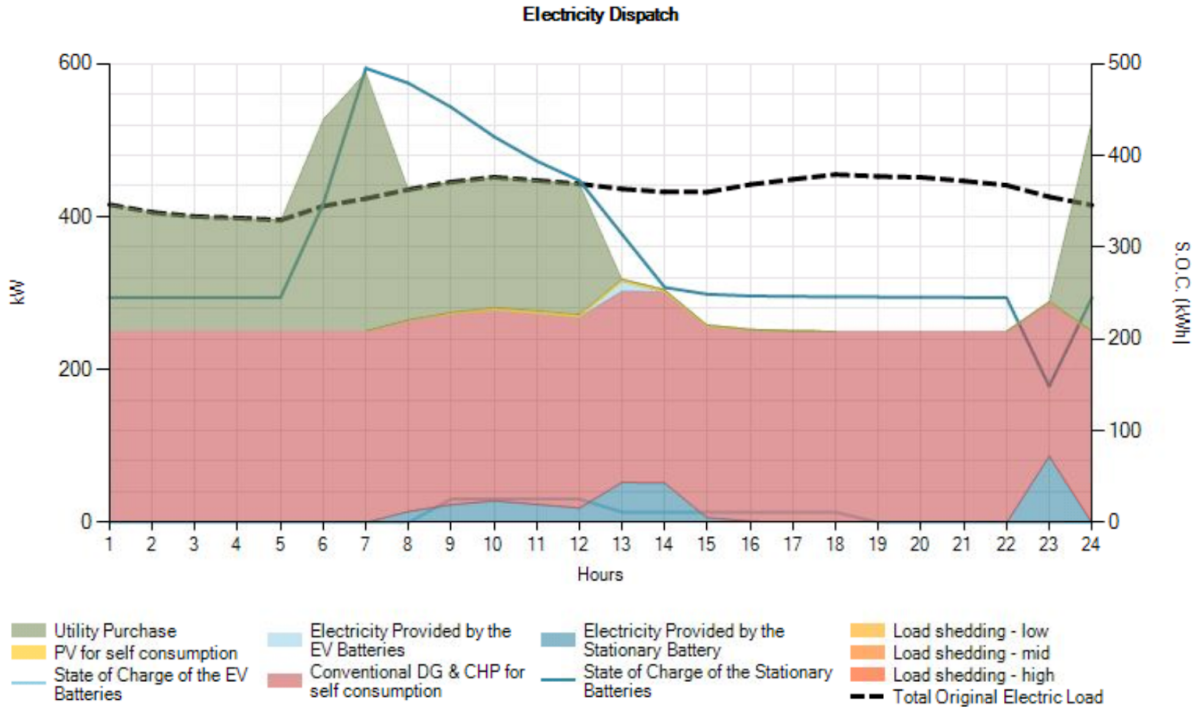
Total CO2	tons CO ₂	697
CO2 from Electricity	tons CO ₂	136
CO2 from Fuels	tons CO ₂	561
CO2 Offsets from Export	tons CO ₂	0

Buckley Electricity Dispatch Summary

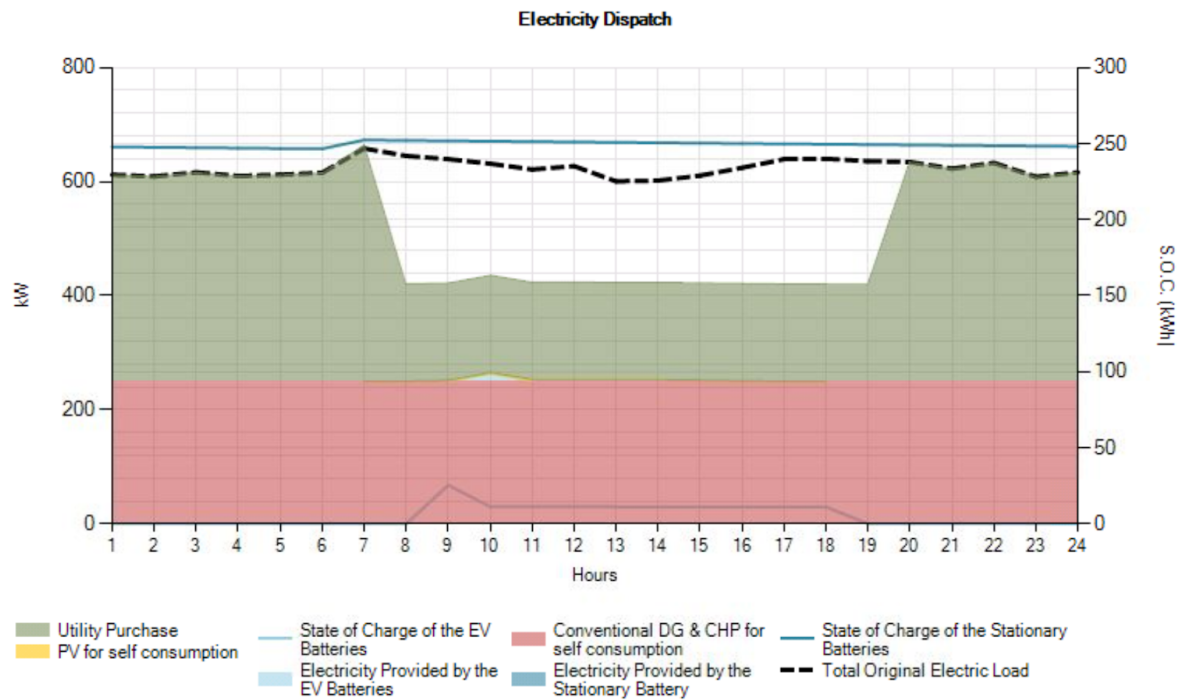
Winter Hourly Load Profiles (Week, Emergency-Week, Peak)



Month Daytype

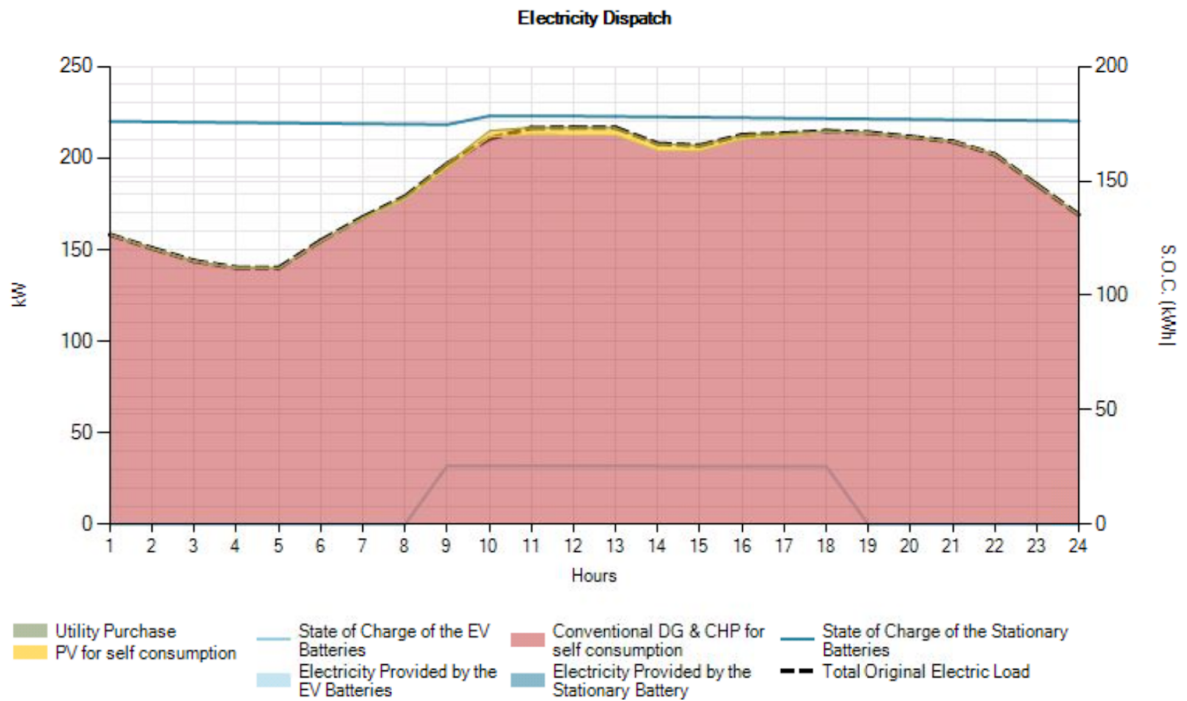


Month Daytype

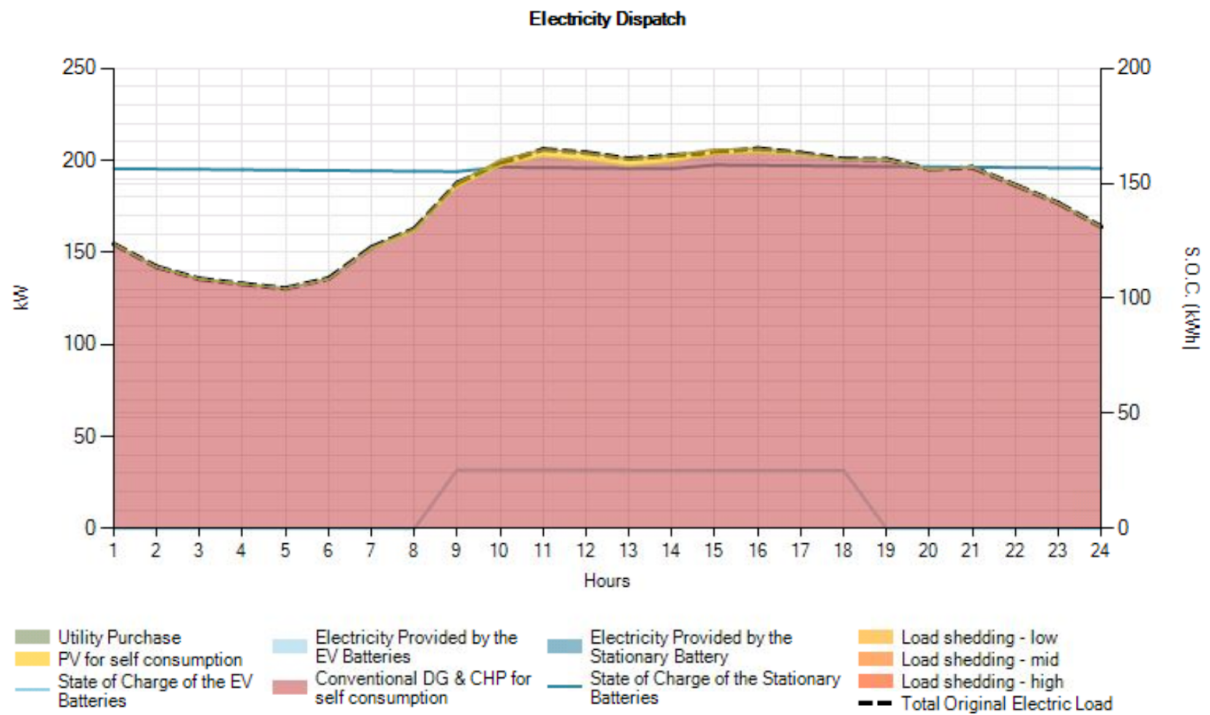


Summer Hourly Load Profiles (Week, Emergency-Week, Peak)

Month Daytype

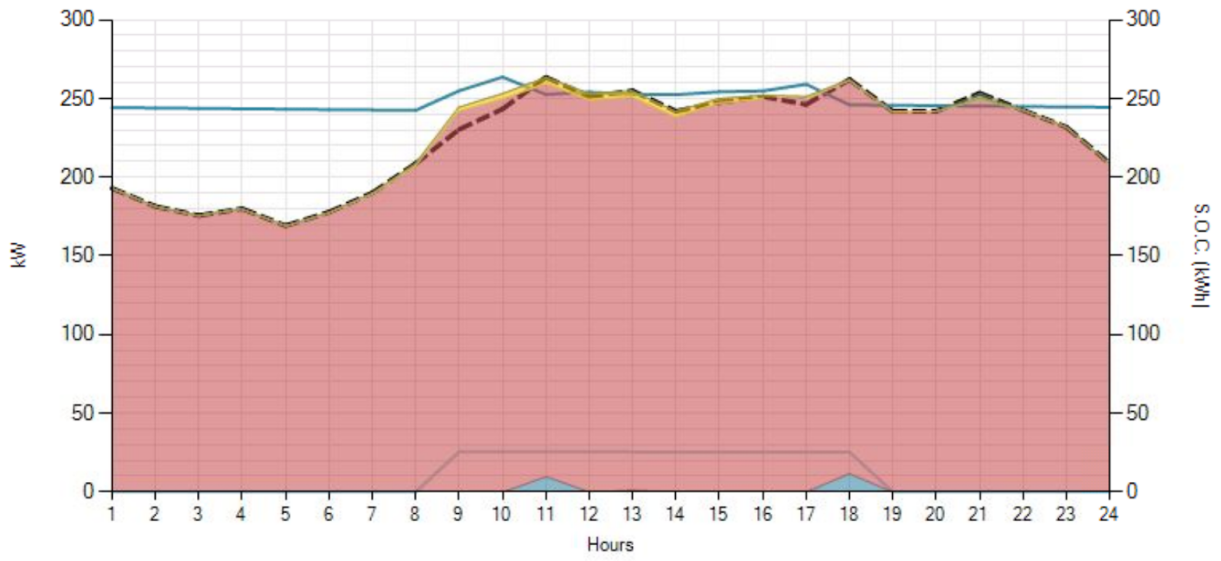


Month Daytype



Month: Daytype:

Electricity Dispatch



- Utility Purchase
- PV for self consumption
- Conventional DG & CHP for self consumption
- State of Charge of the EV Batteries
- Electricity Provided by the EV Batteries
- Electricity Provided by the Stationary Battery
- State of Charge of the Stationary Batteries
- Total Original Electric Load

Appendix D: Connected Utility Infrastructure

The three facilities are connected to radial lines via the utility infrastructure summarized at the utility bus in each drawing. Following are explanations of these connections:

- A. Buckley Apts. — 14 Bloomingdale St, Chelsea: Primary meter @ P33/2 (800kVA Demand); Ckt 488-H3 (STA 488) --- 336/485 (SP/SN), 69% loaded – Supplied at 14 kV (customer owns the 14 kV to 208v step down) connected to 14 kV circuit no. 488-H3 at station 488 – Chelsea 115/14 kV substation. The 14 kV circuit is 69% loaded on peak.
- B. Beth Israel Deaconess Medical Center – 1000 Broadway, Chelsea: PMH13323 – 300kVA xfmr; Ckt 488-H7 (STA 488) — 410/485 (SP/SN), 84% loaded – Supplied from manhole number 13323 via a 300 kVA 14 kV to 208v step down transformer which is connected to circuit number 488-H7 at station 488 - Chelsea 115/14 kV substation. The 14 kV circuit is at 84% of capacity on peak.
- C. Chelsea City Hall — 500 Broadway, Chelsea: PMH13312 – 300kVA xfmr; Ckt 488-H1 (STA 488) --- 425/485 (SP/SN), 87% loaded – Supplied from manhole number 13312 from a 300 kVA 14 kV to 208v transformer which is connected to circuit no. 488-H1 at station 488 – Chelsea 115/14 kV substation. The 14 kV circuit is 87% loaded.

Appendix E: Energy-Related Credits & Incentives Available for Muni Affiliate’s Resilience Programs

Summary

Massachusetts allocates significant resources for energy efficiency and renewable energy projects. Chelsea’s municipal affiliate is well positioned to help its program participants identify and integrate these resources into the microgrid’s resiliency initiatives. This section has several goals:

- To explain the funding process
- To list the programs for which the municipal affiliate’s participants might qualify
- To estimate the funds that might be available for the municipal affiliate’s participants
- To explain the detailed performance requirements necessary to be successful for each program

What is the funding process?

As a general rule, all the incentives and potential credits require:

- Prior approval
- Documentation showing that the design meets the program criteria

These programs provide funding in two ways:

- Energy-related program incentives: paid during construction or shortly after construction is successfully completed per the approved design
- Energy-related credits: paid annually for 20 years based on measured renewable energy output

Appendix E, Table i.

For which programs is the muni affiliate eligible?			
Program	Construction Incentive	First Year Energy Credits	Annual Credits Duration
MA SAVE Commercial Incentive	Prescriptive – rebates or MA SAVE vendor	NA	NA
MA SAVE Multi-family Incentive	Programmatic – coordinate with MA SAVE	NA	NA
MA DOER SMART PROGRAM Solar PV Credits ⁶⁸	NA	\$.25 - \$.39 per kW ⁶⁹	10 years
MA DOER SMART PROGRAM Battery Storage Credits	NA	\$.02 - \$.05 per kWh	10 years
MA DOER Alternative Portfolio Standard Alternative Energy Credits ⁷⁰	NA	\$23.50 per MWh ⁷¹	NA ⁷²

⁶⁸ “Guideline on Capacity Blocks, Base Compensation Rates, and Compensation Rate Adders.”

Massachusetts Department of Energy Resources, 11 January 2018.

<https://www.mass.gov/doc/capacity-block-base-compensation-rate-and-compensation-rate-adder-guideline>

⁶⁹ Compensation Rates as of March 2019 show Block 1 rates are likely full, but the whole range for projects that are “low income less than or equal to 25 kW AC” and projects that are “less than or equal to 25 kW AC” across Blocks 1 through 8 are included in Table 6.

“SMART Statements of Qualification.” Massachusetts Department of Energy Resources, 19 August 2019.

https://www.mass.gov/media/1980301/download?_ga=2.164352895.1195842681.1552334484-890583606.1551128897

⁷⁰ “Alternative Energy Portfolio Standard.” Renewable Energy Division, 2020.

<https://www.mass.gov/alternative-energy-portfolio-standard>

⁷¹ Annual APS APC Rate for 2020.

“Annual APC Rate Adjustments.” Annual Compliance Information for Retail Electric Suppliers, Renewable Energy Division, 2020. <https://www.mass.gov/service-details/annual-compliance-information-for-retail-electric-suppliers>

⁷² The DOER expects the adoption of new technologies to increase the supply of AECs and influence the annual changes in Annual Compliance Payment (ACP) totals.

“Massachusetts 2016 Renewable Portfolio Standard (RPS) And Alternative Portfolio Standard (APS) Annual Compliance Reports.” Renewable and Alternative Energy Division, Department of Energy Resources. Executive Office of Energy and Environmental Affairs, Commonwealth of Massachusetts, 27 December 2018.

https://www.mass.gov/files/documents/2019/01/22/RPS-APS%202016%20Annual%20Compliance%20Report%20FINAL_REV1.pdf

How should the muni affiliate interact with these programs?

Most of these programs require prior authorization. The municipal affiliate can vet the equipment selected to see if it meets the requirements of the various programs and suggest alternative equipment where appropriate.

Insulation and High-Efficiency Equipment

MA DOER offers rebates and incentives for insulation and high efficiency equipment through its **MA SAVE** program run by the State's investor-owned utilities. The rebates and incentives, which require prior approval from a "sponsor"⁷³ are provided to the owner or contractor after the measures have been installed and verified. MA SAVE's programs are reviewed and approved every three years. Program incentives will change over time but should be available for the municipal affiliate's microgrid project.

The municipal affiliate's project will qualify for one of two MA SAVE programs: commercial or multi-family. Each program has its unique programmatic requirements, process to follow, vendors and providers that are pre-approved for the municipal affiliate to work with, and quality control and payment process. The municipal affiliate's first step for these programs would be to reach out to the program managers and potential vendors to determine the preapproval process, program resources, and program constraints.

Commercial

Most commercial building incentives are prescriptive for individual measures that a pre-approved vendor or energy engineer identifies.

Multi-family

Multi-family buildings (buildings with more than 5 units- in this case applicable to Buckley Apts) require prior assessments by pre-approved energy auditors and service providers. CLEAResult is one of the providers. The rules for the program should be confirmed. In most cases, multi-family developments are viewed holistically as a single building. In some cases residents living in individually metered apartments can be served directly. Multi-family buildings are eligible for weatherization upgrades. Low-Income Energy Affordability Network (LEAN) in partnership with MA SAVE runs the weatherization program for multi-family homes over 5 units in Chelsea. (Community Action Programs Inter-City, Inc. (CAPIC) runs the weatherization program for single-family and smaller multi-family homes of up to four units in Chelsea.) Funding for weatherization varies significantly from year to year. Large multi-family buildings that qualify for the program put significant stress on the annual budget and may not receive the full amount of program support that the municipal affiliate might anticipate.

⁷³ The Sponsor for electric services in Chelsea is Eversource.

"Electricity Providers by Municipality." Massachusetts Department of Public Utilities, September 2015. <https://www.mass.gov/files/documents/2017/09/11/map-of-electric-company-service-territories-by-municipality.pdf>

Clean Heating and Resiliency

Credits and Incentives

MA CEC offers clean heating incentives for qualifying modern wood heating, high efficiency air source heat pumps, and high efficiency ground source heat pumps, solar thermal systems, and climate change resiliency battery storage systems. MA CEC has minimum system performance requirements listed in its technology program guides and a list of preapproved clean heating equipment. The incentives, which require prior approval⁷⁴, are provided to the owner or contractor after the measures have been installed and verified. Total incentives are capped at \$500,000 per system owner per technology type per year. The muni affiliate could apply yearly for each qualifying technology to maximize the incentive benefits. Individual technologies have incentive caps. With solar thermal, nonprofit and public entities are entitled to a 50% rebate and affordable housing projects are entitled to a 75% rebate with a limit of \$100,000 and an additional \$1,500 for the meter installation per building per year.

The municipal affiliate should contact MA CEC about this project because the agency will need to work internally to strike a balance between adequate funding support for a project of this scale while providing funding support for other projects. Funding support from MA CEC for clean heating technologies has been approved through FY2020. Incentive amounts have changed and most likely will continue to change over time.

MA CEC also offers up to \$5K for commercial solar thermal assessments. The solar thermal assessment is required in order to qualify for solar DHW incentives. In December 2017, MA DOER announced clean heating credits called Alternative Energy Credits (AECs) for measured clean heating generation. These credits are similar to renewable energy credits (RECs) offered in the SMART program.

The credits are monetized annually based on the measured clean energy generated for the life of the equipment. The current value for each clean heating energy credit uses different units of measurement than RECs and is about \$15 per MMBTU. Each clean heating technology has a different multiplier for the AECs that reflect system efficiency. The multiplier for modern wood heating is 1 (although this is not a type of energy this microgrid would use). The multiplier for Variable Refrigerant Flow (VRF) air source heat pumps is 3. The multiplier for ground source heat pumps is 5.⁷⁵

⁷⁴ According to the MassCEC Procurement Guidelines, step 5, "In almost all cases, the installer will be responsible for acquiring the permits and agreements necessary for the solar installation. These approvals will include the utility interconnection agreement, local building and electrical permits, local zoning permits, and state and federal incentive approvals. Make sure the installer provides clear instructions on steps that may be required by the system owner to finalize or receive any permits or incentives."

"Step 5: Municipal and Utility Permits and Approvals." Procurement Guidelines, MassCEC.

<https://www.masscec.com/procurement-guidance>

⁷⁵ "Small Ground Source Heat Pumps in the Massachusetts Alternative Portfolio Standard." Massachusetts Department of Energy Resources, February 2018.

<https://www.mass.gov/files/documents/2018/04/05/Small%20GSHP%20030518.pdf>

Renewable Energy

Credits and Incentives

MA DOER's SMART program offers renewable energy credits for measured solar PV electricity generation. As is true with all onsite generation projects, interconnection access and costs and potential capacity constraints may limit the extent that PV can be installed at the muni affiliate's sites. SMART program credits are monetized annually for 20 years based on the measured renewable energy generated for systems greater than 25 kW. Beth Israel Deaconess Medical Center falls under this category. For systems under 25 kW, the incentives are monetized annually for 10 years. Buckley Apartments will start with 5 kW of PV, putting this facility in the category of incentives that are monetized for 10 years. The potential base value for each renewable energy credit is about \$.17/kWh but may be less depending on when the application is submitted (specifically, the extent to which the higher-incentive tranches have been filled so incentives have been reduced). It should be noted that the final incentive price is inclusive of the value of energy payment, which is backed out of the incentive amount. Potential adders for the panels include:

Style	Credit/ kWh
Roof mounted panels	\$.02
Parking canopy panels	\$.06
Electricity allocated to public entities	\$.02
Electricity allocated to community shared solar participants	\$.05
Systems with battery storage (new as of September 2018)	\$.025 - \$.076

Power Purchase Agreements Not-for-profit and municipal partners should consider using a power purchase agreement (PPA) to procure solar PV and potentially clean heating equipment. PPAs allow renewable energy and clean heating project developers to capture accelerated depreciation, sales tax exemptions, federal tax credits, and other incentives that are available to private renewable energy system owners but not to not-for-profit and municipal entities. Most municipal and state entities leverage these incentives by purchasing electricity from a private entity at a rate equal to or lower than the cost to purchase and operate a solar PV system directly.

Renewable considerations:

1. Interconnection costs and potential capacity constraints may limit what the muni-affiliate can do with renewable energy generation at each site. Eversource will need to determine the interconnection process for each facility and identify any constraints or additional costs for the proposed and potential solar PV, generator, and battery systems that might feed electricity to the local distribution lines.

2. Smaller PV systems qualify for higher SMART program incentives. For example, PV systems under 500 kW qualify for an incentive that is about \$.02/kWh higher than systems greater than 500 kW. RUN-GJC contacted MA DOER and asked how the number of solar PV systems on a single site is determined on a single site. At a minimum, a solar PV system connected to an individual electricity account qualifies as a single system. A single site with multiple electricity accounts can have multiple solar PV systems, one per account. In addition, each account can have up to two solar PV systems if both solar PV systems have individual production sub meters.
3. Electricity cost savings will vary depending on the site's utility account rate and/or the stipulated electric rate assigned to excess electricity the project supplies to the electric grid.
4. A few recent PV Canopy projects with EV chargers have included battery storage to avoid peak kW charges from car charging. In addition, a central battery storage system can help reduce the interconnection design load. There are minimum and maximum size, equipment location, and generation and emergency power panel integration considerations for battery storage associated with the battery storage solar PV incentive adder and other financial stream considerations.

Green Community Grants

Chelsea is a designated Green Community to whom **MA DOER** offers grants up to \$250K per year for cost effective (about 10 year payback or less) energy efficiency measures. Grant applications are due in March each year. Awards are made in July/August and work needs to be completed by January. In addition, MA DOER also offers technical assistance grants up to \$12,500 for specific projects.

Green Community grant question:

We recommend that the design team identify two individual or groups of energy efficiency upgrade measures with an estimated cost between \$250K and \$500K and a simple payback of 10 years or less to submit for Green Community grant assistance. Applications are due in March each year and funding is confirmed mid-summer. The measure(s) must be completed by January in order for the town to qualify for another grant request the following March.

Appendix F: Facilities Served by Initial Microgrid Deployment, Including Value of Resilience

Appendix F, Table i.

Facilities Served by Initial Microgrid Deployment, Including Value of Resilience			
	Buckley Apartments	Beth Israel	Chelsea City Hall
Rate Class	Residential	Large C&I	Large C&I
Economic Sector	Multi-family	Health center	Municipal facility
Multiple Ratepayers?	No	No	No
Financial Criteria to Qualify	None	None	None
Average Annual MWh per Customer	2,279	925	323
Average peak MW per Customer	0.658	0.1845	0.12
Percent Demand Supported	100%	100%	100%
Hours/ Day Supported	24	24	24 as a command center
Value of Resilience			
● By ICE Calculator per LBNL	\$226,648	\$527,619	\$1,209,706
● By National Ave. per ACEEE	\$87,300	\$400,125	\$320,100
● By Cost Avoidance per NREL	\$9,841/hr*	\$9,841/hr*	\$9,841/hr*
● By Medicare Dependence	Survival	Treatment	N/A
*Using the average of “large office” and “large hotel” calculations.			

The estimates of “Value of Resilience” above require some explanation:

- The ICE Calculator (Interruption Cost Estimates) is maintained online by the Lawrence Berkeley National Laboratory (LBNL) and is pre-populated with a large number of national estimates and data to make it user-friendly. The table above shows ICE outputs in annual cost of grid interruptions for Massachusetts parameters, using:
 - the number of users of each of the three facilities (previously submitted in Task 4 Table 1) and
 - median North American values of the System Average Interruption Duration Index (SAIDI), in hours and the System Average Interruption Frequency Index (SAIFI), in annual number of interruptions per customer, per IEEE Standard 1366-1998.
- The ACEEE national averages are based on a 2018 study of published assessments by eight organizations⁷⁶, each computing annual cost of energy interruptions or “poor performance.” Taking an average of their results, which varied from \$18 billion per year to \$190 billion per year, and dividing by the US population of 325 million, returns an average cost of \$291 per year per capita. The table above then multiplies this per capita cost by the number of users in each facility.
- A 2018 NREL report⁷⁷ attempts to value the Resilience Provided by Solar and Battery Energy Storage Systems installed in primary schools, large office buildings, and large hotels. The data are taken from a compilation of 30 utility customer surveys done by Sullivan, Schellenberg, and Blundell in 2015 (LBNL Technical Report⁷⁸). The primary data were related to relatively short outages and thus undervalue the impact of longer service interruptions.
- Lew Milford’s paper⁷⁹ is the least quantitative but may be the most telling. It is based on a recent study of “PV-Battery Systems for Critical Loads During Emergencies: A Case Study from Puerto Rico After Hurricane Maria⁸⁰” by Lilo Pozzo and her colleagues at the University of Washington. They spent time in Puerto Rico observing real-world impacts from the loss of critical energy, communications, and transportation on residents dependent on health care.

Many other attempts have been made to attach a dollar value to loss avoidance from future emergencies, and the casualty insurance industry is slowly increasing attention to the actuarial calculations. As the table illustrates, however, the variation among facilities, locations, occupants, economic conditions, and other parameters is wide enough to confound any confident projections.

⁷⁶ Chittum & Relf. “Valuing Distributed Energy Resources” See note 35.

⁷⁷ Laws, Nicholas D., Kate Anderson, Nicholas A. DiOrio, Xiangkun Li, and Joyce McLaren. “Valuing the Resilience Provided by Solar and Battery Energy Storage Systems.” National Renewable Energy Laboratory, January 2018. <https://www.nrel.gov/docs/fy18osti/70679.pdf>

⁷⁸ Sullivan, Michael J., Josh Schellenberg, Marshall Blundell. “Updated Value of Service Reliability Estimates for Electric Utility Customers in the United States” Lawrence Berkeley National Laboratory, January 2015. <https://emp.lbl.gov/sites/all/files/lbnl-6941e.pdf>

⁷⁹ Milford, Lewis. “Battery Storage Could Revolutionize Home Health Care: Lessons Learned from Puerto Rico.” Clean Energy Group, 30 January 2019.

<https://www.cleangroup.org/battery-storage-could-revolutionize-home-health-care-puerto-rico/>

⁸⁰ Pozzo, Lilo, Chanaka Keerthisinghe, Mareldi Ahumada-Paras, D.S. Kirschen, Wesley Tatum. (2019, January) “PV-Battery Systems for Critical Loads During Emergencies: A Case Study from Puerto Rico After Hurricane Maria.” *IEEE* 17 no. 1 (9 January 2019): 82-92. <https://ieeexplore.ieee.org/document/8606510>

Moreover, the really important value of resilience is its support of the health and welfare of participants. For the immobile residents and the institutions serving them in low-income communities, this can be a matter of life or death.

Appendix G: Pro Forma Projections

In 2020, the RUN-GJC team was expanded and financial projections outside the scope of the contracted feasibility assessment were made to support future implementation. Over the two years since the CEC contract was executed, many changes in building loads, incentives, markets for revenues, and public policy have been made, so some early numbers in the preceding Tasks are outdated. The parametric model has allowed us to keep up with changes by adjusting assumptions.

An updated projection, including base, optimistic, and pessimistic versions, has been drawn from the model, which of course differs from earlier reports. It is still just a pro forma forecast. Real numbers will emerge only with substantial design and operation over future years.

For those interested in such a forecast, a summary of potential revenues and standard financial ratios is copied below.

Standard Financial Ratios

Appendix G, Table i.

	Year 3	Year 5	Year 10
Liquidity Ratios			
Debt service coverage (net operating income/debt service)			
Base	1.25	1.39	1.16
Optimistic	1.30	1.44	1.47
Pessimistic	1.15	1.28	1.06
Cash flow coverage (operating cash flow/debt)			
Base	8%	11%	17%
Optimistic	9%	12%	24%
Pessimistic	7%	10%	15%
Viability ratio (net assets/debt)			
Base	1%	8%	29%
Optimistic	2%	10%	60%
Pessimistic	-1%	2%	10%
Operating reserve (net assets/total costs)			
Base	8%	47%	128%
Optimistic	16%	63%	267%
Pessimistic	-7%	15%	46%
Return Ratios			
Profit / revenue			
Base	5%	17%	14%
Optimistic	8%	20%	31%
Pessimistic	-2%	11%	7%
Cash flow margin (operating cash flow/revenue)			

Base	53%	60%	66%
Optimistic	55%	61%	73%
Pessimistic	50%	57%	64%
Return on assets (profit/assets)			
Base	0.8%	3%	3%
Optimistic	1.3%	4%	6%
Pessimistic	-0.3%	2%	2%

Potential Revenue Streams and Values

Appendix G, Table ii.

Year	1	2	3	4	5	6	7	8	9	10
\$000										
Revenue										
Savings										
Energy & water	\$ 50	\$ 100	\$ 200	\$ 300	\$ 300	\$ 300	\$ 300	\$ 300	\$ 300	\$ 300
PV+SMART	\$ 65	\$ 195	\$ 260	\$ 260	\$ 260	\$ 260	\$ 260	\$ 260	\$ 260	\$ 260
Utility/ISO	\$ 62	\$ 124	\$ 165	\$ 165	\$ 165	\$ 103	\$ 41			
Performance Incentives	\$ 100	\$ 200	\$ 250	\$ 250	\$ 250	\$ 250	\$ 250	\$ 250	\$ 250	\$ 250
Subtotal Revenues	\$ 277	\$ 619	\$ 875	\$ 975	\$ 975	\$ 913	\$ 851	\$ 810	\$ 810	\$ 810

Appendix H: Team Bios

Community Labor United (CLU)

Community Labor United (CLU) is a long-term partnership between some of the strongest base building community organizations and unions in Greater Boston. Since 2005, CLU has successfully moved strategic

campaigns that protect and promote the interests of working class families and communities of color in Greater Boston and throughout the Commonwealth. Through a program of coalition building, research and policy development, public education and grassroots mobilization, CLU moves forward policies that promote quality jobs, affordable housing and sustainable local economies.

In 2008, CLU formed the Green Justice Coalition (GJC) in order to build a broader base of support for a sustainable, equitable, and clean energy economy in the Greater Boston region. That same year they added environmental organizations to their list of partners and moved forward their first campaign to transform statewide residential weatherization programs. As a result of their efforts, Massachusetts' working class households saved \$59 million in fuel costs, weatherization workers were paid \$42 million more than before, and the state reduced 84,000 pounds of greenhouse gas emissions. And since transportation is the second largest sector responsible for greenhouse gases emissions after inefficient buildings, CLU/GJC decided to take on a campaign to increase investment in public transit. This campaign brought together Amalgamated Transit Union locals and transit rider advocacy groups from across the state and helped to secure \$2.5 billion in state funding for public transit, won a 5% cap on fare increases, lowered fares for the elderly and disabled, created a new discounted youth pass, and guaranteed a voting seat on each of the 16 regional transit authorities with a mandate that they also had to include riders and workers in their transit planning.

The Green Justice Coalition (GJC) began to explore the opportunities of microgrids in January 2016 after the Massachusetts Clean Energy Center released a Request for Proposals to assess potential projects across the state. GJC members are now pursuing separate microgrid projects as a cohort, including GreenRoots in Chelsea.

Although the projects are still in the early stages of development, one unique element of the approach has been critical for GJC: rooting development from the earliest stage possible in local grassroots organizations with a bottom-up approach. GJC member organizations, with their long standing community credibility, reputation, and relationships, can develop the critical partnerships on the ground required to move projects forward. This includes organizing members to be ready to join and govern the projects; recruiting local property owners and landlords to participate; and engaging with local government to move projects forward. Through GJC's prior work in developing a residential energy efficiency model for low-income communities and communities of color, the coalition also has important experience in developing relationships with the local utility companies that will need to consent to any microgrid projects developed in their service areas. GJC's ultimate objective in advancing these projects is to develop a model of community-led development for community-owned power and resiliency that

can be replicated in working class communities of color across the state, and potentially across the country.

Lee Matsueda is the Executive Director at CLU and has worked to build and grow nonprofit organizations in Dorchester and Roxbury since 2001. Most recently as Political Director at Alternatives for Community & Environment (ACE), Lee helped to ensure that workers and environmental justice communities most impacted by the climate crisis had a strong voice in developing long-term solutions that advanced a more sustainable economy.

Lee has been inspired by community and union members and that he's worked with who choose to come together to fight for their rights against all odds. He believes deeply in building strategic coalitions and partnerships to create significant and transformative change. Lee has been an active participant in CLU's Green Justice Coalition since its inception and also serves on CLU's Board of Directors. Lee has a Bachelor's degree from Brandeis University and a Master's degree in Environmental Studies in the Advocacy for Social Justice & Sustainability Program at Antioch New England Graduate School.

Sarah Jimenez is a Senior Researcher at CLU; she came to CLU as a research fellow with the Center for Popular Democracy in September 2014. Prior to joining CLU, she worked for three years as an office manager for a small Boston design firm. She received her M.A. in Urban and Environmental Policy and Planning from Tufts University. At CLU, Sarah is thriving as a generalist with experience analyzing and writing about wage and hour laws; affordable housing policy; child care policy; and energy policy. She is interested in exploring participatory action research as a means to generate a strategic synergy between information gathering and community organizing.

GreenRoots Inc.

GreenRoots is a grassroots community-based organization with more than two decades of environmental justice and public health accomplishments. GreenRoots has proven itself representative of the best interests of the residents, small businesses, and institutions in Chelsea over years of advocacy and successful social and environmental campaigns. They have recruited subscribers to the community microgrid, defined community energy needs and determined how the project can strengthen a local resource network for the long term. The proposed project fits into GreenRoots' vision to achieve environmental justice and greater quality of life through collective action, unity, education and youth leadership across neighborhoods and communities, as well as their plans for a full-time, permanent, resilient resource network in their neighborhood. Over the past twenty years, GreenRoots has defeated the siting of a diesel power plant; implemented three ARRA-funded EPA diesel emissions reduction projects which invested more than \$3 million to eliminate 2,000 tons of annual air pollutants and 400,000 gallons of fuel usage, and to repower (or replace) 132 high sulfur content diesel engines in Chelsea and Everett, MA; improved the public realm along Mill Creek; launched a successful team of teen leaders through the Environmental Chelsea Organizers (ECO) youth crew; and generally established strong community relationships leading to a track record of advancing environmental justice, business accountability and public access along the Chelsea Creek, Island End River and lower Mystic River watershed.

María Belén Power, oversees GreenRoots’ environmental justice campaigns and supports the work of the organizing team. She represents GreenRoots in the Green Justice Coalition of the Greater Boston Area as well as national movements for environmental and climate justice.

Growing up in a bicultural family in Nicaragua, the second poorest country in the western hemisphere in the aftermath of a revolution, coupled with her work as an organizer in migrant communities has informed her understanding of social justice and the need for systemic change. Maria Belen brings over 15 years of experience in organizing with undocumented immigrants, day laborers, and public housing tenants. This experience has deepened her understanding of economic, social and environmental issues.

Maria Belen was awarded the Neighborhood Fellowship and completed her Masters Degree in Public Policy at Tufts University’s Urban and Environmental Policy and Planning Department. Prior to that, she successfully completed a yearlong certificate program in Nonprofit Management and Leadership with the Institute for Nonprofit Management and Leadership at Boston University. Maria Belen serves on the Board of Directors of the Student Immigrant Movement.

[Clean Energy Solutions, Inc. \(CESI\)](#)

Clean Energy Solutions, Inc. (CESI), a Massachusetts and DC-based consulting firm, has three decades of experience working with state and local governments, housing authorities, nonprofits, businesses, foundations and utilities to design and assist early implementation of comprehensive energy efficiency, renewable energy and water conservation initiatives promising significant reductions in carbon footprints, electricity demand, and energy use across all sectors. Successful energy programs have been administered by CESI in many jurisdictions across the United States, including Chapel Hill and Carrboro, North Carolina; New Orleans, Louisiana; Hamilton County, Ohio; Cambridge, MA; and as sub-grantee on SEP awards to VA, MD, and TN. In these and other jurisdictions, CESI has a long track record of winning public funding opportunities to develop cutting-edge energy programs that can provide sustainable revenues to secure their long-term vitality beyond the duration of start-up grants. CESI principals have raised hundreds of millions of dollars in private capital investment in EE and RE plants, have founded and run ESCOs, and been officers in the major national trade associations. CESI assists utilities and local governments in designing and implementing residential and commercial energy and water efficiency programs; aggregates communities for energy performance contracting; assists property management organizations in establishing energy businesses; undertakes strategic plans for environmental organizations; assists emerging technologists in going to the marketplace; and state energy offices in financing and managing a variety of energy efficiency initiatives.

CESI also forms new enterprises and helps them succeed. CESI raises their capital, recruits and forms their managements and staff, and sets up their marketing. Most are independent nonprofit corporations, but some are government-sponsored or profit-making. A majority are small but some grow to be quite large. For example, CESI was the primary author of the winning proposals for the Southeast Energy and Greater Cincinnati Energy Alliances, winning \$20 million and \$17 million respectively from the U.S. Department of Energy’s national “Better Buildings” competition. (SEEA and GCEA were two of only five non-government winners.) The Cambridge Energy Alliance, the Weatherization Innovation Pilot Programs managed by Charlottesville’s Local Energy Alliance Program and the PACE financing programs

in DC, MD, and VA are examples of smaller, but innovative, programs. All engage the “leverage” of private capital, utility incentives, sale of energy “attributes,” and other revenue sources to extend their reach and penetrate new markets. The role of CESI in the microgrid projects is to engage and supervise the work of expert consultants, and with them to model and assess the engineering and financial feasibility of the proposed hybrid community microgrid and its storage, DG, and load management resources. CESI will also model the costs and revenues of the lease-and-service, energy watchperson, and ISO-NE markets.

David Dayton is Chairman and Treasurer of CESI, which he founded in 2000 to advise municipalities, utilities, government agencies, housing organizations and financial organizations on energy efficiency program design and its integration with renewable technologies. Mr. Dayton began his career as an engineering section leader in a Raytheon laboratory, and was subsequently promoted to the Raytheon Corporate Staff. He left Raytheon to help form Technical Communications Corporation as its Technical Director, where he developed self-organizing, multiple-access, discrete-address technologies that became dominant in military and commercial communications.

Mr. Dayton published widely on these modulation techniques and patented a swept-fm design for digital communication and navigation. Mr. Dayton founded the non-profit Technical Development Corporation (TDC) in Boston and served as its President until 1982. TDC performed many innovative projects in energy conservation, criminal justice and job creation, and set up a number of other corporations in its fields of interest. Mr. Dayton then founded Hospital Efficiency Corporation, one of the first ESCOs in the U.S., which was acquired by Northeast Utilities (now Eversource) in 1990. As an officer and Director from 1990 until his retirement in 2002, Dave led the company's acquisition program and its development of new energy services in new markets. Select Energy Services recommended and installed (and often financed) over a billion dollars' worth of energy efficiency improvements to government and commercial facilities during his tenure. As Consultant to the Director of the MA Renewable Energy Trust, Mr. Dayton provided engineering and budgeting support to the Director, developed staffing and grant allocation plans, and led evaluations of renewable energy applications aggregating several hundred million dollars of grants. Mr. Dayton has also been the chairman or president of many public policy, health, cultural, and community organizations in Massachusetts, and has received several appointments by past governors to advisory boards and state councils. He has spoken and published widely on energy efficiency and was on the Energy Task Force of the President's Commission on Environmental Quality. He served two years as President of the National Association of Energy Service Companies and two years on the Executive Committee of the International Performance Measurement and Evaluation Protocol (IPMVP). Mr. Dayton is considered by many to be a leader in the evolution of the energy services industry. Mr. Dayton received a B.S.E.E. from Worcester Polytechnic Institute and an M.B.A. from the Kellogg School at Northwestern University.

John Clune is a Senior Technical Consultant at CESI. Mr. Clune has more than 20 years of experience in the development and implementation of strategies to address energy investment opportunities in multi-family housing. His experience includes oversight of energy studies, measure analysis for savings calculations, project cash flow development, construction management, utility program management, utility consumption and cost analysis, base year development, and monitoring and verification of

savings. Mr. Clune's technical audit clients include New Haven, Willimantic, and Danbury Housing Authorities, in his prior role at an energy services company. Mr. Clune formerly worked for Ameresco, Inc., and EUA Citizens Conservation Services, Inc. He also worked for the nonprofit Citizens Conservation Corporation for almost a decade. Early in his career, Mr. Clune weatherized homes, installed solar and fossil fuel heating equipment and helped to construct passive solar homes. Mr. Clune holds a BS in Business Management from Westfield State College.

[Climable.org](https://climable.org)

Climable, Inc. is a woman-run nonprofit that works to make the information behind climate science and clean energy understandable, accessible and actionable. Acting as technical translators, Climable takes robust reports and research and distills them into plain language so anyone can understand them. The information produced is available on a variety of platforms such as a blog, podcast, social media, YouTube videos, small bimonthly events, etc. The organization works towards energy democracy and environmental justice with their on-the-ground projects that started with the Resilient Urban Neighborhood (RUN) concept and have since branched out to a number of communities interested in pursuing clean, reliable energy with microgrids.

Jean Ann Ramey is the Executive Director of Climable.org where she directs and supports economic research projects regarding the human health and societal impacts of energy use and global climate change. She accomplishes this by focusing on how best to communicate climate science and clean tech issues to the general public so that the information is accessible and actionable. Recognizing the need for environmental justice awareness and advocacy, she helped formulate the Resilient Urban Neighborhood concept. RUN believes that clean energy should be available to all people regardless of socioeconomic condition and further believes that everyone should have a say in how they receive power. The RUN team is currently engaged in low-income community microgrids that leverage a grassroots driven approach; by partnering with local organizers, the microgrid is truly a community-led effort. RUN's technical expertise, combined with Climable's plain language forte, have led to a hybrid virtual microgrid model that ensures the most economical measures create maximum resilience in traditionally vulnerable neighborhoods. Jean Ann is also co-founder of Synapse Energy Economics, where she organizes the development and achievement of current and long-term organization goals, objectives, policies, and procedures; advises in facilities and business management functions; and she previously consulted on issues within the electric industry, with particular attention on public health and consumer education. Jean Ann has also worked as an economist in the Electric Power Division of the Massachusetts Department of Public Utilities and as an analyst at Tellus Institute. She holds an MA in Energy and Environmental Studies from Boston University, and a BA in English from the University of Oklahoma. She spent a summer studying climate change at the Rocky Mountain Biological Laboratory and has taken courses at the Harvard School of Public Health.

Jen Stevenson Zepeda is the Deputy Director at Climable.org. As such, she manages the day to day affairs of the organization while also planning future content and areas of focus. After receiving her Master's degree in Sustainable Design from the Boston Architectural College, she left her finance job to pursue work that explores energy and water efficiency as a way of counteracting climate change. Her thesis project researched low-impact development and green infrastructure solutions to stormwater

management as a response to flooding issues in Somerville, MA. She has a B.A. in Anthropology/Sociology and Spanish from Middlebury College.

Peregrine Energy Group, Inc.

Peregrine Energy Group, Inc. of Boston was founded by Paul Gromer in 1992. Its services now span energy data analysis and reporting, energy management and strategic consulting. Peregrine offers a long history of applying clean energy policy and planning expertise to projects for government, utilities, nonprofits and trade associations. They bring a thorough understanding of solar, storage, microgrid and other rapidly evolving distributed energy technologies, markets, business models, data sources and policies and the capability to provide analysis, data visualization and problem-solving services. Their approach to communicating complex energy information is to structure charts and reports to make key points clear and understandable for the intended audience.

Francis Cummings, Peregrine Vice President, is an energy economist who focuses on the analysis and facilitation of strategies to integrate low-carbon distributed energy resources into energy-using facilities, microgrids and utility networks. His particular skills include financial, market and regulatory analysis, energy program design and multi-stakeholder collaboration. Fran is also trained as a practitioner of USGBC's PEER program for sustainability and reliability of energy districts and campuses (Performance Excellence in Electricity Renewal). Before joining Peregrine in 2009, Mr. Cummings was Policy Director at the Renewable Energy Trust at the Massachusetts Technology Collaborative, where he collaborated with public and private sector stakeholders to overcome market and regulatory barriers to renewable energy and directed community-based pilot projects with Eversource/NSTAR (the Marshfield Energy Challenge) and National Grid (in Everett, MA) that tested the ability to reduce demand on the grid by integrating high market penetration of solar PV systems, energy efficiency, demand response, storage and other technologies. Previously, he was a Principal at KEMA Consulting, where he directed engagements in renewable energy and distributed generation. He has also worked for a renewable energy development company and a residential energy auditing startup.

John Snell, CEM at Peregrine Energy Group, heads Peregrine's multi-family housing practice and has more than 25 years of experience in multi-family energy efficiency initiatives. John also leads Peregrine's energy monitoring business, which has included extensive monitoring and data analysis within affordable housing units as well as municipal buildings. John has been with Peregrine since 1999. Prior to joining Peregrine, John worked for Citizens Energy Corporation, a not-for-profit energy services company, as a technical advisor and for Citizens Conservation Corporation as a project manager for federal and state-aided housing energy performance contracts. While at Citizens Conservation Corporation, John prepared physical needs assessments for affordable housing developments. Mr. Snell worked with Mr. Clune in that capacity.

Clean Water Fund (CWF)

Clean Water Fund's mission is to develop strong grassroots environmental leadership and to bring together diverse constituencies to work cooperatively for changes that improve lives, focused on health, consumer, environmental and community problems. Since 1974, CWF has helped people campaign successfully for cleaner and safer water, cleaner air, and protection from toxic pollution in our homes,

neighborhoods and workplaces. Organizations and coalitions formed and assisted by CWF have worked together to improve environmental conditions, prevent or clean up health-threatening pollution in hundreds of communities and to strengthen policies in Massachusetts and nationally. CWF's programs build on and complement those of Clean Water Action (CWA), a nearly one million member national organization which has helped develop, pass and defend strong laws that protect community and health while promoting a more sustainable paradigm shift. In Massachusetts, CWF has a long track record of success on a number of the defining policies of their movement including pollution reductions from the "Filthy Five" power plants, virtual elimination of mercury emissions, mandatory global warming pollution reductions, energy efficiency advances, initial steps to address methane leaks from gas infrastructure, and more. They are proud partners and help lead a number of highly effective coalitions such as MA Power Forward and the Green Justice Coalition. Their Massachusetts board includes experienced grassroots leaders from around the state; most also lead their own community-based groups. CWA membership in Massachusetts tops 50,000 households, providing them with a strong statewide base to mobilize in the most strategic districts in the Commonwealth. CWF's overarching goal is pollution prevention through smart transitions to innovative and environmentally benign alternatives. They are committed to growing community power through the expansion of grassroots leadership development and they embrace equity at all levels of how they conduct their campaigns.

Alex Papali, a Green Justice Organizer, has lived in the Boston area over 30 years, organizing locally since high school and building strong ties across the city's culturally and economically diverse communities. His areas of focus have ranged from prison issues to immigrant rights to tenant organizing—with the common goal of addressing structural causes of injustice and obstacles to sustainability. At Clean Water, Alex works towards 'energy democracy' with the Green Justice Campaign: fair access to the benefits of energy efficiency, and a robust green economy for all through the collective efforts of more than 40 community, labor and environmental groups statewide. He is assisting the development of a grassroots energy group in the Worcester area, with a focus on building clean distributed energy resources that serve linguistically diverse low-income communities. He also helps coordinate the Zero Waste Boston coalition, aiming to grow a world-class Zero Waste system in Boston that captures untapped economic potential and eliminates toxics and climate pollution by reimagining how we produce, consume and dispose of everything we use. Currently, he is participating in the RUN-GJC team's effort to jumpstart clean local energy in low-income communities of color through the two RUN-GJC clean power-based and democratically-run "community microgrids".

Climate Action Business Association (CABA)

CABA was founded in 2013 by Susan Labandibar, the then President and CEO of Tech Networks of Boston. After the devastation that followed Hurricane Sandy, Susan Labandibar realized that she needed someone to represent her business in the fight against climate change, which resulted in the founding of the Climate Action Liaison Coalition (CALC), which later became CABA. In 2014 the organization was incorporated as the Climate Action Business Association, Inc. with Quinton Zondervan as its volunteer, unpaid Executive Director. In the fall of 2015, Program Director Michael Green was promoted to Executive Director, and he has continued to oversee its growth and development. CABA is currently comprised of four full-time employees. Since its founding, CABA has continued to expand and grow to include businesses throughout Massachusetts representing many different industries, including custodial

services, moving, solar, information technology, and financial management. Using a metrics-driven sustainability program developed specifically for small businesses, CABA has helped member businesses achieve measurable energy reduction results.

CABA also works to strengthen local communities and promote small business leadership. Through building an empowered and engaged local business community, CABA is able to create opportunities for business leaders to support smart climate and energy policy in their communities. Their approach balances member education, public outreach, dialogue with officials, and publicity about successful business and community climate change initiatives.

Michael Green, CABA Executive Director, is a seasoned leader on climate and energy solutions. With experience working with government leaders, agencies, advocates and the private sector, he has been at the forefront of finding opportunity in the world's greatest challenge. Since 2012, he has served as a representative to the United Nations focusing on international climate science and policy. As an activist, he has played strategic roles in several of the largest national, as well as international campaigns dedicated to fighting climate change. He sits on the Board of Boston area nonprofits and serves as a policy advisor to national business associations on topics ranging from energy policy to climate adaptation. Michael is a Northeastern University graduate with degrees in international affairs and environmental studies, with coursework at the University of Edinburgh's MSc Program in Environmental Protection and Management and Harvard Business School's CORE Program.

Synapse Energy Economics, Inc.

Synapse Energy Economics is a research and consulting firm specializing in energy, economic, and environmental topics. Since its inception in 1996, Synapse has grown to become a leader in providing rigorous analysis of the electric power and natural gas sectors for public interest and governmental clients. Synapse's staff of 30+ includes experts in energy and environmental economics, resource planning, electricity dispatch and economic modeling, all-sector emissions modeling, energy efficiency, renewable energy, transmission and distribution, rate design and cost allocation, risk management, cost-benefit analysis, environmental compliance, and both regulated and competitive electricity and natural gas markets. Their senior-level staff members have decades of experience in the economics, regulation, and deregulation of the electricity and natural gas sectors, and have held positions as regulators, economists, and utility commission and ISO staff. Many Synapse clients seek out their experience and expertise to help them participate effectively in planning, regulatory, and litigated cases, and other forums for public involvement and decision making.

BlueHub Capital

DeWitt (Dick) Jones is Executive Vice President of BlueHub Capital, a CDFI that has invested over \$1 billion in low income communities. He also serves as president of its solar affiliate and has been a member of BlueHub's leadership team since it was established in 1985. Under his leadership, BlueHub Energy (formerly BCC Solar) has developed 6 megawatts of PV capacity serving low income communities, including 3 MW of shared solar facilities. Dick was a co-founder of WegoWise and has served on its board since it was established. Dick was a founder of the Opportunity Finance Network and served on its board from 1988-1996. Dick has developed innovative financing and business models for delivering

renewable energy and energy services to low income communities and institutions. Under his leadership, BCC Solar was recognized as a “Solar Champion of Change” by President Obama and the Clean Energy States Alliance. BlueHub Energy is currently working on a series of projects to integrate storage with its existing and new solar facilities. WegoWise is a national industry leader in providing utility benchmarking and building analytics for multi-family real estate and supports the largest database of multi-family utility data in the world. BlueHub Energy was initially established with a \$5 million grant from the Renewable Energy Trust’s Green Affordable Housing Initiative (from MCEC’s predecessor organization) in 2008. BlueHub Energy is a demonstration partner with BrightSpot Automation, which received an InnovateMass award from MCEC in 2016.

Prior to joining BlueHub, Dick was Executive Director of the Massachusetts Urban Reinvestment Advisory Group and served as a VISTA volunteer from 1980-1981. From 1991-1998, Dick was co-owner of Maria and Ricardo's Tortilla Factory. His board experience has included Boston Day and Evening Academy, a public charter high school serving over-age students, the Penikese Island School, a wilderness school for boys in trouble with the law, and the Center for Women and Enterprise. He is a graduate of Harvard College and the Kennedy School of Government. In 2008, Dick and his wife, Viki Bok, received the City of Boston’s Green Residential Award.

Cape Power Systems Consulting

An independent consultant specializing in transmission and distribution system planning with a focus on reliability assessments, transmission project development, interconnection analysis and distributed generation with over 42 years of experience working in the power system planning field for electric utilities in New England. Also serves as an expert witness testifying before state and federal regulatory commissions in support of siting review for new transmission projects, for review of reliability performance under rate case proceedings and review of system benefit assessments for programs such as smart grid deployment and system storm re-enforcement projects.

Formerly Director of System Planning at NSTAR (previously known as Boston Edison and Commonwealth Electric Companies) responsible for overseeing transmission and distribution system planning including development of such projects as the recently energized Boston 345 kV transmission project. Experience also includes providing technical support for a number of utilities in New England, working directly with ISO-New England and participation in the New England Power Pool. A registered professional engineer in the state of Massachusetts and a senior member of the IEEE.