Energy Research and Development Division

FINAL PROJECT REPORT

Berkeley Energy Assurance Transformation (BEAT)

Advancing Clean-Energy Microgrid Communities in an Urban Context

California Energy Commission

Gavin Newsom., Governor

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PREFACE

The California Energy Commission's Energy Research and Development Division supports energy research and development programs to spur innovation in energy efficiency, renewable energy and advanced clean generation, energy-related environmental protection, energy transmission, and distribution and transportation.

In 2012, the Electric Program Investment Charge (EPIC) was established by the California Public Utilities Commission to fund public investments in research to create and advance new energy solution, foster regional innovation and bring ideas from the lab to the marketplace. The California Energy Commission and the state's three largest investor-owned utilities – Pacific Gas and Electric Company, San Diego Gas & Electric Company, and Southern California Edison Company – were selected to administer the EPIC funds and advance novel technologies, tools, and strategies that provide benefits to their electric ratepayers.

The Energy Commission is committed to ensuring public participation in its research and development programs, which promote greater reliability, lower costs, and increased safety for the California electric ratepayer and which include the following goals:

- Providing societal benefits
- Reducing greenhouse gas emission in the electricity sector at the lowest possible cost
- Supporting California's loading order to meet energy needs first with energy efficiency and demand response, next with renewable energy (distributed generation and utility scale), and finally with a clean, conventional electricity supply
- Supporting low-emission vehicles and transportation
- Providing economic development
- Using ratepayer funds efficiently

The Berkeley Energy Assurance Transformation (BEAT) Final Project Report is the final report for the BEAT project (Contract Number EPC-15-065, Grant Number GFO-15-312) conducted by the City of Berkeley. The information from this project contributes to the Energy Research and Development Division's EPIC Program.

For more information about the Energy Research and Development Division, please visit the Energy Commission's website at www.energy.ca.gov/research/ or contact the Energy Commission at 916-327-1551.

ABSTRACT

Microgrids, when powered by on-site renewable energy, can sustain clean power for critical facilities even when grid power fails. Through a grant awarded by the California Energy Commission as part of its Electric Program Investment Charge program, the City of Berkeley explored how to design a clean energy microgrid community to serve key municipal buildings and to improve community resilience by maintaining essential city functions during a major power outage. This final project report summarizes the City of Berkeley's experience in designing a replicable, clean-energy microgrid community in a dense urban area.

Berkeley's proposed microgrid uses automated controls, on-site renewable energy, and battery storage to minimize reliance on conventional backup diesel power. To enhance the replicability of this project for other cities, this approach focuses on alternative financing to minimize upfront costs, evaluates ways to quantify the resiliency value, identifies regulatory pathways that other cities can follow, and includes a financially feasible, shovel-ready solar + storage design as a preliminary step for building a fully connected microgrid.

In a holistic approach to microgrid development, the project brings together policy makers, economists, engineers, and stakeholders to create a thoughtful and innovative community resilience solution. The team conducted a series of coordinated regulatory, financial, and technical feasibility analyses for designing a clean-energy microgrid community for key facilities in downtown Berkeley.

Local jurisdictions are focusing their attention on energy reliability, resilience, and urban sustainability, and this report addresses questions that many cities are trying to answer. The report explores the process, constraints, and key lessons learned in developing the City of Berkeley's microgrid design and identifies opportunities for future developments to advance the deployment of clean-energy microgrid communities.

Keywords: Microgrid, resilience, solar energy, battery storage, clean-energy microgrid community (CEMC), backup power, crossing the public right–of-way, public purpose microgrid, energy assurance, solar + storage, cities, municipal buildings, urban microgrid, critical facilities, multi-facility microgrid, grid stability, shared power, grid optimization, power outage, load aggregation

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EXECUTIVE SUMMARY

Introduction

Cities are at the forefront of sustainability and resilience movements. They are looking for multi-benefit solutions that enhance the safety and environmental quality of their communities. Clean energy microgrid communities can help cities meet the ambitious greenhouse gas (GHG) emissions reduction goals set by the State of California and their local governments, and enable the California electrical grid to operate more efficiently and reliably with more distributed energy resources, such as solar photovoltaic (PV). In addition, they can help cities become more resilient and serve to keep critical facilities functional when there is a short- or long-duration power outage.

Given the risk from natural hazards in Berkeley, which is located directly on top of the Hayward Fault, operating critical facilities during an earthquake is necessary to ensure continuing community services. Through a grant awarded by the California Energy Commission, as part of the Electric Program Investment Charge program, the Berkeley Energy Assurance Transformation (BEAT) project explored how to design a clean-energy microgrid community to serve key municipal buildings and to improve community resilience by maintaining essential city functions during a major outage.

This report reviews the approach to developing a shovel-ready design and implementation strategy that secures clean energy backup power for key city facilities in downtown Berkeley and other dense urban communities. The BEAT design provides options for a fully connected multi-facility microgrid as well as an alternative solar + storage project (referred to as Prototype 1 and Prototype 3, respectively). The report includes:

- A review of regulatory and operational considerations.
- A conceptual shovel-ready design of the technical components for a fully connected microgrid and an islandable solar + storage system.
- A phasing strategy and procurement plan for implementation.
- An operational strategy that includes governance and cybersecurity.
- Key lessons learned for other communities.
- Recommendations to advance using community microgrids in California.

As there are few existing viable or replicable multi-facility microgrid demonstration projects in dense urban settings, this report includes lessons learned that can be applied to other projects. One of the main objectives of this project is to make the knowledge gained and results accessible to the public and key decision makers to advance developing clean-energy microgrid communities.

Project Purpose

The BEAT project explores opportunities for cities to create innovative approaches for increasing the energy resilience of critical facilities while reducing greenhouse gas emissions.

To achieve this, the BEAT team analyzed the feasibility of creating a clean-energy microgrid community in Downtown Berkeley.

Microgrids come in many forms, and it is useful to set a common definition for the basis of discussion. As defined by the U.S. Department of Energy Microgrid Exchange Group, a "microgrid is 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." For this report, a *clean-energy microgrid community* is a microgrid that uses clean energy (such as photovoltaic [PV]) and battery storage to share energy across several buildings during normal operations, and which can "island" from the grid. The goal of a clean-energy microgrid community is to produce clean backup power to key facilities to provide critical services to the community in the event of a power outage.

For the BEAT project, a range of critical facilities were considered to include in a downtown Berkeley clean-energy microgrid community based on proximity, critical resilience functions, and potential for PV and storage capacity. These buildings were analyzed as part of three potential configurations, or prototypes: Prototype 1, a fully connected, multi-facility clean-energy microgrid community with only municipal buildings; Prototype 2, a fully connected, multi-facility clean-energy microgrid community that includes additional non-City-owned, community-serving facilities; and Prototype 3, an islandable solar + storage design for city-owned buildings. Each design provides resilience benefits to downtown Berkeley. The buildings considered in these prototypes include:

- The Center Street Garage (Prototype 1, 2, 3).
- The Public Safety Building (Prototype 1, 2, 3).
- The Civic Center (Prototype 1, 2, 3).
- The Civic Center Annex (Prototype 1, 2).
- Berkeley High School (Prototype 2).
- The downtown Berkeley YMCA (Prototype 2).
- The YMCA Teen Center (Prototype 2.)

In the case of a power outage on the electrical grid, the clean-energy microgrid community would prevent loss of power to key community buildings (such as the Public Safety Building) by relying on distributed energy resources and automated controls to supply backup power to critical electrical loads. This "islanding" of the microgrid would sustain critical operations that serve the community until grid power can be restored. During grid-connected mode (also referred to as *blue sky mode*), a primary goal of a clean-energy microgrid community is to approach community-scale zero-net energy. In dense urban areas, some buildings cannot produce enough on-site clean energy to achieve zero-net-energy status on their own, but by allowing multiple facilities to share distributed energy resources, buildings with excess on-site clean energy supply can share resources with other buildings that are resource-constrained. Such energy sharing contributes to the broader goal of community zero-net energy.

An alternative to a multi-facility clean-energy microgrid community is islandable solar + storage installed on a building-by-building basis. The project analyzed islandable solar + storage for critical facilities that have adequate space on site for solar generation and backup storage systems. Like a clean-energy microgrid community, a solar + storage solution would be able to isolate from the grid in the event of a power outage and provide clean backup power. Unlike a clean-energy microgrid community, an islandable solar + storage system would not physically connect buildings together; therefore, buildings would not be able to share power in normal or outage conditions. Despite this limitation, an islandable solar + storage system can act as a first step toward a clean-energy microgrid community as it incorporates upgrades at the facility level that could be interconnected with new distribution lines in the future.

Clean-energy microgrid communities and solar + storage projects can help cities advance community resilience by providing clean, reliable backup power in the event of a disaster, reducing GHG emissions and potentially reducing energy costs. Moreover, they can help with grid stabilization because the energy storage components smooth energy demand from facilities. The addition of more distributed energy resources is causing unpredictable power surges and demands on the grid. On-site energy storage batteries can reduce the demand on the grid during critical peak times and help optimize grid operations while still allowing the integration of additional clean energy resources to achieve the State's Renewables Portfolio Standard, GHG reduction, and storage targets.

Project Process

To determine the feasibility of creating a multi-facility clean-energy microgrid community or islandable solar + storage system in downtown Berkeley, the research team conducted a series of coordinated regulatory, technical, and financial feasibility analyses. The BEAT project team included a regulatory team consisting of URS, Association of Bay Area Governments, Center for Sustainable Energy and West Coast Code Consultants which analyzed the local, state and federal regulatory opportunities and barriers as well as the permitting pathways. The technical team led by URS, Lawrence Berkeley National Laboratory, Interface Engineering, and City of Berkeley Public Works staff completed the technical feasibility analyses, modeling of energy needs and generation capacity, and the engineering requirements for an urban microgrid. The Financial and Governance team included URS, Lawrence Berkeley National Laboratory, NHA Advisors, and Hatch Associates. They completed the financial calculations and business and ownership models.

The analyses from each of these teams informed specific decisions, such as site feasibility, optimal configurations (or prototypes), and potential financing strategies. The findings and lessons learned from the feasibility assessment processes were incorporated into three respective implementation plans and a consolidated pilot plan, which led to the shovel-ready Downtown Berkeley Master Community Design. Finally, findings relevant to other jurisdictions were compiled into a case study that presents outcomes, lessons learned, and recommendations for developing clean-energy microgrid communities in urban areas in California and beyond.

Project Results

Overall, the project proved that clean-energy microgrid communities are technologically feasible, but that some significant regulatory and financial barriers exist that can make them difficult to build. The BEAT project development also resulted in a set of conceptual designs and an implementation strategy for the clean-energy microgrid community and solar + storage prototypes that were identified as viable options for the project. In addition to conceptual designs, this report includes analyses of existing regulations, policies, and financial structures that either support the development of microgrids or present barriers to implementation.

The team modeled technical and financial performances of the clean-energy microgrid communities and islandable solar + storage designs to measure the associated potential impacts against the project goals. From a renewable energy perspective, the combination of energy efficiency, on-site solar generation, and smart building automation can reduce utility energy consumption by between 36 percent and 43 percent (across all prototypes). During an outage, this combination of technologies reduces the necessity for existing diesel generator use by up to 40 percent. From a financial perspective, the cost of installing, operating, and maintaining distribution infrastructure is the greatest cost to the system and prevents the clean-energy microgrid community from having a viable financial payback; however, the solar + storage option does have a positive financial return while providing similar resiliency benefits.

Most of the key findings and conclusions made throughout the BEAT project relate to existing regulatory policy, implementation challenges that stem from utility requirements, and the financial implications of these regulatory and utility considerations. Key findings, which are discussed in greater detail in the report and include the following:

- For a clean-energy microgrid community with buildings that are not directly adjacent to each other, the utility must own and operate all distribution lines that cross a public right-of-way, which results in the need to negotiate with the utility regarding tariffs and ownership/operation structures.
- The BEAT project cannot use existing utility distribution lines for an islandable microgrid, due to the number of other customers on the existing distribution lines causing technical and legal challenges for this approach, and would therefore need new distribution lines.
- New distribution lines come at a significant cost, due to the capital costs, installation costs, utility charges for the operation and maintenance of the distribution lines, and the transfer tax of deeding assets to the utility.
- Per the local utility's policy, the BEAT project cannot have a single meter to aggregate, or combine, and share power between buildings during normal grid operations.
- No rate structures or tariffs currently exist that benefit both microgrid users and utilities in blue sky and outage conditions, although the development of such structures is possible and should be an area of focus to advance clean-energy microgrid community development.

Knowledge Transfer

The team made presentations of this project at numerous events and conferences, including an "easy-to-read" case study that was shared with a many California jurisdictions and international audiences. This project has been showcased through the Rockefeller Foundation 100 Resilient Cities Network and the Urban Sustainability Network.

In addition to the presentations, media coverage, and publications listed in the Knowledge Transfer Report, the team most recently shared the BEAT project at the following events:

Conferences:

- VERGE 2018 Conference- https://www.greenbiz.com/events/verge-conference/oakland/2018; Marna Schwartz Presentation at Microgrid Summit on *Accelerating the Equitable Deployment of Microgrids at the Neighborhood Scale,* 10/17/18

Presentations/ MeetingsM

- **Community Microgrids: Building Sustainability and Resilience:** Marna Schwartz presented 5/10/2018
- **BEAT Project and Resilient Richmond**; Marna Schwartz presented 9/5/18
- **Energy Storage: The Bridget to a Clean Energy Future;** Global Climate Summit; Marna Schwartz attended 9/12/18
- **Advancing City Climate Actions Targeting the Built Environment**; Global Climate Summit; Marna Schwartz attended 9/13/18
- **Local Government Sustainable Energy Coalition**; *Disasters and Energy Resilience: Keeping the Lights on in Our Darkest Hour*; Marna Schwartz attended 10/25/18
- **Innogy Meeting**; Marna Schwartz presented 11/8/18
- **Greentech Media Meeting**: Marna Schwartz presented 1/10/19

Media:

- Microgrid Knowledge, *Watch out for These Roadblocks to California Microgrids*, Author Lisa Cohn; quotes Marna Schwartz and BEAT project 8/17/18
- Microgrid Knowledge, *What California's Microgrid Bill Means to the State and Everybody Else*, author Lisa Cohn; based on BEAT project; 9/7/18

Benefits to California

The BEAT project has the potential for broad impacts on municipalities in California aiming either to improve their community resilience to major disasters or to reduce the environmental impact of their energy systems, or both. Similarly, microgrid technologies can benefit ratepayers and the utilities that serve them by improving community resilience, energy reliability, environmental sustainability, and equity. These technologies can also help utilities and the California Independent System Operator stabilize the utility grid through peak demand reductions and ancillary services and, in addition, help the State to meet its ambitious renewable energy, energy storage, and GHG emissions targets. The BEAT team modeled the benefits of the fully-connected microgrid and the solar + storage option. From a renewable energy perspective, the combination of energy efficiency, on-site solar generation, and smart building automation was modeled to reduce utility energy consumption by about 40 percent across all prototypes. During an outage, this combination of technologies reduces the necessity for existing diesel generator use by up to 40 percent as well as the associated greenhouse gas emissions and particulates from the diesel generator.

The efforts that went into developing the findings of this report pave the way for other municipalities to advance microgrid solutions in their own communities. Other California cities can benefit from the lessons learned in developing the conceptual design and implementation strategy of the BEAT project. The BEAT project identified many of the current barriers in California that limit the rapid scaling of clean-energy microgrids for community resilience.

By identifying these barriers, proposing potential policy solutions, and accelerating conversations with key stakeholders, the BEAT project is helping other jurisdictions across California understand the current landscape of community-serving microgrids. The BEAT project created a case study to share with other communities that details many of the outstanding financial and policy barriers of community microgrid projects that limits their ability to be replicable and scalable. Identifying these barriers will also aid State regulators and policy makers in improving the conditions which resilience and clean energy can thrive. In addition, the BEAT project advanced conversations with the Pacific Gas and Electric (PG&E) on how to better support and create policies and equitable tariffs for the advancement of clean energy microgrid communities.

This Final Report provides communities interested in microgrids or solar + storage systems with the following guidelines:

- Criteria for building selection
- Analysis of technologies and infrastructure requirements
- Comprehensive financing options, including a triple-bottom line analysis to account for the cost of resilience and sustainability
- Regulatory parameters
- Permitting requirements
- Tariffs
- A procurement outline
- Operation and ownership analysis

Clean energy microgrid hold the promise of utilizing local renewable energy sources to provide clean back-up power and improve grid reliability. However, ratepayers will only be able to benefit from clean energy community microgrids if policymakers can address the current financial and regulatory barriers in California that limit the full deployment of microgrids.

CHAPTER 1: Making Clean Energy Microgrid Communities a Reality in California

Cities are at the forefront of sustainability and resilience movements. They are looking for multi-benefit solutions that enhance the environmental quality and safety of their communities. Clean energy microgrid communities (CEMCs) can help cities meet the ambitious State of California and local greenhouse gas (GHG) emissions reduction goals, and they enable the California grid to operate more efficiently with more distributed resources. In addition, they can help cities become more resilient and serve to keep critical facilities functional during a power outage.

A microgrid can aggregate, or combine, and share energy across several facilities during normal operations, and if power from the main utility grid was disrupted, the microgrid could “island” from the grid and continue to provide backup power to those facilities. For this report, a CEMC is a multi-facility microgrid that uses clean energy generation sources like solar and energy storage in addition to, or in replacement of, fossil-fuel generation sources like diesel. A CEMC decreases GHG emissions by using clean solar backup power rather than relying solely on traditional diesel generators. Furthermore, CEMCs can also be used to create a zero-net-energy (ZNE) community by connecting buildings that cannot produce enough clean energy on their own due to various constraints, such as limited roof space or shading, with buildings that can provide excess clean energy on a daily basis.

Alternatively, an islandable solar + storage system represents a simplified and more cost-effective alternative to achieving clean backup power and community resiliency benefits, but it does not have all the benefits of a fully connected CEMC. An islandable solar + storage system could be located at any building with adequate space for on-site photovoltaic (PV) generation and battery energy storage. It would allow a building to save the energy generated by the PV system into a battery energy storage system to integrate clean energy and energy pricing for everyday use, and it would enable continued operations for that building in isolation from the grid in the event of a power outage. An islandable solar + storage system is a stand-alone solution for a facility and does not enable buildings to connect to aggregate and share power in normal or outage conditions. However, multiple solar + storage systems can be built modularly to be the first step toward a CEMC by being fully connected when the right conditions arise.

Community-oriented CEMCs are at an early stage of development, and as such there is ambiguity related to the associated regulatory, technical, and financial feasibility. Greater development of new CEMC projects will advance technology as well as catalyze regulatory and market reforms to support CEMC feasibility. New projects can demonstrate the benefits of CEMCs as well as challenges that may limit their development. They can also showcase new technologies, operating and governance structures, ownership/partnership models, funding strategies, and other operational pathways for local governments to develop, finance, and operate CEMCs.

A major goal of the Berkeley Energy Assurance Transformation (BEAT) project is to identify and address the barriers to the development of a CEMC in Berkeley, as well as elsewhere in California and potentially beyond.

1.1. Berkeley Energy Assurance Transformation Project

At the core of the City of Berkeley's (city) CEMC is the city's Center Street Garage, envisioned as the anchor of the CEMC. The Center Street Garage is being rebuilt. Designed to be "microgrid ready," the garage will have a solar PV system with capacity of up to 318 kilowatts (kW) and up to 29 Level 2 dual-port electric vehicle (EV) charging stations.[1] In addition, extra capacity is being built into the garage electrical system to allow future integration with a microgrid, such as spare vaults, conduits, and transformer capacity.

As the garage itself has minimal energy load requirements, the related energy resources could be used to support the energy demand at other nearby buildings, both on an everyday basis as well as during power outages. Nearby buildings being considered for connection to the Center Street Garage as part of the Berkeley CEMC include the city's Civic Center, the Public Safety Building, which houses the city's emergency operations center and 911 call center, and the Civic Center Annex, which houses several city departments. Nonmunicipal buildings considered for inclusion in future iterations of the CEMC are the YMCA and Berkeley High School. These nonmunicipal buildings were considered promising candidates for inclusion due to the proximity of these facilities to the other city buildings, the ability of these facilities to support critical functions during a significant grid outage, an assessment of existing electricity infrastructure conditions in Downtown Berkeley, the presence of an existing PV system (in the case of Berkeley High School), and the capacity for future PV expansions.[2] Although an islandable solar + storage would not allow the sharing of power between buildings, it would still take advantage of the solar and new infrastructure at the Center Street Garage and other locations. See Figure 1 for an aerial view of these facilities.

1.2. Berkeley Energy Assurance Transformation Team

To develop a Downtown Berkeley Master Community Design for a shovel-ready CEMC, coordinated regulatory, technical, and financial feasibility analyses were completed, which then contributed to the development of the regulatory implementation roadmap, the technical design, and the financial model design. These analyses were developed by a project team composed of members from the City of Berkeley; URS Corporation; Lawrence Berkeley National Laboratory (LBNL); the Association of Bay Area Governments; the Center for Sustainable Energy; West Coast Code Consultants, Inc.; Interface Engineering; and NHA Advisors. The BEAT team

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1 On completion of the Center Street Garage rebuild, the garage will have a 118 kilowatt solar array installed and 20 EV ports. Based on future funding opportunities and demand for EV charging, additional solar capacity and EV ports may be installed.

2 At this time, no agreements have been made with the YMCA or Berkeley High School. These buildings are being included for the educational purposes of this study.

provides the depth of knowledge across disciplines that has been critical to developing a shovel-ready CEMC project from this analytical process.

The BEAT team also coordinated with the local utility, Pacific Gas and Electric Company (PG&E), throughout the development of this design.

Figure 1: Berkeley Energy Assurance Transformation Building Locations

Source: Google Earth, March 2017

1.3. Purpose

The BEAT project is intended to develop an innovative, scalable, and replicable model for advancing energy reliability, increasing energy efficiency, and improving access to clean energy for key facilities in a dense urban context—a model that other communities can learn from and leverage. The BEAT project seeks to develop a resilient energy assurance solution, such as a CEMC or an islandable solar + storage system, for key facilities in Downtown Berkeley to achieve this vision. The development of the Berkeley CEMC is also intended to highlight the constraints that limit development of multi-facility CEMCs in an urban setting and to advance engagement to address these identified limitations.

There are very few existing microgrid projects that serve multiple existing buildings in a dense urban setting due to the regulatory challenges of sharing power among noncontiguous buildings and the expenses related to developing new distribution infrastructure to physically connect buildings. Given these challenges, most existing microgrids are located on private campuses, are developed by a utility, are at the end of a utility distribution line or in remote areas, or are constructed as part of a new development. In contrast, the BEAT CEMC is designed to integrate greater energy resilience into the existing fabric of a dense urban city and showcases how a network of existing buildings and infrastructure can provide energy reliability and advance community resilience.

The goal of the BEAT microgrid is to provide power and share energy across several critical facilities during normal operations and provide clean backup power to those facilities in the event of a power outage. The BEAT CEMC project is considered a complex microgrid because it is located in a dense, urban downtown area; connects existing older buildings with limited energy generation capacities; and requires laying new distribution lines across several public street blocks to connect them together to share power and isolate the microgrid buildings from other customers along existing distribution lines. Each of the microgrid buildings is designed with interconnected smart technologies, including on-site renewable energy, battery energy storage, and demand response and automated load controls that manage the varying generation and storage capacities and energy needs of these microgrid-connected buildings.

These features of the BEAT project are of value to advancing other resilience-oriented community or municipal CEMCs. They provide insight into how to navigate critical issues, such as incorporating generation and storage resources into existing buildings, sharing energy resources between multiple properties across the public right-of-way (PROW), and negotiating service changes with the local utility. As such, development of the BEAT project provides technical, financial, and regulatory findings and process-related guidance that may be directly applied by other municipalities to support development of such projects within their own jurisdictions.

While the original focus of this project was to develop a CEMC, an islandable solar + storage system is also included as an alternative approach that would bring similar benefits to the community, with the exception of power aggregation across multiple facilities. Both systems are intended to be utility-integrated solutions that are scalable and replicable and that address issues that are essential to large-scale commercial deployment. An islandable solar + storage system can also be the first step toward a fully connected CEMC and is more cost-effective under current regulatory and operational conditions.

Both options provide economic, environmental, and resilience benefits during normal conditions as well as outage conditions on the main grid. Although the traditional model for backup generation in buildings is a diesel generator, the BEAT project strives to develop a cleaner, more resilient solution. Neither a CEMC nor an islandable solar + storage system would require any new diesel sources, and both would use less diesel fuel to provide backup power. The fuel saved as a result could be used for other critical services, such as fire trucks and pumps, in the event of a disaster.

1.4. Process and Key Findings

In Phase I of the BEAT project, the project team undertook regulatory, technical, and financial feasibility analyses, as well as a thorough implementation planning process with the purpose of producing a shovel-ready design for the BEAT project. This process identified challenges and addressed the uncertainties related to CEMC development in dense urban areas like Downtown Berkeley. This report consolidates findings from these analyses and presents outcomes and lessons learned from this process related to financing, building, and operating a clean energy microgrid in Downtown Berkeley. An overview of the analysis process undertaken for the BEAT project is presented in Chapter 2, and the key findings from the coordinated analyses in the context of Berkeley are summarized in Chapter 3.

The findings from the coordinated regulatory, technical, and financial analyses informed the BEAT project design to ensure the successful deployment and performance under current conditions. The BEAT project also investigated and designed an islandable solar + storage option, given the current challenges to designing a fully connected, multi-facility microgrid. An overview of the shovel-ready designs is presented in Chapter 4.

The analyses identified best practices for CEMC development as well as challenges that could constrain development. These lessons learned are relevant for other communities in California, and potentially beyond, that are looking to develop CEMCs, and they are presented in Chapter 5. In addition, the coordinated regulatory, technical, and financial analyses also highlighted the regulatory reforms or market advancements that could advance CEMC deployment; these recommendations are explored in more detail in Chapter 6.

This report also includes the following appendices, which provide additional information:

- Appendix A: BEAT CEMC Prototypes and Building Information
- Appendix B: Potential Business Models
- Appendix C: Comparison of Ownership/Operation Options for Distribution

CHAPTER 2:
Path to a Shovel-Ready Design

This section provides an overview of the process that the BEAT team took for getting to a shovel-ready design in the context of the Berkeley CEMC.

2.1. Feasibility Analyses and Implementation Planning

As part of Phase I of the Berkeley CEMC project, coordinated regulatory, technical, and financial feasibility analyses were conducted to determine if a CEMC was feasible in dense urban areas like Downtown Berkeley. Through these feasibility analyses, the BEAT team determined that multi-facility clean-energy microgrids are feasible and achievable under current regulatory, technological, and market conditions. Although some regulatory and financial constraints to development were identified, they do not preclude development. Thus, three shovel-ready designs are presented: Prototype 1, a fully connected, multi-facility CEMC with only municipal buildings; Prototype 2, a fully connected, multi-facility CEMC that includes additional non-City-owned, community-serving facilities; and Prototype 3, an islandable solar + storage design for city-owned buildings. Each of these designs provides resilience benefits to Downtown Berkeley.

Prototype 1 was the focus of the analysis for a fully connected CEMC. Prototype 2 could, in the future, build off the work of Prototype 1 by adding additional customers. Prototype 3, an islandable solar + storage option that omits multi-facility interconnection, was also analyzed as an alternative and potential precursor to a fully connected CEMC. Islandable solar + storage represents a simplified, lower-cost alternative to achieving clean backup power and community resiliency benefits but does not have all the benefits of a fully connected CEMC.

If funding is secured, Phase II of the BEAT project would include constructing the designed CEMC or solar + storage system.

2.1.1. Regulatory Analysis

The regulatory analysis consisted of a review of city, State and federal regulations that could influence CEMC configuration, operation, and profitability and ultimately the design and development of the BEAT project. An overview of the steps in the regulatory analysis is as follows:

1. *Review of local regulations*: This step consisted of consideration for local issues that may affect CEMC construction at the community and municipal jurisdiction level, including how other communities may address similar issues at the local level, such as:
    a. Analyzed city zoning and permitting restrictions for relevant buildings.
    b. Met with City of Berkeley Landmark Planning staff to research landmark status of civic buildings.
    c. Reviewed encroachment for microgrid asset siting and distribution lines.

d. Researched franchise rights and the most recent franchise rights agreement.

2. *Review of State regulations*: This step consisted of a review and summary of relevant current State regulations, including barriers to developing CEMCs under the existing regulatory framework, such as:

   a. Reviewing the State's building code, including relevant electrical code requirements.

   b. Completing a preliminary analysis of the relevancy of the California Environmental Quality Act (CEQA) for the BEAT project.

   c. Investigating the role of California Independent Systems Operator (California ISO) and California Public Utilities Commission (CPUC) regulations of noncampus-style microgrids that cross the PROW.

   d. Analyzed the effect of Electric Rule 21 interconnection requirements for electric generation systems to allow for islanding from the main grid.[3]

      i. Under Rule 21, a stand-alone PV system is not permitted to function during a power outage to protect the safety of line workers. Rule 21 does allow for backup generators like diesel generators or cogenerators to operate when the grid is down, as long as the safety concerns are met. For microgrid operation, once separated from the main grid, PV systems may be used when coupled with a controllable generation resource such as batteries or standby generators to maintain stable operation. The generators on the microgrid also must be coordinated with each other to enable effective microgrid operation.

3. *Review of Federal Regulations:* This step consisted of a review of the Federal Energy Regulatory Commission (FERC) jurisdictional parameters as they pertain to the CEMC.

4. *Review of Utility-Level Rules and Policies*: This step reviewed CPUC regulations that relate to electric utilities, with an emphasis on how they pertain to CEMCs and how they may be acting as barriers to broader advancement of CEMCs, such as:

   a. Exploring local utility requirements, polices, and priorities through a series of meetings with the local utility, PG&E.

   b. Reviewing existing tariff options and explored opportunities for developing new tariffs that may be more beneficial to multi-facility CEMCs.

   c. Considering ownership and operation options in coordination with the utility.

   d. Exploring opportunities of how to share power between microgrid buildings with a master meter or single meter arrangement.

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3 Pacific Gas and Electric Company. (2017). *Electric Rule No. 21 Generating Facility Interconnections.* https://www.pge.com/tariffs/tm2/pdf/ELEC_RULES_21.pdf.

2.1.2. Technical Analysis

The technical analysis informed key design elements of the BEAT project, including site feasibility, number and location of connected buildings, and optimal size of energy resources (like PV and energy storage). The technical analysis used two advanced energy modeling systems to simulate and optimize nine prototypes for the BEAT project. These prototypes included several configurations of fully connected microgrids and a solar + storage option. URS Corporation's Sustainable Systems Integration Model for District Energy (SSIMde) was used to perform an initial technical feasibility assessment of the nine potential site and building combination scenarios in Downtown Berkeley, based on factors that included building load, energy generation, and location. Next, using LBNL's Distributed Energy Resources Customer Adoption Model (DER-CAM) software, the technical team identified optimal site specifications, grid specifications, and distributed generation configurations for the prototypes. Finally, based on the results from these analyses, the BEAT team decided to move forward with three of the most promising prototype configurations for the final design options.

The steps in the technical analysis conducted for the Berkeley CEMC and solar + storage system are listed in order below:

1. *Building selection:* This step consisted of determining buildings that could be considered for the resilience-oriented CEMC. Buildings were selected based on the resilience and other community benefits they provide during blue sky and outage conditions, spatial proximity, and physical considerations such as seismic safety and available space for retrofits.
2. *Prototype identification*: This step consisted of defining the most relevant combinations of buildings to evaluate as microgrid prototypes. This step required coordination with the local utility, PG&E, to understand how existing infrastructure in Downtown Berkeley may influence prototype development. The physical proximity of potential participant buildings, the existing utility distribution lines and transformers, as well as the number of customers between each building were also considered as part of this step.
3. *Load modeling*: This step consisted of determining the energy demands and supply needs of the prototypes under various operational conditions, as well as any additional benefits that the project can provide. This phase involved:
    a. Determining demand profiles during normal operation for each facility.
    b. Determining critical demand and emergency demand profiles for each facility, following an approximate load-shedding strategy during typical outages and major events (e.g., earthquakes).
    c. Quantifying on-site energy generation sources (i.e., backup generators, PV, and battery capacity).
    d. Considering additional strategies such as energy efficiency retrofits, building automation systems, seismic retrofits, fiber laying at the same time as the

distribution lines, and leveraging of existing work or projects that could enhance project and building performance. The project team was mindful that projects that bring multiple benefits to the table and help build relationships within the community also support community resilience.

4. *Selection of prototypes for shovel-ready design*: This step consisted of identifying the most practical configurations for the prototypes and narrowed the prototypes from nine possible options to three: two fully connected microgrids and a solar + storage option. This phase involved:
    a. Defining the financial elements that affect operation and energy resource sizing, such as tariff structures, available incentives, and capital costs.
    b. Optimizing PV and battery storage capacity and microgrid operations strategy by considering demand profiles and tariff structures for each prototype, with the goal of minimizing reliance on nonrenewable energy supplies during microgrid islanding operations by maximizing the use of on-site renewable energy resources.

2.1.3. Financial Analysis

The financial analysis informed key project considerations, such as sources of project savings and returns, vehicles for project financing, project benefits, and ownership/operating structures. An overview of the steps in the financial analysis conducted for the BEAT project is as follows:

1. *Potential* sources *of project financing*: This step consisted of identifying all internal as well as external sources of project financing, such as:
    a. Determining the city's internal capacity to finance part of the project, including the ability to meet necessary match funding requirements.
    b. Identifying requirements for grant funding opportunities and incentives available for various CEMC and solar + storage components.
    c. Identifying opportunities for collaboration with other stakeholders, projects, or investors or a combination to participate in more innovative financing methods.
2. *Potential revenue sources*: This step consisted of identifying all possible revenue sources, such as lower energy bills, credits for excess generation and other available incentive programs (e.g., self-generation incentive program [SGIP] and peak demand pricing incentives).
3. *Potential project benefits*: This step consisted of identifying the environmental and social benefits, in addition to the financial benefits that are typically measured. These benefits, which included increased community resilience, reduced fuel use, and reduced GHG emissions, were monetized to support the value proposition of the project. This monetization showcased the fact that in cases when the financial returns of the project are not enough to support the project, the monetized benefits of

resilience, reduced fuel use, and reduced GHG emissions can help make a compelling case for project development.

4. *Potential business models*: This step involved identifying the range of potential interactions among the city, PG&E, and other potential project participants and weighing the differences between publicly, privately, or utility-owned microgrids.

CHAPTER 3:
Key Findings from the Clean Energy Microgrid Community Planning and Implementation Process

The key findings from the coordinated regulatory, technical, and financial analysis for the BEAT project are summarized in this chapter.

3.1. Objectives and Trade-Offs

The BEAT project is envisioned for primarily community resilience, with the ability to withstand grid outages lasting up to seven days to support operations at the Public Safety Building and other city buildings. As such, profitability was not the primary purpose of this community-serving investment. Community-resilience benefits, not cost-optimization and profitability, informed the development of the CEMC design, including decisions regarding the sizing of energy storage and the inclusion of inter-facility distribution lines for the fully connected CEMC. An islandable solar + storage system option was also included, as it represents a simplified and more cost-effective alternative to achieving clean backup power and community-resilience benefits; however, this option does not have all the benefits of a fully connected CEMC.

3.2. Partnerships

Partnerships play an important role in the successful development and implementation of CEMCs, and the BEAT team has been coordinating with key project partners from the early stages in project planning.

1. *City of Berkeley*: Local governments are responsible for serving the community even when power is disrupted and are well positioned to apply for grants that support CEMC and solar + storage system development and lead municipal infrastructure upgrades. They cannot, however, own and operate a microgrid that crosses the PROW unless they are already a municipal utility or choose to municipalize – that is, being under municipal ownership or supervision. The BEAT team explored the opportunity of municipalization for the City of Berkeley. However, municipalization was found to be complex and time-consuming and was deemed to have higher costs than benefits for a project of this scale; thus the city chose not to form a utility.
2. *Coordination with local utility*: The BEAT team contacted PG&E early in the planning process and maintained open communication to ensure that both parties were aligned in terms of objectives and potential mutual benefits from the community microgrid. The BEAT project design and financial feasibility depend on and respond to the utility's current infrastructure, policies, and cost structures. The following is an overview of the BEAT team's engagement:

a. PG&E provided valuable information on the existing electrical infrastructure of the proposed microgrid area, such as an overview of the existing electrical infrastructure, guidance on preferred infrastructure options, and high-level cost estimates.

b. The BEAT team explored different metering configurations that allow a CEMC to share energy resources across multiple facilities and owners, which could enhance financial performance for a multi-facility CEMC. A single meter (master meter) or virtual single meter tariff structures would allow for renewable energy resources and storage to offset coincident peak demand at multiple facilities, even if solar and storage were not co-located. Such tariff structures could be key to maximizing the potential energy savings of any CEMC. However, there is limited CPUC guidance related to this, and a more favorable metering arrangement may therefore be possible only at the utility's discretion. The BEAT team requested the utility to allow a single meter agreement for the microgrid facilities, but this request was denied. Due in part to this challenge of not being able to aggregate and share power between buildings, the BEAT team is considering Prototype 3, the islandable solar + storage system option, as a first step toward a CEMC.

c. PG&E would need to take on the long-term responsibility for maintaining and operating the inter-facility distribution lines. Unless a local government is a municipal utility, it cannot distribute power across the PROW. As the city has elected not to form a utility at this time, the BEAT team is engaging with PG&E as a potential owner/operator of the distribution infrastructure. The project would pay for the design and installation of the infrastructure and then deed those assets to the utility. There is also a one-time transfer tax, the Income Tax Component of Contributions (ITCC), associated with deeding the distribution assets to the utility.[4]

d. As discussed above, because PG&E would be the owner/operator of the distribution infrastructure for the Berkeley CEMC, the utility would be responsible for setting the rate structure for the operations and maintenance (O&M) costs of those distribution lines, whether or not those buildings were on a single meter. The current costs to operate and maintain new distribution lines are expensive and are at the utility's discretion to negotiate to make projects like CEMCs more affordable and financially feasible. The BEAT team requested the negotiation of these rates, but so far the utility has not agreed to negotiate these rates.

3. *Coordination with third-party microgrid customers*: The BEAT team has been engaging with potential third-party microgrid customers like the YMCA and Berkeley High School, as their inclusion has the potential to enhance CEMC benefits. However, the

4 When new infrastructure is installed and deeded over to a utility to own and operate, such as new distribution lines for a microgrid, the Income Tax Component of Contributions (ITCC) is a charge to cover the local utility's resulting estimated liability for Federal and State income tax. This charge is often passed through to the entity that deeds over those assets. For more information on the ITCC, see https://www.pge.com/tariffs/tm2/pdf/ELEC_PRELIM_J.pdf/.

limited guidance related to sharing microgrid-generated power during normal conditions and during power outages in a multi-owner microgrid scenario, as well as the complexities around contractual agreements, makes it more challenging to incorporate third-party customers at this time. If a solar + storage solution were pursued, it would be much easier to engage with and implement solar + storage at the facilities of many customers that serve critical needs. This could also set the stage for a fully connected, multi-customer CEMC in the future.

3.3. Regulatory Requirements

Although there are many local regulatory requirements to navigate for the construction of a CEMC, none were identified in Berkeley that would prevent the development of a CEMC. Federal regulations are also not a barrier to developing the Berkeley CEMC, as it will not transmit energy on or impact interstate transmission lines.

The main barriers to advancing CEMCs are from regulations at the state level under the CPUC and from any terms regarding the participation of investor-owned utilities (IOUs) in the CEMC.

1. *Connecting the CEMC to the macrogrid*: CPUC's Rule 21 allows for interconnection of the solar and storage resources to the macrogrid. CPUC Rules 2, 3, 15, and 16 allow microgrid projects to negotiate service levels, distribution line extensions, and service extensions in support of both blue sky and islanded operations.[5, 6, 7, 8]
2. *Connecting CEMC facilities across the PROW*: A multi-facility microgrid or CEMC that crosses the PROW must be owned and operated by either an IOU or a municipal utility, per California Public Utilities Code Section 218(b).[9]
3. *Utility terms for participating in a CEMC*: As stated above, for CEMCs that cross the PROW, a utility must own and operate the microgrid distribution lines when power is shared across buildings in blue sky conditions. Moreover, to some extent, enabling certain operational and financial terms that would advance CEMCs is at the utility's discretion. For example, utilities have the discretion to allow buildings on multiple meters to be aggregated into a single meter so these buildings can share power during normal operations. Utilities also have the discretion to develop distribution and O&M rate structures for the microgrid distribution infrastructure that are based on the actual costs of operating the microgrid. This would differ from the typically high costs associated with standard utility rate structures, such as those relating to the use of

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5 Pacific Gas and Electric Company. (1990). Electric Rule No. 2 Description of Service. https://www.pge.com/tariffs/tm2/pdf/ELEC_RULES_2.pdf/.

6 Pacific Gas and Electric Company. (2008). Electric Rule No. 3 Application for Service. https://www.pge.com/tariffs/tm2/pdf/ELEC_RULES_3.pdf/.

7 Pacific Gas and Electric Company. (2003). Electric Rule No. 15 Distribution Line Extensions. https://www.pge.com/tariffs/tm2/pdf/ELEC_RULES_15.pdf/.

8 Pacific Gas and Electric Company. (2003). Electric Rule No. 16 Service Extensions. https://www.pge.com/tariffs/tm2/pdf/ELEC_RULES_16.pdf/.

9 California Code, Public Utilities Code § 218.B. (2009).

standard tariffs (which include full transmission and distribution costs) and special facilities.

3.4. Tariff Structures

The following provides an overview of currently available tariffs, as well as future opportunities that may result in more favorable tariffs for the BEAT project and other CEMCs:

1. *Currently available tariffs*: The Berkeley CEMC would be interconnected with the regional grid within the PG&E service jurisdiction and would be eligible for the following tariffs:
    a. *Credit for excess generation*: Excess power generated from the PV system at the Center Street Garage would be eligible for PG&E-provided credits during blue sky conditions through the net energy metering (NEM) program.[10] However, there is no CPUC guidance to support a utility tariff for microgrid-generated power during a grid outage.
    b. *Credit sharing*: Excess power generated from the PV at the Center Street Garage may be virtually shared with other municipal buildings participating in the CEMC through the PG&E-provided Renewable Energy Self-Generation Bill Credit Transfer program (RES-BCT).[11] However, no utility-provided programs support credit sharing between multiple owners; thus, participation of the YMCA and Berkeley High School would not result in any changes in the credit-sharing potential of the Berkeley CEMC.
2. *Possible future tariff opportunities*: The BEAT team explored several future opportunities that may result in more favorable tariff options for a CEMC. An overview of the option that is being pursued with PG&E is presented here. For other possible future tariff opportunities, see Chapter 5.
3. *Single metering arrangement*: A single meter (master meter) or virtual single meter would address the limitations of existing tariffs, as it would allow for renewable energy and/or energy storage to offset coincident peak demand at multiple facilities, even if solar and storage are not co-located. This would result in greater potential energy savings for the Berkeley CEMC.
4. *Actual costs for distribution O&M*: The current costs charged by the local utility to operate and maintain new distribution lines are so expensive that they are one of the main barriers to building a CEMC in Downtown Berkeley. Agreements with the utility

10 *Net energy metering* (NEM) is a policy that allows consumers who generate their own electricity to use that electricity anytime, rather than when it is generated. This allows, for example, excess summertime solar generation to offset electricity costs in the winter. For more information on California NEM policies, see http://www.cpuc.ca.gov/General.aspx?id=3800.

11 The *Renewable Energy Self-Generation Bill Credit Transfer program* (RES-BCT) is a program for local governments or campuses that allows participants to transfer excess bill credits earned through on-site renewable energy self-generation to other eligible accounts within the organization. For more information see https://www.pge.com/en_US/for-our-business-partners/interconnection-renewables/export-power/distributed-generation-handbook/net-energy-metering/res-bct-program.page/.

for the microgrid customers to pay O&M costs that are based on actual costs rather than the full transmission and distribution costs or special facilities requirements would provide a fairer cost basis for the systems and reduce the financial burden of building and maintaining these systems. This is especially true for microgrid projects like BEAT, which would build new distribution lines.

5. *East Bay Community Energy:* Alameda County, the county in which Berkeley resides, plans to join a community choice energy (CCE) program called East Bay Community Energy (EBCE) in 2018.[12] Any EBCE customers of the CEMC or solar + storage system would need to negotiate generation tariffs with EBCE. Transmission and distribution rates, however, would continue to be determined by PG&E.

3.5. BEAT Governance and Operational Structure

The BEAT team explored several governance and operational structure options and determined that an optimal organizational structure would include public, private, as well as utility participation. Utility participation in particular is critical to the success of the CEMC as inter-facility distribution assets may be operated only by a utility during blue sky conditions. Participation of the utility is expected to be limited to the distribution assets. The development and operation of generation assets, such as solar and storage, are best served with joint city and private control. Partnership with a private energy developer/operator would allow the system to operate efficiently and would be expected to create additional private financing opportunities, including access to financing mechanisms that are unavailable to municipal entities, such as the federal Business Energy Investment Tax Credit (ITC).

3.6. Considerations for CEMC Design

Considerations for CEMC or solar + storage designs vary by component.

1. *Solar*: Solar generation assets have been observed to have strong financial performance. As such, the BEAT approach to PV sizing for all prototypes is to maximize PV at the Center Street Garage, as well consider additional solar at other participating facilities.
2. *Storage*: Sizing of energy storage based on cost-optimization resulted in a smaller battery than would be able to withstand a multiday outage. As such, for maximizing resilience benefits, battery storage sizing for the BEAT project (all prototypes) was guided by duration targets to maintain operations for a seven-day outage scenario.
3. *Distribution:* In current conditions, while inter-facility distribution lines do not provide any direct financial returns to the Berkeley CEMC, they do provide resilience benefits, such as easing transfer of energy to critical uses during grid outage events. However, they are a substantially more expensive investment than storage and solar alone, and the decision to develop the inter-facility distribution lines will depend on the ability to finance them (through external fund-raising). As such, the BEAT team also explored the

12 For more information on East Bay Community Energy, see https://ebce.org/.

design option of an islandable solar + storage system (Prototype 3), which excluded the inter-facility lines from the design. While this design alternative results in substantial capital cost reductions, it also reduces resilience benefits during a grid outage or emergency event, as the buildings cannot share power, and not all buildings are good candidates for PV and battery storage.

3.7. Business Model Planning

The BEAT Team evaluated the financial potential for the project by component, as there are large differences in capital cost requirements, sources of external funding, and revenue generation potential due to the current market and regulatory conditions for solar + storage versus constructing new inter-facility distribution lines for a fully connected microgrid.

1. *Islandable solar + storage*: Solar + storage on its own has a positive return on investment, indicating that the revenues generated internally exceed the capital costs associated with these components of the CEMC. These system components may be financed using a combination of private and public funds, including internal financing from the City of Berkeley and the private developer/operator. Some project components may be eligible for utility incentive programs, such as the SGIP,[13] which may be adequate to finance the capital requirement for storage in its entirety. As the ITC[14] is available for use only for private entities and for renewable energy technologies, only the generation and storage assets financed by the private energy developer/operator could use the ITC.
2. *Distribution*: Existing regulations restrict a nonutility entity's ability to own and operate inter-facility distribution infrastructure, and as such, the distribution assets may be owned only by a utility entity. Given that the City of Berkeley is not a municipal utility, the city would need to pay for the distribution infrastructure and then deed the infrastructure over to PG&E. There is also a one-time transfer tax (referred to as the ITCC) associated with deeding this infrastructure to the utility. The ability of the assets to generate additional revenue for the Berkeley CEMC in blue sky conditions would be limited under this ownership/operation structure and current regulations, and as such, financing would be limited to public sources. Public funding sources may include municipal bonds or clean renewable energy bond funding and State or Federal grants.
3. *Total project:* Overall, under the current, fully connected, multi-facility CEMC design, which includes construction of the inter-facility distribution lines, the project has a negative return on investment, indicating that revenues generated internally are insufficient to cover the full capital cost of the CEMC. This is to be expected, given that the bulk of project capital costs are dedicated to the distribution infrastructure, which

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13 The Self-Generation Incentive Program (SGIP) is a program that provides incentives to support existing, new, and emerging distributed energy resources, including energy storage systems installed on the customers' side of the utility meter. See Chapter 6 for more details.

14 The Federal Business Energy Investment Tax Credit (ITC) is a tax credit that may be applied to renewable energy projects including solar projects. The credit for PV is equivalent to 30 percent of expenditures, with a gradual step down of credits between 2019 and 2022 to 10 percent. See Chapter 6 for more details.

provides a nominal share of project revenues. The high costs charged by the utility to operate and maintain the system further exacerbate the expense of the new distribution lines. External funding sources (such as grants or forgivable or low-interest loans) would be necessary to limit the city's financial outlay for the full capital cost of the project. Given the costs to develop a CEMC, an islandable solar + storage system is also included as an alternative approach that would bring similar benefits to the community, with the exception of power aggregation across multiple facilities. The solar + storage project would have a positive return on investment, even without external funding sources.

3.8. Alternative Measures of Performance

The Berkeley CEMC is intended to be a community-serving resilience investment, and as such profitability was not the primary purpose. Inclusion of inter-facility distribution lines and sizing of the battery storage for the worst-case outage condition (up to a seven-day outage caused by a major disaster) result in higher capital costs than would be recovered solely from project-generated revenues in current regulatory and market conditions. From a purely financial perspective, the CEMC (Prototype 1) results in a negative return on investment unless outside funding sources, such as grants, are applied. (Prototype 2 was not included in the detailed financial analysis, but the conclusions would be similar.) Instead, alternative measures of performance, such as sustainable return on investment (SROI) or triple bottom line (TBL) analyses, which include a wider range of community benefits in the measurement of project performance, may be used to represent more effectively the value proposition of such projects to stakeholders and potential project financiers. The inclusion of monetized resilience and environmental benefits in the SROI analysis resulted in a positive return on investment for the BEAT project with the same design that resulted in a negative return on investment through the traditional financial analysis. This has made a case for the inclusion of distribution lines in the BEAT CEMC design, as well as designing an alternative islandable solar + storage system (Prototype 3) that would not need new distribution lines.

CHAPTER 4:
Shovel-Ready Design

The Pilot Plan presents a concise review of the conceptual design components and implementation strategy of the Downtown Berkeley Master Community Design for a shovel-ready pilot of the BEAT project. The Pilot Plan jointly considers the constraints, requirements, and opportunities that were assessed in the series of coordinated regulatory, technical, and financial feasibility analyses. The findings in this report are a consolidation of the findings presented in the Regulatory Implementation Roadmap, Technical Design, and Financial Design.

4.1. Prototypes Selected for Shovel-Ready Design

Three prototypes were selected for development into shovel-ready project designs as a result of assessing a series of nine potential Berkeley prototypes across regulatory, technical, and financial parameters as part of the feasibility assessment process. The BEAT team modeled nine prototypes ranging from an islandable solar + storage solution that included only the Center Street Garage to a fully connected CEMC that included four city buildings, as well as additional non-city buildings. Three prototypes (referred to hereafter as Prototype 1, Prototype 2, and Prototype 3) were selected for development into shovel-ready project designs. These prototypes were selected as a result of input from the BEAT Technical Advisory Committee (TAC) and key stakeholders, and their selection was based on a goal of achieving the most resilience benefits as possible from the BEAT project.

Prototype 1 consists of four city-owned buildings that could provide critical services to the public in the event of an emergency. Prototype 1 buildings are the Center Street Garage, the Civic Center, the Civic Center Annex, and the Public Safety Building. Under the current design for Prototype 1, solar generation would be at the Center Street Garage, and storage would be at the Civic Center. However, because battery storage technology is constantly evolving, the location of the batteries may change.

Prototype 2 is an expansion of Prototype 1 that includes three additional community-serving facilities not owned by the city: the YMCA, the YMCA Teen Center, and Berkeley High School. The buildings in Prototype 2 add additional PV generation capacity and can serve as community shelter sites in an emergency, thereby further increasing resilience benefits. In addition, Prototype 2 is an exciting opportunity to analyze a complex ownership and tariff model.

Prototype 3 consists of islandable solar + storage systems at the Center Street Garage, Civic Center, and the Public Safety Building. Prototype 3 is a more cost-effective solution because it does not require construction of new distribution lines. In this solar + storage alternative, the Center Street Garage and the Public Safety Building would both house PV and battery storage on site to help with backup power in case of an outage and with leveling of peak pricing in daily operations. The Civic Center would include a small new rooftop PV system to reduce utility and existing backup generator demand but would not include batteries due to the low PV capacity.

The solar + storage option does not include the Civic Center Annex, as there is not sufficient room for solar or storage at the site. This option does have an opportunity to expand solar + storage to other facilities, even those with other owners (e.g., Berkeley High School and the YMCA) in the future.

The three prototypes were chosen because they maximize the number of facilities that could be included under each ownership scenario and offer flexibility for adding facilities under each ownership model when additional generation and storage can be developed. They also offer the flexibility of capitalizing on the number of facilities where services could be delivered during an emergency, and they range in costs and complexity.

The selection was also driven by the scope and goals of the Berkeley CEMC. The design approach is intended to be modular and, thus, scalable. The selected prototypes may be scaled up in the future in response to factors such as more favorable regulatory or market conditions. For example, Prototype 3 may be scaled up to include distribution lines, as are modeled in Prototype 1, and Prototype 1 may be scaled up to include additional buildings and owners in Downtown Berkeley, as are modeled in Prototype 2.

4.2. Technical Design

The Technical Design builds on the series of coordinated regulatory, technical, and financial feasibility analyses conducted to determine the feasibility of the Berkeley CEMC. This series of documents analyzed nine prototypes that considered different combinations of city- and non-City-owned facilities for inclusion in the final design. The Technical Design and the correlated Financial Model and Implementation Roadmap narrowed these alternatives to three prototypes—Prototypes 1, 2 and 3—that were selected for the maximum resiliency benefit and the maximum benefit to the industry as a study of urban, community-oriented microgrids. Prototype 1, consisting of four municipally owned facilities interconnected with the microgrid distribution infrastructure, can be considered the core Berkeley CEMC. Prototype 2, which adds three nonmunicipal facilities to the four municipal ones, can be considered an expansion of Prototype 1. Emphasis in the design was made in developing Prototype 1 in as much detail as possible because it establishes the backbone infrastructure for future expansion into Prototype 2 and is more feasible to implement under current conditions. Prototype 2 introduces multiple owners and other factors to the project, adding greater complexity that will need to be resolved in future stages. The design is configured to accommodate future expansion as much as possible by being modular and scalable, allowing expansion to Prototype 2 and potentially beyond.

Challenges include the high cost of new distribution infrastructure and the ownership and operation relationship with the utility. To address this, Prototype 3 would face fewer regulatory and financial barriers and is more likely to remain feasible under current conditions. While simpler, this design alternative is not intended to replace Prototype 1, but rather to provide a potential first step in the longer-term process of developing a larger microgrid as regulatory and financial barriers are resolved. Although Prototype 3 is not a true, physically interconnected microgrid, it still provides the Berkeley community with resilience benefits, as it provides clean, reliable backup power, reduces GHG emissions, offsets reliance on diesel generation, advances local renewable energy, and reduces energy costs. The new renewable resources and storage can be installed to improve the energy resilience of the facilities individually, and then the new facilities can be interconnected with microgrid distribution infrastructure later.

This section presents the conceptual design for Prototype 1 and Prototype 3. Due to the lack of available data on the nonmunicipal buildings at the time of the design development, a full design was not developed for Prototype 2. Potential future evolutions of Prototype 3 could include a full microgrid, such as described in Prototypes 1 and 2, or possibly further expansion to additional nearby facilities or both.

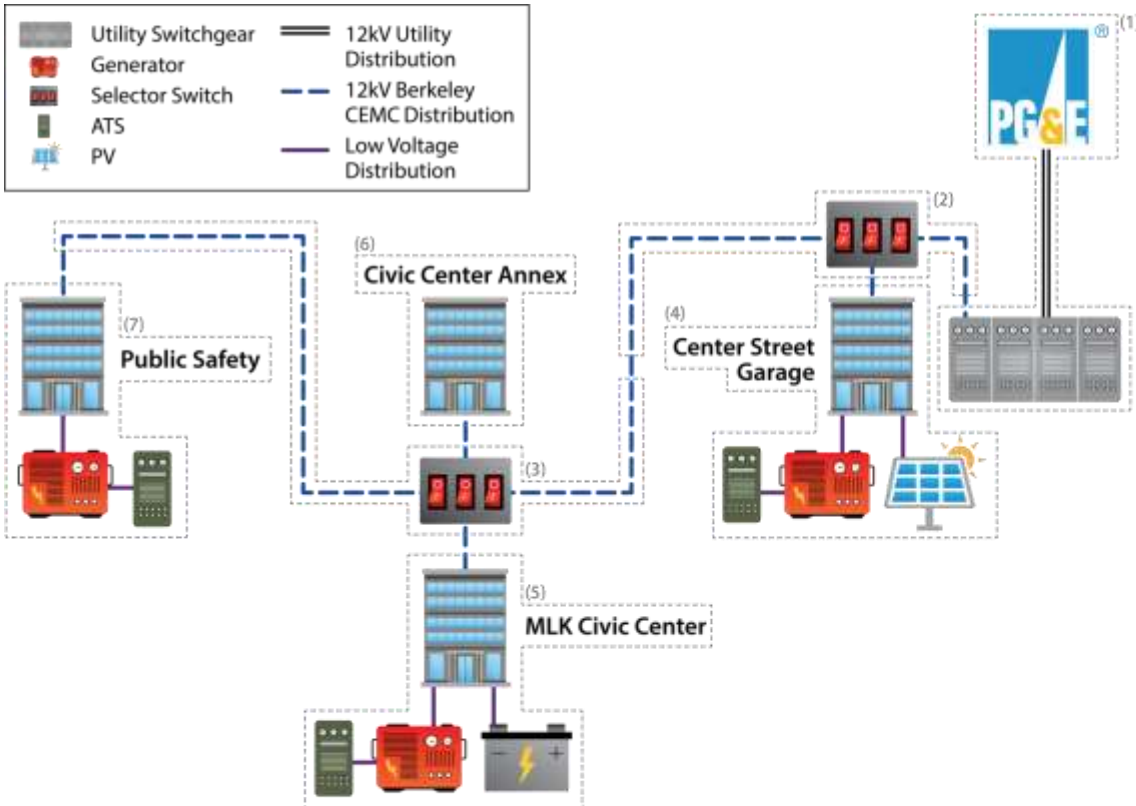
4.2.1. Conceptual Single-Line Drawing

As part of the design process, single-line drawings (SLD) were created for Prototypes 1 and 3 of the BEAT project. The designs for Prototypes 1 and 3, however, could be expanded to Prototype 2 in the future.

For Prototype 1, the SLD describes the configuration of the Berkeley CEMC, including how the facilities are interconnected, the distribution equipment requiring installation, and key aspects of the design, such as voltage and capacity. Prototype 3 does not include inter-facility distribution lines, but the SLD provides a schematic of the site-level retrofits proposed for the Public Safety Building and the Civic Center, including new PV arrays, battery storage, and modifications to the existing generators and electrical switchboards. To protect the safety of the buildings included in the designs, these design documents are not included in this report, but the general configuration and explanation of how the system would work are described in the rest of this subsection. See Figure 2 for a conceptual schematic of the Berkeley CEMC (Prototype 1) and refer to the list below the figure for a description of each component.

The Berkeley CEMC is being designed to PG&E standards and will be reviewed by the utility throughout the development of the 100 percent design. The current conceptual design accounts for all major PG&E current requirements, but given that changes to the design may be made after the publication of this report, continued collaboration with PG&E on technical requirements is needed.

Figure 2: Berkeley CEMC Conceptual Schematic (Prototype 1)



1. The utility grid meets the CEMC at a single point of connection at the Center Street Garage. A 12 kilovolt (kV) PG&E feeder, or distribution line, will feed into the utility switchgear. The output of the switchgear is the starting point of the Berkeley CEMC.
2. A 12 kV line will feed back out to an underground vault located in the PROW outside the garage. This vault will contain a four-way selector switch (SS-1) that includes connection to the utility switchgear, connection to the Center Street Garage transformer, connection to the rest of the Berkeley CEMC (via the second selector switch), and one spare connection for future expansion.
3. SS-1 connects to the second switchgear (SS-2), a six-way switchgear located in an underground vault in the PROW outside the Civic Center. SS-2 includes one connection to SS-1; one connection to the transformer that serves the Civic Center, the battery storage outside the Civic Center,[15] and part of the Civic Center Annex; one connection to the transformer that serves the remainder of the Civic Center Annex; one connection to the Public Safety Building transformer (this connection may also be used

15 Battery storage for the CEMC was originally intended to be located inside the Center Street Garage, but due to the height and weight constraints of current battery storage technology, the BEAT team does not have a solution for batteries that will fit inside the garage. As this technology is changing, there will likely be a battery storage solution that can indeed fit inside the garage in the future. If that occurs, the technical design and potential regulatory requirements would change.

for the Prototype 2 expansion to the YMCA Teen Center); one spare connection for the Prototype 2 expansion to connect to the YMCA and Berkeley High School; and one spare connection for future expansion beyond Prototype 2.

4. The existing Center Street Garage transformer, which is connected to the Berkeley CEMC at SS-1, serves the 208/120 volt (V) loads at the Center Street Garage. This includes all loads within the garage during blue sky and critical operations, the existing and proposed EV charging stations, the existing and proposed PV installation, and the existing diesel generator.

5. The proposed Civic Center transformer, connected to the Berkeley CEMC at SS-2, serves the 480/277V loads at the Civic Center. This includes all loads within the Civic Center during blue sky and critical operations, the existing diesel generator, and the proposed battery storage installation (proposed to be located outside the Civic Center). This transformer is also proposed to serve the portion of the Civic Center Annex that is also operated at 480/277V.

6. The proposed Civic Center Annex transformer, which is connected to the Berkeley CEMC at SS-2, serves the remainder of the Civic Center Annex loads, which are operated at 208/120V.

7. The existing Public Safety Building transformer, which is connected to the Berkeley CEMC at SS-2, serves the 480/277V loads, including all blue sky and critical loads, at the Public Safety Building and the existing diesel generator.

4.2.1.1. Facility-Level Retrofits

At the facility level, retrofits will be needed to make each building fully connectable with the Berkeley CEMC or islandable solar + storage system. This particularly involves the building automation system (BAS), existing generator, and main switchboard (MSB) of each facility.

The BAS allows for centralized and automated control over particular loads in a building, meaning each facility can shed all noncritical loads in an outage without having to redesign the internal circuitry of a building. Each BAS installed at city facilities will be configured for seamless communication with the microgrid controller, which will allow for simplified energy management during blue sky conditions and automated controls during an outage.

Each existing diesel generators will need to be upgraded with a new automatic transfer switch (ATS). This upgrade will allow the microgrid controller to signal each generator to feed back to the MSB for the respective facility, charge the transformer, and supply power to the microgrid. While this design uses existing diesel generators to support the system, no new diesel generators are included as the design is intended to minimize the amount of diesel used. A key project assumption is that each generator can accommodate such retrofits, which will need to be verified through the 100 percent design process.

Finally, the MSB of each facility will need to be evaluated to determine if it can be back fed by sources of power (e.g., on-site PV). If not, retrofits will be specified.

4.2.1.2. Single-Line Diagram for Prototype 3

The SLD for Prototype 3 includes the facility-level retrofits required at the Public Safety Building and the Civic Center.

Retrofits proposed for the Public Safety Building include:

- Installing rooftop and parking lot canopy PV.
- Installing battery storage.
- Installing and configuring BAS.
- Installing new ATS at the existing generator (to power remaining facility loads).
- Replacing MSB to accommodate new loads from PV and battery storage.

Retrofits proposed for the Civic Center include:

- Installing rooftop PV.
- Installing and configure BAS.
- Installing ATS at the existing generator.

Prototype 3 does not include battery storage at the Civic Center due to the low PV capacity.

To protect the safety of the facilities included in the designs, the SLD is not included in this report.

4.2.2. Conceptual Single-Line Drawing (Communications and Controls)

The trenches being designed for the CEMC medium-voltage distribution infrastructure will also house designated fiber optic cables for the microgrid communication and controls system. The system is described in the communication and controls SLD. This design places emphasis on decentralized microgrid controls. A decentralized system ensures greater redundancy and resiliency because if any point in the control system fails, the rest of the system can still function.

The primary microgrid controller will be the primary point of interconnection for all distributed controllers throughout the system and will also be the location of the Human Machine Interface (HMI), which is the cyber-secure digital interface that the city can use to modify operational parameters of the microgrid. A secondary microgrid controller and secondary HMI ensure full functionality for the system if the primary system fails.

A localized controller will be installed at each node in the microgrid. This includes the MSB at each facility, all backup generators, all PV systems, the battery storage, the selector switches, and the utility switchgear. These local controllers will be able to operate independently of the primary and secondary microgrid controllers, ensuring that if all components fail (including failure in the distribution trenches), individual facilities will still function at optimal efficiency.

4.2.2.1. Communication and Controls Diagram for Prototype 3

No new communication equipment or infrastructure is needed for Prototype 3 as each building will operate separately. At the facility level, each building will have a BAS to optimize energy performance and manage the transition to stand-alone facility islanding mode during an outage. The only difference from the Prototype 1 design is that, without distribution infrastructure for Prototype 3, there will be no centralized microgrid controller and each facility will be managed individually.

4.2.3. Conceptual Site Plan

The Technical Design included the development of conceptual drawings of the civil site plan. Site plans were developed for Prototype 1 and 3, and can be expanded to include Prototype 2.

4.2.3.1. Site Plan for Prototype 1

To create a fully connected microgrid (i.e., Prototype 1) it was determined early in the BEAT project that new trenching and electrical distribution infrastructure is needed for the Berkeley CEMC to operate as a true microgrid with islanding capabilities. It was determined that the microgrid could not use the existing distribution lines because there are too many customers on the line that would connect the buildings. According to PG&E, without new, separate distribution lines, non-microgrid customers would have to be switched off individually during a power outage for the microgrid to run in islanded-mode. This would require a contractual agreement with each .PG&E also informed the BEAT team that spare utility-owned conduits cannot be used for this project, as the utility does not develop spare capacity for customers to lease.

The installation of new distribution infrastructure for Prototype 1 includes digging a new joint trench to connect facilities with new conduits for electrical distribution and fiber optics for communication and smart control of the microgrid components, including buildings and switchgear. Conceptual drawings of the civil site plan were developed for this project, but are not included in this report to protect the safety of the proposed microgrid facilities. These drawings include routing for trenches, preliminary underground vault locations for selector switches and proposed transformers, and potential locations for the proposed battery storage at the Civic Center. In routing the trenches and siting the vaults, utility lines and other infrastructure in the PROW were noted where available. A detailed site survey will be completed in phase 2 of the Berkeley CEMC as part of the development of the 100 percent construction documents.

Medium-voltage distribution (12kV) will occupy 4-inch conduits inside 5-foot trenches; low-voltage distribution (120/208V or 277/480V) will occupy 4-inch conduits inside 4-foot trenches; and fiber optic communication lines will occupy 4-inch conduits with four 1-inch inner ducts in both trenches.

At the Center Street Garage, an additional 150 kilowatt (kW) PV canopy would be installed, bringing the total PV site capacity to 318 kW.

Because space is constrained in the existing electrical rooms, some items may need to be installed externally with physical security measures added and conduits routing to the electrical rooms. For external equipment installations, additional zoning and permitting requirements may apply.

4.2.3.2. Site Plan for Prototype 3

Prototype 3 excludes the distribution infrastructure between facilities, but adds new PV and battery storage installations that will require site work at the facility level. Site work will likely include: rooftop PV installations at the Public Safety Building and Civic Center with associated conduits, inverters and panel board installations; a canopy PV installation over the Public Safety Building parking lot; battery storage at the Public Safety Building; a new ATS for the Public Safety Building's existing generator; and MSB modifications or replacement to enable two-way power flow. These improvements may also apply to Prototype 1, as Prototype 3 can be a precursor to Prototype 1 with maximum site-level energy resilience gains made at all facilities before they are connected. Space is constrained in the existing electrical rooms, so some items may need to be installed externally, with physical security measures added and conduits routed to the electrical rooms. For external equipment installations, additional zoning and permitting requirements may apply.

At the Center Street Garage, modifications would be limited to the 150 kW PV canopy installation, bringing the total PV site capacity to 318 kW. No changes would be made at the Civic Center Annex because there is no space available on the roof for a PV installation.

Prototype 3 has the potential to expand to include solar + storage options at Berkeley High School, the YMCA, the YMCA Teen Center, and other buildings that could serve critical functions in the event of a disaster. Although these buildings are not discussed in the sections that follow, they could be included in a future design.

4.2.4. Loads and List of Major Equipment

The design of the distribution equipment was built up from the measured and expected loads at each facility. Peak demands were taken from annual utility interval data and were validated via an on-site data logger survey.

Table 1 summarizes the demand and supply values for each facility in Prototype 1, including peak and critical loads, and peak generation capacity. Table 2 summarizes the technical requirements of the major equipment needed for the Prototype 1 design for the Berkeley CEMC. The Berkeley CEMC is being designed to PG&E standards and will be reviewed by the utility throughout the development of the 100 percent design. The conceptual design accounts for all major PG&E requirements, but given that design changes may be made after the publication of this report, continued collaboration with PG&E is needed.

4.2.4.1. Prototype 3 Loads and List of Major Equipment

Table 3 summarizes the demand and supply values for each facility in Prototype 3, including peak and critical loads, and peak generation capacity.

Table 1: Peak Demand and Peak Generation Capacity, by Transformer

Transformer	Transformer Size (kVa)	Blue Sky Demand (kW)	Critical Demand (kW)	Generator Capacity (kW)	Battery Storage Capacity (kW)	PV Capacity (kW)
Center Street Garage	750	142	11	100	-	318
Civic Center	750	132	132	200	500	-
Civic Center Annex Transformer 1 (480/277V; tied to Civic Center)	—	158	51	—	—	—
Civic Center Annex Transformer 2 (208/120V)	300	106	106	—	—	—
Public Safety Building	750	190	142	450	—	—
Total Load	-	728	442	750	500	318
Acronyms and Abbreviations: kVa = kilo-volt-ampere(s); kW = kilowatt(s); PV = photovoltaic; V = volt(s)						

Table 2: List of Major New Electrical Equipment

Equipment	Capacity	Size	Features/Notes
Underground Power Distribution Lines	15 kV, 500A	500 kcmil	3-phase, EPR, MV-105, 133% insulation
Underground Communication Lines	24-count, 50 µm	8 mm	Multimode, indoor/outdoor, OFNR
Utility Switchgear and Meter Cabinet	15 kV, 600A	24”Wx32”Dx74”H	Double isolation switch
Selector Switch (4-way)	15 kV, 600A	110”Wx35”Dx74”H	Motorized (automated) dielectric selector switches, vault style
Selector Switch (6-way)	15 kV, 600A	160”Wx35”Dx74”H	Motorized (automated) dielectric selector switches, vault style
Transformer (Civic Center)	12kV-480/277V, 750kVA	102”Wx54”Dx60”H	Subsurface, bidirectional
Transformer (Civic Center Annex)	12kV-208/120V, 300kVA	102”Wx54”Dx60”H	Subsurface, bidirectional
PV (Center Street Garage)	150 kW	—	Including DC to AC inverter
Distribution Panel	480V, 400A	—	For PV installation
Battery Storage (Civic Center)	500 kWh	20’Wx10’Dx8’H	Preliminary capacity estimate, subject to change

Equipment	Capacity	Size	Features/Notes
DC to AC Battery Inverter	250 kW	Integrated with Battery system	Bidirectional “smart” inverter, NEMA 4x enclosure
Automatic Transfer Switch (Center Street Garage)	208/120V, 100A	20”Wx16”Dx60”H	Exterior rated, for existing generator
Automatic Transfer Switch (Civic Center)	480/277V, 400A	42”Wx24”Dx79”H	Exterior rated, for existing generator
Automatic Transfer Switch (Public Safety Building)	480/277V, 800A	42”Wx24”Dx79”H	Exterior rated, for existing generator
Breaker for Generator (Center Street Garage)	100A, 3-Pole	—	Need to verify generator modification is possible
Breaker for Generator (Civic Center)	400A, 3-Pole	—	Need to verify generator modification is possible
Breaker for Generator (Public Safety Building)	800A, 3-Pole	—	Need to verify generator modification is possible
Acronyms and Abbreviations: A = ampere(s); AC = Alternating Current; DC = Direct Current; kcmil = thousand circular millimeters ; kV = kilovolt(s); kVa = kilovolt-ampere(s); kW = kilowatt(s); kWh = kilowatt-hour(s); µm = micrometer; mm = millimeter; NEMA = National Electrical Manufacturers Association; OFNR = optical fiber, nonconductive, riser; PV = photovoltaic; V = volt(s)			

Table 3: Peak Demand and Peak Generation Capacity, by Transformer

Transformer	Transformer Size (kVa)	Blue Sky Demand (kW)	Critical Demand (kW)	Generator Capacity (kW)	Battery Storage Capacity (kW)	PV Capacity (kW)
Center Street Garage	750	142	11	100	-	318
Civic Center	750	132	132	200	—	10
Civic Center Annex Transformer 1 (480/277V; tied to Civic Center)	—	158	51	—	—	—
Civic Center Annex Transformer 2 (208/120V)	—	—	—	—	—	—
Public Safety Building	750	190	142	450	200	108
Total Load	—	728	442	750	200	436

Acronyms and Abbreviations: kVa = kilo-volt-ampere(s); kW = kilowatt(s); PV = photovoltaic; V = volt(s)

Table 4 provides a list of the major equipment needed for Prototype 3. This design excludes distribution infrastructure, but adds new installations at the Public Safety Building and Civic Center.

Table 4: List of Major New Electrical Equipment

Equipment	Capacity	Size	Features/Notes
PV (Center Street Garage)	150 kW	—	Including DC to AC inverter and cables
Distribution Panel (Center Street Garage)	480V, 400A	—	For PV installation
PV (Civic Center)	10 kW	—	Including DC to AC inverter and cables
Breaker for Main Switchboard (Civic Center)	20A, 3-Pole	—	For PV installation
PV (Public Safety Building)	108 kW	—	Including DC to AC inverter and cables
Distribution Panel (Public Safety Building)	480V, 400A	—	For PV installation
Battery Storage (Public Safety Building)	400 kWh	20’Wx10’Dx8’H	Preliminary capacity estimate, subject to change
DC to AC Battery Inverter	200 kW	Integrated with battery system	Bidirectional “smart” inverter, NEMA 4x enclosure
Main Switchboard (Public Safety Building)	480/277V, 2000A	84”Wx36”Dx90”H	With 800A main circuit breaker
Automatic Transfer Switch (Civic Center)	480/277V, 400A	42”Wx24”Dx79”H	Exterior rated, for existing generator
Automatic Transfer Switch (Public Safety Building)	480/277V, 800A	42”Wx24”Dx79”H	Exterior rated, for existing generator
Breaker for Generator (Center Street Garage)	100A, 3-Pole	—	Need to verify that generator modification is possible
Breaker for Generator (Civic Center)	400A, 3-Pole	—	Need to verify that generator modification is possible
Breaker for Generator (Public Safety Building)	800A, 3-Pole	—	Need to verify that generator modification is possible

Acronyms and Abbreviations: A = ampere(s); AC = Alternating Current; DC = Direct Current ; kV = kilovolt(s); kVa = kilovolt-ampere(s); kW = kilowatt(s); kWh = kilowatt-hour(s); NEMA = National Electrical Manufacturers Association ; PV = photovoltaic; V = volt(s)

4.2.5. Conceptual Cost Estimates

A conceptual (30 percent) cost estimate for full implementation of the BEAT CEMC design, including capital cost, installation cost, design fees, construction management fees, and all other multipliers (taxes, inflation, contingencies), was developed to capture a high-level estimate of the cost to implement the BEAT CEMC. Cost estimates for both Prototype 1 and Prototype 3 were also developed. The estimates are based on standard industry costs for technical components and are generalized across available manufacturer data for specialized equipment.

4.2.5.1. Prototype 1 Conceptual Cost Estimate

The following is a summary of the costs for Prototype 1.

Utilities and Power Distribution

- Electric utilities ducts and manholes (including trenching)
- Underground high-voltage conduits and wiring
- Underground low-voltage conduits and wiring
- Telecommunications conduits and wiring
- Microgrid control systems—hardware and software, including BAS
- Selector switches and precast concrete vaults
- Utility switchgear and pad mount
- Transformers and vaults
- Retrofits to diesel generators (including ATS installation and MSB modifications)
- Utility interconnection, testing, and commissioning
- *Subtotal: $4,400,000 (34 percent of total)*

Power Generation

- Photovoltaics and associated equipment (inverter, transformer)
- Battery storage with inverter, pad mount, and protection
- *Subtotal: $1,800,000 (14 percent of total)*

General Requirements, Unknown Conditions, and Other Contingencies

- General conditions/requirements
- Taxes, permits, and bonds
- Contractor's overhead and profit
- Construction contingency
- Unknown existing conditions contingency, hazardous materials, etc.
- Current code/standard compliance
- *Subtotal: $3,400,000 (26 percent of total)*

Services and Fees

- Owner's cost
- Architecture/engineering services
- Construction management services
- Commissioning services
- Client management and city administrative services
- Regulatory agency permits/approvals
- Market conditions, extraordinary inflation, and project control
- *Subtotal: $2,300,000 (18 percent of total)*

Escalation

- Escalation to midpoint of construction (roughly April 2020)
- *Subtotal: $1,100,000 (8 percent of total)*

Total Estimated Cost: $13,000,000

As the Berkeley CEMC Technical Design and Implementation Plan are refined prior to construction, changes in the cost estimate are likely. Expected changes are captured in the estimate by using conservative values and contingencies. Factors that will likely result in changes to the final cost of the project include, but are not limited to:

- Civil/site plan changes that result from the detailed site survey.
- Changes in the cost of emerging technologies (such as batteries).
- Changes to electrical equipment specifications per the PG&E standards division.
- Design changes that maximize the value of the Berkeley CEMC to other city departments (e.g., partnership with the information technology department in telecommunication lines).
- Changes in regulations or financial structures that impact how the Berkeley CEMC can be configured or implemented.
- Further planning and implementation of the cybersecurity plan.

Moreover, the following items have been excluded from this cost estimate, but will be incorporated in the project cost as refinements are made.

- Revenue-neutral building energy efficiency retrofits
- Compression of schedule, premium or shift work, and restrictions on the contractor's working hours
- Scope changes and post-contract contingencies
- Assessments, taxes, and finance, legal, and development charges
- Environmental impact mitigation
- Land and easement acquisition
- Cost escalation beyond the midpoint of construction as identified

4.2.5.2. Prototype 3 Conceptual Cost Estimate

The following is a summary of the costs for Prototype 3:

Utilities and Power Distribution

- Electric utilities ducts (low voltage only)
- Underground low-voltage conduits and wiring
- Microgrid control systems—hardware and software, including BAS
- Retrofits to diesel generators (including ATS installation and MSB modifications)
- Utility interconnection, testing, and commissioning
- *Subtotal: $600,000 (14 percent of total)*

Power Generation

- Photovoltaics and associated equipment (inverter, transformer)
- Battery storage with inverter, pad mount, and protection

- *Subtotal: $2,000,000 (47 percent of total)*

General Requirements, Unknown Conditions, and Other Contingencies

- General conditions/general requirements
- Taxes, permits, and bonds
- Contractor's overhead and profit
- Construction contingency
- Unknown existing conditions contingency, hazardous materials, etc.
- Current code/standard compliance
- *Subtotal: $900,000 (21 percent of total)*

Services and Fees

- Owner's cost
- Architecture/engineering services
- Construction management services
- Commissioning services
- Client management and city administrative services
- Regulatory agency permits/approvals
- Market conditions, extraordinary inflation, and project control
- *Subtotal: $600,000 (14 percent of total)*

Escalation

- Escalation to midpoint of construction (roughly December 2019)
- *Subtotal: $200,000 (5 percent of total)*

Total Estimated Cost: $4,300,000

As the Technical Design and Implementation Plan are refined prior to construction, changes in the cost estimate are likely. Expected changes are captured by using conservative values and contingencies. Factors that will likely result in changes to the final cost include, but are not limited to:

- Civil/site plan changes that result from the detailed site survey.
- Changes in the cost of emerging technologies (such as batteries).
- Design changes that maximize the value of the islandable solar + storage system to other city departments.
- Changes in regulations or financial structures that impact how the islandable solar + storage system can be configured or implemented.
- Further planning and implementation of the detailed cybersecurity plan.

Moreover, the following items have been excluded from this cost estimate, and will be incorporated in the project cost as refinements are made.

- Revenue-neutral building energy efficiency retrofits
- Compression of schedule, premium or shift work, and restrictions on the Contractor's working hours

- Scope changes and post-contract contingencies
- Assessments, taxes, and finance, legal, and development charges
- Environmental impact mitigation
- Cost escalation beyond the midpoint of construction as identified

4.3. Implementation Strategy

The implementation strategy outlines how the project will be executed. This includes a review of the project phases, procurement and contracting plan, regulatory requirements, and expected project timeline. This section largely represents a summary for Prototype 1, with updates where necessary for Prototype 3. The concepts are presented in more detail in the Implementation Roadmap and Financial Model Design Case reports. The strategy for Prototype 1 can be expanded for Prototype 2, but a specific strategy for Prototype 2 is not included.

4.3.1. Project Phasing

The intent of this pilot plan is to provide a 30 percent conceptual design of a successful microgrid. Emphasis is placed on resolving the critical constraints of the project (e.g., alignment with utility standards, constructability, rightsizing of all equipment, accommodation for future expansion, and a regulatory implementation strategy). To achieve this, it is useful to consider the subcomponents of the BEAT project by grouping them in ways that frame where the most challenging points will be and developing plans to responding to them.

Financial performance: One way to group the subcomponents is to separate them according to financial performance. Some components of the Berkeley CEMC and islandable solar + storage system has clearly established value streams for recovering implementation costs. These components are summarized in the Financial Performance section as having a positive internal rate of return (IRR). Other components, while critical for achieving energy resilience, do not have established value streams or clear pathways for cost recovery. These components are the focus of discussing innovative means to finance their implementation. Components with an established value stream:

  - Energy efficiency retrofits
  - PV installations
  - Battery storage installations
  - BAS installations for optimized energy performance
- Components without an established value stream:
  - Trenching in the PROW for new distribution lines
  - Distribution infrastructure and equipment
  - Building electrical component retrofits to accommodate inter-facility load sharing

Regulatory feasibility: As with financial performance, some subcomponents of the project fall within standard practice for a building energy or distribution infrastructure retrofit project. Other aspects are less common and require creative strategies to navigate regulatory frameworks.

- Components with a clear regulatory pathway:
  - Energy efficiency retrofits
  - PV, battery storage, and BAS installations
  - Building retrofits to accommodate inter-facility load sharing
  - Distribution infrastructure construction and installation
- Components without a clear regulatory pathway:
  - Ownership and operation of distribution infrastructure in a PROW
  - Enabling islanding capability of facilities across a PROW
  - Load sharing between facilities and distributed generation sources across a PROW

Physical location: The BEAT project prototypes can be broken up by categories of physical location where each project subcomponent is taking place. The location of each subcomponent impacts the design and implementation work that will need to be done.

- PROW (for Prototype 1 only)
  - New joint trench for distribution lines
  - Interconnection with existing utility
  - Traffic management and other construction impacts
- Building exterior (for Prototypes 1 and 3)
  - Medium-voltage equipment (e.g., utility switchgear, selector switches, transformers)
  - Existing generator retrofits
  - Battery storage installation
- Building interior (for Prototypes 1 and 3)
  - MSB modifications (connections to new equipment)
  - ATS installations
  - PV installations, conduit routing, and connection to the MSB
  - Energy efficiency retrofits and BAS installations
- Ongoing operations
  - Maintenance of distribution infrastructure (for Prototype 1 only)
  - Maintenance of distributed energy resources (e.g., PV, battery storage, existing generators) (for Prototypes 1 and 3)
  - Software management of distributed microgrid controls (for Prototype 1 only)
  - Continual optimization of building energy performance (e.g., BAS management, energy arbitrage with battery storage) (for Prototypes 1 and 3)
  - Ongoing commissioning to maintain and improve energy efficiency (for Prototypes 1 and 3)
  - Critical load analysis and optimization for outage preparedness (for Prototypes 1 and 3)

Type of work: Different subcomponents of the Berkeley CEMC and islandable solar + storage system requires different work specializations. Contracts for completing the project may be grouped and distinguished along these lines, with separate entities completing the various types of specialized work. To simplify the procurement process, types of work will be combined where it is possible for a single entity to complete multiple subcomponents.

- Distribution infrastructure (civil) (Prototype 1 only)
    - Trenching for distribution cables
    - Vault installation for transformers and switchgear
    - Mounting pad installation for large equipment
    - Physical security installations (e.g., fencing)
- Distribution infrastructure (electrical) (for Prototype 1 only)
    - Installation of distribution cables
    - Utility switchgear installation
    - Interconnection with the utility
    - Selector switch installation
    - Transformer replacement/modification to transfer facilities from the utility grid to the microgrid
- Facility-level electrical retrofits (for Prototypes 1 and 3)
    - Existing generator retrofits
    - New ATS installations
    - Modifications to the MSB (e.g., connect new ATS, connect new PV or battery storage, connect to new transformer, modify/replace MSB to increase capacity)
    - Conduit routing to connect exterior equipment to the electrical room (e.g., ATS installed at exterior generator, new PV or battery storage installations)
- PV installation (for Prototype 1s and 3)
    - Mounting hardware on roof (and parking lot canopy for Prototype 3)
    - PV panel installation
    - PV inverter and collector panel board installation
    - Configuration of PV performance monitoring software
- Battery storage installation (for Prototype 1 and 3)
    - Finalization of optimal battery storage capacity based on bid-specific financials
    - Installation of packaged battery storage and inverter system
    - Configuration of battery storage monitoring, controls and performance optimization software
- Energy efficiency retrofits (for Prototype 1 and 3)
    - Energy audit to identify specific energy saving retrofit projects
    - Management and execution of retrofits (e.g., lighting, insulation, mechanical equipment)
- BAS installation and optimization (for Prototypes 1 and 3)
    - Configuration of BAS software
    - Installation of controls hardware
    - Training for software use or ongoing optimization of building energy performance
    - Establishment of energy dashboard for communication of energy consumption/generation trends
    - Establishment of cybersecurity protocols
- Microgrid optimization controls (for Prototype 1 only)
    - Installation of controls hardware
    - Installation of communication hardware (e.g., fiber)

- Installation of primary controller and HMI
- Integration with facility-level BAS
- Training for or ongoing optimization of microgrid energy performance and load balancing during islanding mode
- Establishment of cybersecurity protocols

4.3.2. Procurement Plan

In this section of the document, the procurement strategy of the Berkeley CEMC (Prototype 1) and islandable solar + storage system (Prototype 3) will be discussed. The strategy for Prototype 1 can be expanded for Prototype 2, but a specific strategy is not included. The strategy for the procurement of microgrid equipment, required construction services, and microgrid operations will be included in the discussion.

In general, the procurement strategy for Prototype 1 is similar to that for Prototype 3. Prototype 3 consists of all the same subcomponents as Prototype 1 except for inter-facility distribution infrastructure; the modified PV and battery storage strategy has the same procurement requirements as the original Prototype 1. For conciseness, the two alternatives are considered jointly in this procurement plan, and specific references to Prototype 3 are called out as necessary.

4.3.2.1. Procurement Strategy

The City of Berkeley will need to procure one or more contracts to construct, operate, and maintain the Berkeley CEMC or islandable solar + storage system, and the procurement process for each is presented below. It may be possible for a singular private operator/developer to be contracted to procure, install, and operate the storage, generation, and management assets. These tasks could also be done by separate firms. The procurement strategy is presented as two core tasks, but remains flexible to allow for different contracting structure.

1. Procurement of services for construction and installation of microgrid components and services required for the CEMC or islandable solar + storage include installation of microgrid assets (e.g., procuring and mounting PV at the Center Street Garage) and construction services for the inter-facility distribution lines.

    a. For Prototype 1, procurement of construction services for inter-facility distribution lines would depend on the ownership/operation model of the distribution assets. Procurement may be facilitated through either a sole-source contract with PG&E or another municipal utility district, or alternatively, a public bid, which goes to the lowest responsible/responsive bidder with a private contractor firm. Related procurement of goods would also be the responsibility of the utility or the entity selected for construction of the distribution infrastructure.

    b. For Prototype 1 or 3, procurement of services for the installation of microgrid components such as PV and storage will also be facilitated through a public bid. Related procurement of these components will be responsibility of the selected contractor.

2. For Prototype 1 or 3, procurement of services to operate and maintain the generation, storage, and microgrid control assets will also be facilitated through a Request for Qualifications (RFQ) or Request for Proposals (RFP) as necessary.

4.3.2.2. Procurement Plan Roadmap

This section will serve as a roadmap for completing future, detailed procurement documents that include project background, a general schedule, selection criteria, city requirements, and an overview of the submission process. Representative text is provided for each, but is subject to revision to reflect the final technical specifications, and market and regulatory conditions at the time of project initiation.

4.3.2.2.1. Purpose of Procurement

The purpose of procurement may be included in the procurement documents to provide a high-level introduction to bidders with respect to the scope of work and level of effort required. Representative text that may be included in this section is presented below, and is subject to change at the time of project initiation.

The City of Berkeley will need to procure one or more contracts to implement either the CEMC (Prototype 1) or a solar + storage system (Prototype 3) in downtown Berkeley. The chosen firm(s) will be expected to advance planning and design, and support implementation of the system through the following phases of the project: financing, construction and installation of microgrid components, and operation and maintenance of the microgrid to meet operational targets during normal blue sky and grid outage events. One or more entities may be responsible for completing the required services, subject to qualifications. A project background may be included in the procurement documents to provide project context to bidders.

4.3.2.2.2. Inquiries and Correspondence:

The procurement documents may include contact information for personnel with the capacity and working knowledge to address specific inquiries related to the project as well as the bid process. The contact that will lead correspondence related to the procurement process will be determined as the project develops further.

4.3.2.2.3. Scope of Services

The scope of services included in the procurement documents will be used as a tool to organize processes and delegate responsibilities to be undertaken for implementation of the CEMC or islandable solar + storage system. One or more entities may be responsible for completing the required services, subject to qualifications. Representative text that may be included in this section of the document is presented below, and is subject to change.

For the procurement process, it is recommended that bidders refer to the detailed feasibility and implementation plans to get a full understanding of the Berkeley CEMC design and expected roles and responsibilities.

Procurement of microgrid or solar + storage components would be the responsibility of the entity responsible for its construction or installation (the successful bidder), and the procurement documents will provide guidance regarding specific components required and preferred specifications. The microgrid industry is rapidly evolving and bidders are encouraged to suggest new, performance-enhancing technologies and financing techniques that align with project goals.

There will also be procurement of services to develop, operate, and maintain the CEMC or islandable solar + storage system. The scope of services includes specific responsibilities and desired outcomes. For the CEMC, the development and operation of the inter-facility distribution lines are expected to be the responsibility of PG&E and, as such, the services to develop and operate the CEMC relate only to the generation, storage, and system management of the CEMC. The city would consider entering into a fixed-term power purchase agreement (PPA) or other partnership that would enable the bidder to be an active participant in the development and operation of the CEMC or islandable solar + storage system.

4.3.2.2.4. General Procurement Schedule

A general procurement schedule may be included in the procurement documents to highlight time constraints with respect to the scope of work and level of effort required for this project. The schedule helps bidders gauge their ability to meet project targets based on available resources. The entire bid process should be complete within a year. Bidders would have roughly three months from the date of schedule issuance to submit proposals. Once a successful bidder is selected, contract negotiation and finalization is expected to be completed roughly nine months from the date of issuance.

4.3.2.2.5. Selection Criteria

If a competitive bidding process (i.e., RFP or RFQ) is used, a section for selection criteria may be included in the procurement documents to provide prerequisites and qualifications. This provides an opportunity for the City of Berkeley or any other entity leading the procurement process to highlight how project priorities align with organizational priorities. For the Berkeley CEMC in particular, creativity and flexibility have been prioritized. As the microgrid industry is still nascent, proposals that incorporate innovative technologies, financing mechanisms, and partnership structures are desired. Proposals that demonstrate the ability to respond to and facilitate advancements in regulatory, technical, or market conditions are also encouraged.

Proposals will be evaluated by a panel of city staff and external reviewers. The panel may invite respondents to present their proposals in Berkeley, California. This will be done at no cost to the city. The presentations will be used, although not exclusively, to assess and rank proposals that offer the best value to the city. The submittal will be negotiable, and cost data would be confidential until the contract is awarded. The city reserves the right to reject any proposal.

Additional proposal and submission requirements will be included as part of the procurement process.

4.3.3. Regulatory Requirements and Design Standards

This section describes the local, state, and federal requirements for implementing Prototype 1 and Prototype 3, and, where applicable, offers preferred pathways. Requirements for Prototype

1 can be expanded to Prototype 2 and may include requirements pertaining to multiple-customer models. This section also identifies areas that need clarification to implement the microgrid. For more detail, refer to the Implementation Roadmap Report.

4.3.3.1. Technical Design Standards

The Berkeley CEMC is designed to meet standards encompassing electrical distribution equipment, utility trenching, communications protocols, and cybersecurity. Standards that the microgrid must be designed to include:

- California Electrical Code
- PG&E Green Book, Electric and Gas Service Requirements TD-7001M 2017-2018[16]
- UL 9540 – Standard for Energy Storage Systems and Equipment
- UL 1741 – SA Advanced Inverter Testing and Electric Rule 21
- Institute of Electrical and Electronics Engineers (IEEE) 1547 – Standard for Interconnecting Distributed Resources with Electrical Power Systems
- IEEE C37.74 – IEEE Standard Requirements for Subsurface, Vault, and Pad Mounted Load-Interrupter Switchgear and Fused Load-Interrupter Switchgear for Alternating Current Systems up to 38 kV
- IEEE C37.60-2012 – IEEE/IEC High-voltage switchgear and control gear - Part 111: Automatic circuit reclosers and fault interrupters for alternating current systems up to 38 kV
- North American Electric Reliability Corporation (NERC) Critical Infrastructure Protection (CIP) Standards
- National Institute of Standards (NIST) IR 7628:2
- NIST SP800 – 82 Rev 2, 39, 88 Rev 1
- International Organization for Standardization (ISO) 27001
- IEEE 1686-2013

4.3.3.2. Local Permit Requirements

Multiple city permits would be required for a CEMC (Prototype 1) or an islandable solar + storage system (Prototype 3). Required permits include zoning permits and building (electrical) permits. For the CEMC, additional permits for work in the PROW for electrical work and trenching for placement of underground distribution lines would be required. Permits must be pulled for each project site (PROW and each building). All local permits for building sites must be applied for through the City of Berkeley Department of Planning and Development's Permit Service Center.

4.3.3.2.1. Zoning Permits:

No zoning review is anticipated for the installation of internal equipment, such as conduit, associated with either the CEMC (Prototype 1) or the islandable solar + storage system (Prototype 3). However, battery storage enclosures that are designed to be located just outside

16 Because the current design has PG&E owning and operating the Berkeley CEMC after construction, all technical elements are being designed to meet PG&E standards.

of the Civic Center Building (for Prototype 1) and outside the Public Safety Building (for Prototype 3) may require zoning review, including landmarks review and permitting, such as an Administrative Use Permit (AUP), depending on the type and size of the enclosure. AUPs can take months to obtain and are discretionary. In addition, as the sites are within the Civic Center Historic District, the structures will be subject to review by the Landmarks Preservation Commission.

4.3.3.2.2. Engineering Permits:

The city would require permits for:

1. Contractors or utilities performing work in the PROW, including excavation and installation of electrical equipment, an engineering permit obtained through the Berkeley Public Works Department would be required (Prototype 1 only). Prototype 3 would not involve work in the PROW.
2. For any excavations or construction on city-owned parcels, including the Civic Center Annex, Civic Center, Public Safety Building or Center Street Garage, pertinent building, electrical, or mechanical permits issued through thec of Berkeley Department of Planning and Development's Permit Service Center would be required. (Prototypes 1 and 3)

The city requires electrical permits for all electrical work, including work on city-owned parcels. Permits must be pulled for each project site (each building/land parcel) for any work related to electrical service, circuits, interconnections and disconnections, electricity generation (PV), storage (battery storage), and transformers. One electrical permit application must be submitted for each city-owned parcel to authorize the installation of new electrical equipment on that site. Estimated plan check time is six to eight weeks for projects over $1 million in valuation. [17]

The following permits are either exempt or not required under the design. As this design is finalized, design changes could trigger additional regulatory requirements.

- *Encroachment*: No permanent encroachments are planned in the PROW; therefore, no encroachment permits are required at this stage.
- *Permits for sidewalk construction and repair, and street and sidewalk use*: Permits for sidewalk construction and repair, and street and sidewalk use are not required for this project, as public utilities and public agencies are exempt from applicability.[18]

17 See the City of Berkeley website for more information: https://www.cityofberkeley.info/uploadedFiles/Planning_and_Development/Level_3_-_Building_and_Safety/Plan%20Check%20Turnaround%20Times.pdf/.

18 Berkeley, California, Municipal Code § 16.04.180 and § 16.16. (2018). http://www.codepublishing.com/CA/Berkeley/?Berkeley16/Berkeley1604/Berkeley1604.html&?f.

4.3.3.3. Local Franchise Rights

Franchise rights, which outline the requirements for a utility to use the city's PROW, are addressed in Article XII of the *Charter of the City of Berkeley California*.[19] Unless granted franchise rights under the federal or state constitution, franchise rights must be granted by a City Council ordinance. Furthermore, Article XII empowers the City Council to prescribe the terms and conditions of franchises in accordance with the applicable provisions of the charter and any ordinance adopted, and may in such franchise impose additional terms and conditions not in conflict with the charter or ordinances, whether governmental or contractual in character, that are in the public interest. The city recently renewed its franchise agreement with PG&E and would not be able to renegotiate a new franchise fee structure at this time.

4.3.3.4. State and Federal Regulatory Requirements

4.3.3.4.1. CEQA Requirements

For this analysis, the selected prototypes for the Berkeley CEMC would likely be exempt from or subject to a streamlined CEQA review. Projects in Berkeley and other dense urban areas are often eligible for a categorical CEQA exemption for infill development projects[20] or for the streamlining of CEQA procedures. Infill projects must meet specific performance standards, such as on-site renewable energy generation, to be eligible for infill streamlining.

The BEAT team has identified the most efficient and effective CEQA pathway for filing a Notice of Exemption claiming a Statutory Exemption per section 21080.35 of the California Public Resources Code.[21] This pathway could be used regardless of the prototype. The Berkeley Planning and Development Department provided a previously approved Notice of Exemption document for the installation of underground conduit improvements as a template. After the Notice of Exemption is approved by the lead agency and filed with the county clerk, a 35-day statute of limitations period commences for any challenge to the agency's decision.

4.3.3.4.2. CPUC and IOU-related Requirements

The prototypes will also have the following CPUC and IOU-related requirements:

1. *Operation across the PROW*: For a multi-facility microgrid that crosses the PROW, the distribution infrastructure must be owned and operated by a utility, per CPUC Rule 218 (b). However, there is limited guidance related to operation of the distribution infrastructure during a grid outage event, and the city is engaging with relevant entities regarding the non-utility operation of the inter-facility lines during a grid outage (Prototype 1).

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19 Berkeley, California, Municipal Code, Article XII: Franchises. (2018). http://www.codepublishing.com/CA/Berkeley/html/BerkeleyCH/BerkeleyCH12.html.

20 Title 14 California Code of Regulations, Chapter 3 Guidelines for Implementation of the California Environmental Quality Act, Article 19, Section 15332. http://resources.ca.gov/ceqa/guidelines/art19.html/. Accessed April 2017.

21 California Code, Public Resources Code, PRC Section 21080.35. http://codes.findlaw.com/ca/public-resources-code/prc-sect-21080-35.html/. Accessed March 2018.

2. *Regulations related to tariffs*: PG&E-provided tariffs and incentive programs such as NEM 2.0 and RES-BCT would be available to the Berkeley CEMC.

    a. *Credit for excess generation*: Excess solar power generated at the generating site(s) would be eligible for credits during blue sky conditions. The Berkeley CEMC under Prototype 1 would be eligible to participate in NEM 2.0 and RES-BCT, and final selection of the incentive program will depend on a variety of project parameters, including the number of generating sites and difference in annual on-site generation and demand. However, there is no CPUC guidance to support a tariff for power generated during a grid outage, and the city is still engaging with relevant entities to navigate this issue. Prototype 3 would likely utilize NEM 2.0.

    b. *Credit sharing*: For Prototype 1, there is no mechanism for a non-utility entity to share power across facilities or owners. Excess power generated at the generating site may only be virtually shared with other buildings participating in the CEMC using utility-provided programs such as RES-BCT, which is only available to municipal buildings under the same account. Furthermore, RES-BCT only allows for one generation site. However, no utility-provided programs support credit sharing between owners or non-adjacent buildings. This limits the ability of the Berkeley CEMC to support operation of critical community amenities at non-municipal buildings.

4.3.3.4.3. Federal Regulatory Requirements

Both Prototype 1 and Prototype 3 will be interconnected to the local distribution grid, which is not subject to federal jurisdiction. Therefore, there are no federal regulatory requirements that the BEAT microgrid must consider.

4.3.4. Expected Project Timeline

The preliminary project timelines for Prototype 1 and Prototype 3 account for both a draft schedule for the procurement plan and a preliminary timeline for technical implementation. The timeline is based on high-level estimates of the length of time and level of effort needed to complete each stage in the development process. These schedules are subject to change as refinements are made to the technical design ahead of completing the 100 percent construction documents.

The timeline presented in Table 5 is for the build-out of the project, as described in Prototype 1, including new distribution lines.

Table 5: Preliminary Project Timeline for Prototype 1

Project Event	Estimated Completion
Issuance of RFP	Late-2018 *(dependent on timeline of funding opportunities, such as California Energy Commission EPIC Advanced Energy Communities Phase II)*
Pre-Application Call/Webinar	3 weeks from issuance
Final Date for Questions	6 weeks from issuance
Proposals Due	2-3 months from issuance
Selection Announced	4-5 months from issuance
Contract Negotiations and Finalization (including contingency)	3-4 months from selection
Project Start	Late-2019
Perform audits and develop implementation plan for cost-effective BAS and energy efficiency retrofits	Late-2019
Break ground on PV/battery storage installation	Late-2019[1]
Perform gap analysis to identify data needs for distribution infrastructure design	Late-2019
Develop 60% design documents for CEMC distribution infrastructure and facility interconnection retrofits	2020
Complete cost-effective energy efficiency retrofits and BAS installation	2020
Complete PV/battery storage installation	2020
Complete 100% design documents for CEMC distribution infrastructure and facility interconnection retrofits	2021
Begin construction of CEMC distribution infrastructure and facility interconnection retrofits	2022
Complete construction of CEMC distribution infrastructure and facility interconnection retrofits	2023
Utility interconnection and system commissioning	Year-end 2023
Project Completion Solar + Storage Inter-facility Distribution Lines	Year-end 2023 *(dependent on timeline of funding opportunities)*[2] Mid-2020 Late-2023

Notes:
1 PV and battery storage installation must begin by December 31, 2019, to derive full benefit from the Federal Investment Tax Credit (ITC), which is scheduled to begin reducing in value in 2020. Due to these timeline constraints, procurement for solar and battery storage may need to be take place separately from and earlier than the rest of the RFP process.
2 For example, the EPIC Phase II timeline is anticipated to require project completion within 5 years of grant issuance. The required project completion date may shift in accordance with details in the grant funding terms.
Acronyms and abbreviations: BAS = Building Automation System; CEMC = clean energy microgrid community; EPIC = Electric Program Investment Charge; PV = photovoltaic; RFP = Request for Proposal

The timeline presented in Table 6 is for the build-out of the project as described in Prototype 3, excluding new distribution lines, but including the additional PV and battery storage.

Table 6: Preliminary Project Timeline for Prototype 3

Project Event	Estimated Completion
Issuance of RFP	Late-2018 *(dependent on timeline of funding opportunities, such as the California Energy Commission EPIC Advanced Energy Communities Phase II)*
Pre-Application Call/Webinar	3 weeks from issuance
Final Date for Questions	6 weeks from issuance
Proposals Due	2 months from issuance
Selection Announced	3-4 months from issuance
Contract Negotiations and Finalization (including contingency)	3-4 months from selection
Project Start	Late-2019
Perform audits and develop implementation plan for cost-effective BAS and energy efficiency retrofits.	Late-2019
Break ground on PV / battery storage installation.	Late-2019[1]
Complete cost-effective energy efficiency retrofits and BAS installation.	2020
Complete retrofits to parking lot, electrical room, and existing generator, and other site-level upgrades.	2021
Complete PV / battery storage installation	2022
Project Completion	Year-end 2022 *(dependent on timeline of funding opportunities)*[2]

Notes:
1 PV and battery storage installation must begin by December 31, 2019, to derive full benefit from the Federal Investment Tax Credit (ITC), which is scheduled to begin reducing in value in 2020. Due to these timeline constraints, procurement for solar and battery storage may need to take place separately from and earlier than the rest of the RFP process.
2 For example, the EPIC Phase II timeline is anticipated to require completion of the project within 5 years of grant issuance. The required project completion date may shift in accordance with details in the grant funding terms.
Acronyms and abbreviations: BAS = Building Automation System; EPIC = Electric Program Investment Charge; PV = photovoltaic; RFP = Request for Proposal

4.4. Governance and Operational Plan

This section provides an overview of the governance and operational plan for the BEAT project. Specifically, for Prototype 1, it defines the relationship between the owner, operator, utility, and users, and outlines from a technical perspective how the Berkeley CEMC transitions into islanding mode and balances loads across all facilities. The Prototype 3 governance and operation plan has similarities to Prototype 1 but is simpler overall with fewer factors relating to distribution assets connecting facilities across the PROW.

During the development of the Berkeley CEMC design, consideration was given to maximizing the city's access to capital, access to external technical expertise in operating energy projects, and the regulatory constraints that limit the city's ownership of distribution assets. Changes in the microgrid industry may warrant changes in the plan. As such, the Governance and Operational Plan may be revised to reflect market conditions.

The CEMC system consists of the following components: generation, distribution, storage assets, and microgrid system controls, including EV demand management and BAS. The Governance and Operational Plan provides the structure that addresses the interaction between system components and the entities associated with each component. As regulations influence how the distribution assets are owned and operated, assets are addressed independently for the plan, while all other system components of the CEMC are aggregated under a single structure. For Prototype 3, which includes site-level upgrades but no distribution assets, only a single structure is necessary for the plan (to capture generation, storage, EV demand management, and BAS).

4.4.1. Organizational Structure

As the city has limited expertise to operate and maintain CEMCs or islandable solar + storage systems, partnership with a private energy developer/operator or the local utility would provide the appropriate support. Partnerships with other entities are discussed in the feasibility analyses. Given the current regulatory environment and market conditions, an optimal partnership would include utility as well as private participation.

Utility partnership and support is critical to the success of the CEMC approach (Prototype 1), particularly as inter-facility distribution assets may only be operated by utilities during blue sky conditions. Furthermore, as the inter-facility distribution infrastructure will be connected with the larger electric grid, the utility would be most likely to take on the responsibility for distribution system operation and management. However, the participation of the utility would be limited to the distribution assets, and development and operation of the remaining components of the microgrid, including solar and storage, are best accomplished with joint city and private control. This would provide the desired autonomy to prioritize resilience while gaining efficiencies from a specialized partner for managing the operations of either the CEMC design or the islandable solar + storage system.[22]

For the solar + storage approach, utility participation may be limited to providing rate schedules and other standard services related to interconnection. The utility would not be required to manage distribution assets, as no distribution assets would be required for Prototype 3.

Financing and ownership for system components may be structured as follows:

1. *Generation, storage, and system management*: These system components may be financed using a combination of private and public funds, including financing from the private developer/operator and the City of Berkeley. Some project components may be eligible for utility incentive programs, such as SGIP, which may be adequate to finance the capital requirement for storage. The ITC is only available to private entities for

22 For more analysis related to this see the BEAT Set of Potential Business Models Report

renewable energy technologies; therefore, only the generation and storage assets financed by a private energy developer/operator could utilize the ITC.

a. Generation assets: The generation assets would be jointly financed and owned by the city and a private energy developer/operator, facilitated through a PPA.

   i. The City of Berkeley would maintain ownership of part of the generation assets, the 168 kW of PV, which have already been financed as part of the Center Street Garage project. This would be the city's stake in the project's total equity.

   ii. For Prototype 1, the remaining generation assets (remaining 150 kW of PV at the Center Street Garage) would be owned and financed by the private energy developer/operator, using a combination of private and public funds.

   iii. For Prototype 3, the additional PV (108 kW at the Public Safety Building and 10 kW at the Civic Center) would also most likely be owned and financed by the private energy developer/operator. Alternatively, if the PV were purchased through a funding mechanism such as a grant, the assets would be owned by the city and a third-party entity would provide O&M services.

b. Storage assets:

   i. For Prototype 1, the Berkeley CEMC's storage assets would likely be owned by the private energy developer/operator.

   ii. For Prototype 3, if the storage were purchased with grant funding, the assets would be owned by the city, and the city would engage a third-party entity to provide O&M services.

c. System management: The microgrid controls, including the building automation and EV demand management system for optimized energy performance and utility cost reductions, will be owned and managed by the private energy developer/operator to optimize energy performance and reduce utility costs.

2. *Distribution assets (for Prototype 1 only)*: As mentioned in Section **Error! Reference source not found.**, existing regulations restrict a non-utility entity's ability to own and operate inter-facility distribution infrastructure; the distribution assets may only be owned by a utility entity. The parameters of such a partnership with PG&E are being explored. As the assets would be operated as a component of the larger grid under the control of the utility, their ability to generate additional revenue for the Berkeley CEMC in blue sky conditions may be limited under current regulations[23] and as such, financing would be limited to public or utility-supported sources. Public funding

23 Although in current regulatory conditions the distribution lines may not generate financial benefits for the CEMC, they would still generate large resilience benefits during grid outages. As such, these inter-facility distribution lines were included in the CEMC design. See the TBL Analysis in the Financial Feasibility Analysis Report for more information related to the resilience benefits that drove prototype selection.

sources may include municipal bonds or clean renewable energy bond funding and state grants.

a. Although Prototype 3 excludes distribution infrastructure, thus avoiding the potential obstacles in this aspect of the project, it is envisioned that Prototype 3 can be expanded into a version of Prototype 1 if and when the organizational structure and financial barriers for the distribution assets are resolved.

4.4.2. Governance and Operational Structure

For all prototypes, the islandable system would be jointly owned by the city and the private operator/developer, except for the distribution infrastructure in Prototypes 1 and 2, which would be owned by the utility. Based on the city's initial capital contribution of 168 kW of PV, the city's stake in the system equity would be approximately equivalent to 15 percent, and the remaining would be under the control of the private operator/developer. This is an initial estimate, and final capital requirements and other contributions may alter these estimates.

The private developer/operator would be considered a majority system owner, and may be expected to operate the system as whole. The city and potentially other future CEMC users such as Berkeley High and the YMCA (Prototype 2) could purchase the electricity produced by the system through a fixed-term PPA. As the majority owner and system operator, the private developer/operator would be expected to be responsible for the:

- Planning, design, and construction management of the system (excluding distribution).
- Gaining necessary permits and approval (including interconnection with utility).
- Operation of the system during both blue-sky and island mode
- Repair and maintenance of the system as necessary.

For Prototype 1, it has been assumed that the distribution assets will be wholly financed by the city, with potential financial support from grant funding or bonds. The long-term operation and maintenance of distribution assets during blue sky conditions would be transferred to PG&E in return for an O&M fee charged to the City of Berkeley.[24] As the Berkeley CEMC inter-facility infrastructure would be connected with the larger electric grid, PG&E's participation in the design and construction phases is essential. In general, the utility would be expected to be responsible for the:

- Planning, design, and construction management of distribution infrastructure.
- Operation of the distribution system during blue-sky (and potentially during islanding mode).
- Repair and maintenance of the system as necessary

24 A filing will need to be submitted to the CPUC to describe special conditions of the new microgrid distribution lines; otherwise, those distribution lines once deeded to PG&E will be treated as any other PG&E asset, and other non-microgrid customers could be added to them in the future.

4.4.3. Operational Design for Islanding Mode

This section describes the operations sequence that will occur after a grid outage to bring all critical loads in the Berkeley CEMC online in islanding mode. This sequence is governed by Electric Rule 21 for interconnection requirements (see Chapter 2 for more information on Rule 21 and how it relates to the operation of distributed generation sources, including PV and diesel generators, during blue sky and islanding modes). Both Prototype 1 and Prototype 3, the islandable solar + storage system alternative, include a transition to islanding mode, even though the facilities in Prototype 3 are not interconnected.

4.4.3.1. Prototype 1 Sequence of Operations

Transitioning from a complete loss of power (i.e., a "black start") to a fully integrated islanding mode involves a step-by-step process at each facility to ensure that the voltage and frequency of all electrical systems are in sync to maintain the power quality of the microgrid. When all facilities and generation resources are brought online automatically by the microgrid controller, a process that takes 5 to 10 minutes per facility (20 to 40 minutes total for the Berkeley CEMC Prototype 1), the CEMC is in full islanding mode and will remain so for the duration of the outage. To reconnect the Berkeley CEMC to the utility after power is restored, the CEMC voltage and frequency must synchronize with the utility grid via communication at the utility switchgear. When the two distribution networks are synchronized, PG&E will signal the utility switchgear to close and reconnect the CEMC to the grid. After this has occurred, grid-tied mode has been restored and the CEMC can return to blue sky operation. See the Technical Design Report for more details on these options for organizational structures.

4.4.3.2. Prototype 3 Sequence of Operations

The sequence of operations for Prototype 3 would be similar to the Prototype 1 sequence of operations, but would occur independently at each site with both solar and storage installed. Sites that do not have solar and storage would rely solely on existing diesel generators or remain unpowered for the duration of the outage.

4.4.4. Cybersecurity Plan

The detailed cybersecurity plan provides practical security best practices and controls designed to help improve the security posture of all prototypes for the BEAT project. The plan, which is provided in the Technical Design Report, is based on guidance from organizations such as NIST and NERC. The information in the plan has been condensed from information provided by these organizations and experience from working with entities that own and operate hundreds of industrial control systems. The Detailed Cybersecurity Plan focuses on Prototype 1, as it is the more complex design with multi-facility microgrid controls and dedicated communications lines in the distribution trench, but the principles of the plan still apply to Prototype 3.

The guidance provided by the plan represents actionable best practices and controls that should be adopted to mitigate security risks. The Detailed Cybersecurity Plan is intended for general facility and microgrid protection purposes; it is not intended to address any current or potential regulations. It is intended as a forward-looking document outlining a strategy for improving smart grid interoperability and security.

The Detailed Cybersecurity Plan describes security risks and recommends security controls in each of the following categories:

- People and policy security risks
- Operational security risks
- Physical security risks
- Third-party relationship risks
- Network security risks
- Platform security risks

Real security requires more than simply compliance with rules—the CEMC design must embrace security as a basic requirement of municipal operations and develop a broad understanding of security. The basic concept is not “do this and you are secure.” Rather, it is a commitment to continuous improvement. The plan provides guidance for an approach that will facilitate the commitment to ongoing security.

4.5. Technical and Financial Model

Modeling the technical and financial performance of the Berkeley CEMC is a key step in the development of the final design.

The technical model evaluates the impact of energy efficiency retrofits and renewable energy installations to estimate the potential reduction in grid energy demand. A conservative estimate of peak critical demand for electricity was also developed to evaluate the baseline diesel generator demand, and the potential reduction due to energy efficiency gains and new renewable energy resources. The demand for all four facilities is evaluated cumulatively for Prototype 1 to show the impact of sharing loads and resources between facilities. For Prototype 3, facility demands are evaluated individually, focusing on the proposed PV expansions at the Civic Center and Public Safety Building.

The financial model evaluates the costs and benefits of the project, including capital planning, potential revenue sources, and cost savings through the Business Model Design and SROI analysis. The model evaluates the costs and benefits of Prototype 1, including the distribution infrastructure; and of Prototype 3, which accounts for expanded PV and battery storage but no distribution infrastructure.

4.5.1. Modeled Technical Performance

Prototype 1 includes the four interconnected city-owned buildings under blue sky and islanding scenarios. Table 7 summarizes the modeling inputs used. Figure 3 illustrates the potential performance of Prototype 1, and Table 8 summarizes the results.

As Table 7 shows, a significant portion of the CEMC’s improved performance comes from energy efficiency retrofits. These are expected to be completed in addition to the new PV installations for a combined reduction in utility electricity demand.

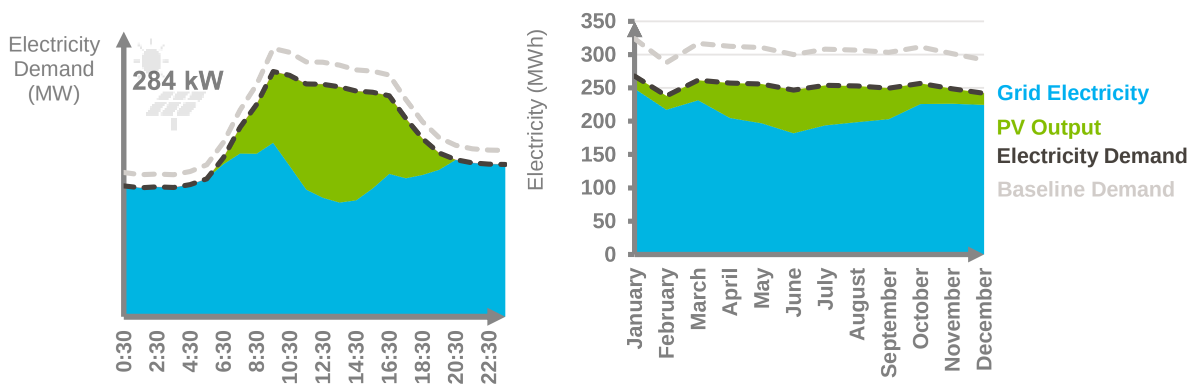
Table 7: Prototype 1 Summary of Modeling Inputs

Facility	Electricity Demand Source	Peak Demand Blue Sky (Critical)	Distributed Energy Resource	Energy Efficiency Savings Potential (Percent of annual consumption)
Center Street Garage	Energy model from construction documents	83 kW (11 kW)	318 kW PV 100 kW Generator	0%
Center Street Garage EV Charging	Modeled demand of 20 charging stations	22 kW (0 kW)		N/A
Civic Center	Utility data (hourly interval)	135 kW (135 kW)	200 kW Generator	23%
Civic Center Annex	Utility data (hourly interval)	246 kW (139 kW)		15%
Public Safety Building	Utility data (hourly interval)	198 kW (142 kW)	450 kW Generator	23%

Acronyms and abbreviations: EV = electric vehicle; kW = kilowatt(s); PV = photovoltaic

Figure 3 shows the potential peak and annual offset of PV and energy efficiency measures on the cumulative demand of the four facilities for Prototype 1.

Figure 3: Prototype 1 Peak and Annual PV Offset



The cumulative demand peaks during daylight hours, which works well for maximizing the use of available PV resources. During blue sky conditions, on-site battery storage may be able to strategically charge and discharge to smooth out the remaining peaks in the demand profile, or arbitrate to reduce utility consumption during peak rate hours (pending regulatory feasibility). Annually, total consumption is relatively consistent. This is because space heating is supplied by gas-powered boilers and because cooling demand is relatively low in this climate. The potential energy efficiency retrofits may have a much greater impact on annual energy consumption than PV alone, and that the proposed PV installations produce more electricity in the summer than in the winter.

Table 8 summarizes the modeled performance of the Berkeley CEMC Prototype 1. Energy efficiency and renewable energy together can reduce utility electricity demand by up to one-third on an annual basis. During outages, these clean energy resources can reduce the existing diesel generator consumption by up to 40 percent (assuming peak generation).

This improved performance is observed while supplying power to the Civic Center Annex, which has no back-up power, and significantly increasing the functionality of all other facilities during an outage.

Table 8: Prototype 1 Summary of Results

Variable	Result
Annual Electricity Consumption	3,700 MWh
Annual PV Generation	480 MWh
Potential Energy Efficiency Savings	20%
Percent Renewable Electricity	16%
Baseline Annual Peak Demand	660 kW
Baseline Critical Peak Demand	410 kW
Baseline Peak Diesel Consumption	7,700 kWh/day (540 gal/day)
Peak Efficiency Savings for Critical Demand	800 kWh/day
Peak Daily PV Generation	2,400 kWh/day
Potential Reduced Diesel Consumption	4,500 kWh/day (320 gal/day)

Acronyms and Abbreviations: gal/day = gallons per day; kW = kilowatt(s); kWh/day = kilowatt hour(s) per day; MWh = megawatt hour(s); PV = photovoltaic

Prototype 3 does not interconnect the four city-owned buildings of Prototype 1. Rather, PV is installed at the Civic Center, and PV and battery storage are installed at the Public Safety Building and potentially at the Center Street Garage. Table 9 provides a summary of the modeling inputs used for this effort. Figure 4 and Figure 5 illustrate the potential performance of Prototype 3 at the Civic Center and the Public Safety Building, respectively, and Table 10 summarizes the results.

For Prototype 3, emphasis in the modeling is placed on the Public Safety Building and Civic Center, as these facilities comprise the majority of the new work. The Civic Center Annex will have energy efficiency retrofits performed, and the Center Street Garage will receive expanded PV with potential new storage (limited to NEM requirements). Since the Civic Center Annex and Center Street Garage will not serve significant resiliency functions during an outage, analysis of these facilities is not summarized in Table 9.

Table 9: Prototype 3 Summary of Modeling Inputs

Facility	Electricity Demand Source	Peak Demand Blue Sky (Critical)	Distributed Energy Resource	Energy Efficiency Potential
Civic Center	Utility data (hourly interval)	135 kW (135 kW)	200 kW Generator	23%
Public Safety Building	Utility data (hourly interval)	198 kW (142 kW)	450 kW Generator	23%

Acronyms and Abbreviations: kW = kilowatt(s)

Figure 4 shows the peak and annual offset potential of available PV and energy efficiency measures for the Civic Center. With only 10 kW of PV capacity available, the impact of peak generation is relatively minor. However, the potential impact of energy efficiency savings is much higher, highlighting the importance of implementing these cost-effective measures. Note that the 10 kW installed capacity translates to a projected 9 kW peak output. Further note that battery storage is not included because peak PV generation does not exceed peak demand. Annually, consumption is relatively consistent and does not show much variation due to weather. This is because space heating is supplied by gas-powered boilers and space cooling is not supplied to this location. The potential energy efficiency retrofits will likely have a greater impact on annual energy consumption than PV alone.

Figure 4: Civic Center Peak and Annual PV Offset

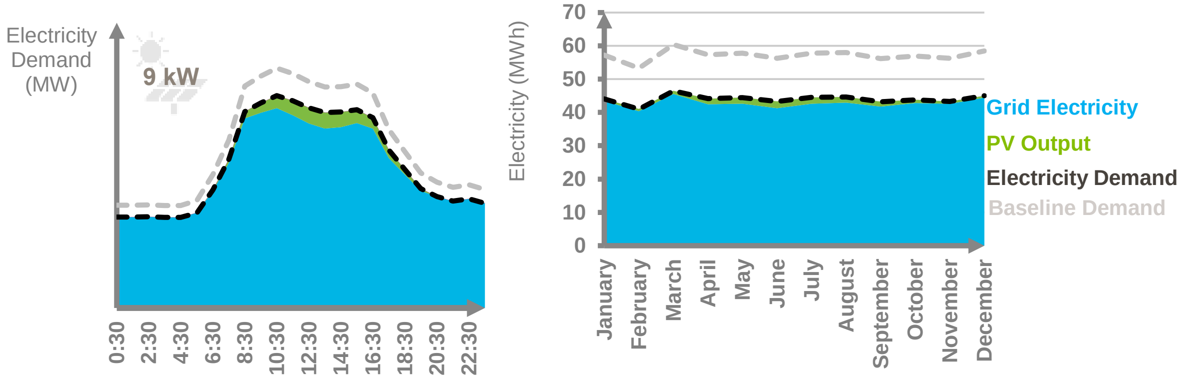


Figure 5 shows the peak and annual offset potential of available PV and energy efficiency measures. A combined canopy and rooftop installation of roughly 108 kW PV has the potential to offset the bulk of the daytime peak demand. The 108 kW installed capacity translates to a projected 95 kW peak output. Further, battery storage is not included because peak PV generation does not exceed peak demand. Annually, consumption is relatively consistent, with minor growth in demand during the summer for space cooling. The potential energy efficiency retrofits will likely have at least as great an impact on annual energy consumption as PV alone.

Figure 5: Public Safety Building Peak and Annual PV Offset

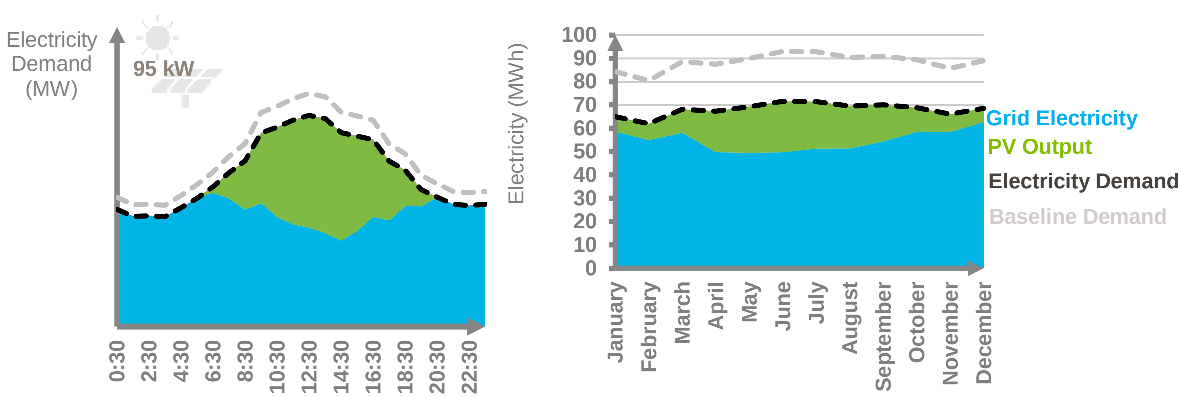


Table 10 summarizes the modeled performance of Prototype 3.

Table 10: Prototype 3 Summary of Modeled Performance

Variable	Civic Center Result	Public Safety Building Result
Annual Electricity Consumption	700 MWh	1,100 MWh
Annual PV Generation	15 MWh	160 MWh
Potential Energy Efficiency Savings (Percent of Annual Consumption)	23%	23%
Percent Renewable Electricity	3%	20%
Annual Peak Demand	140 kW	200 kW
Critical Peak Demand	130 kW	140 kW
Baseline Peak Diesel Consumption	2,200 kWh/day (160 gal/day)	2,900 kWh/day (200 gal/day)
Peak Efficiency Savings for Critical Demand	300 kWh/day	300 kWh/day
Peak Daily PV Generation	100 kWh/day	800 kWh/day
Maximum Reduced Diesel Consumption	1,900 kWh/day (140 gal/day)	1,800 kWh/day (120 gal/day)

Acronyms and Abbreviations: gal/day = gallons per day; kW = kilowatt(s); kWh/day = kilowatt hour(s) per day; MWh = megawatt hour(s); PV = photovoltaic

The results of each facility are shown separately because this prototype does not include facility interconnection. Major upgrades are limited to the Civic Center and the Public Safety Building; the Center Street Garage and the Civic Center Annex are therefore not summarized in Table 10. Energy efficiency and renewable energy together can reduce utility electricity demand by up to 25 percent at the Civic Center and 40 percent at the Public Safety Building on an annual basis. During outages, the clean energy resources can reduce the existing diesel generator consumption by up to 10 percent at the Civic Center and up to 40 percent at the Public Safety Building (assuming peak generation).

Compared to the modeled performance of Prototype 1, the improved performance at the Public Safety Building by itself in Prototype 3 is relatively similar (a 40 percent reduction despite increased functionality). The greatest benefit of Prototype 1 is that it shows a similar performance improvement across the whole portfolio of buildings while extending back-up supply to a new facility (the Civic Center Annex).

4.5.2. Financial Performance

The BEAT project is envisioned as a public asset that enhances resilience and provides social and environmental benefits to Berkeley residents during a natural disaster, rather than as a project that provides financial returns to a project developer. This has influenced CEMC design considerations related to sizing and inclusion of system components, such as energy storage and inter-facility distribution lines and, as result, the CEMC is not expected to generate a financial profit for the City of Berkeley.

Six financial scenarios reflecting potential development and operational configurations were modeled. The scenarios vary to examine the impact of factors that include PV sizing, PV location, and tariffs for energy exports. The results of these scenarios are presented in Table 11.

4.5.2.1. Scenarios Modeled

Each scenario consists of the four municipal buildings participating in the BEAT project—the Center Street Garage, Civic Center, Civic Center Annex, and the Public Safety Building. The other two non-City building participants from Prototype 2 (Berkeley High School and the YMCA) were not modeled, as there are no regulatory pathways or tariff mechanisms to share power or credits with multiple owners. As a result, their inclusion would not change the financial returns from the project.

The scenarios are modeled with the following key assumptions:

<u>System Configuration</u>:

1. *Solar location and capacity*: Scenarios have been modeled with either 318 kW or 436 kW of solar capacity. Scenarios with 318 kW assume that there is a single generating site at the Center Street Garage. Scenarios with 436 kW assume that there will be multiple generating sites and solar locations at the Center Street Garage, Civic Center, and Public Safety building.
2. *Inter-facility distribution infrastructure*: Scenarios 1 to 5 assumed new dedicated inter-facility infrastructure. Only scenario 6 was modeled with no inter-facility distribution infrastructure as a solar and storage-only alternative to represent Prototype 3.
3. *Energy storage*: Energy storage capacity has been assumed to be 300 kWh for all scenarios and is located at the Civic Center for Prototype 1 scenarios and the Public Safety Building for the Prototype 3 scenario.
4. *Energy efficiency retrofits*: All scenarios include low-cost energy upgrades, such as lighting and BAS, at the Public Safety Building, Civic Center, and Civic Center Annex. Payback periods for such low-cost energy upgrades are typically less than five years. The implementation of energy-efficiency measures at these buildings is expected to result in a 14 percent reduction in electricity purchases from the utility from current baseline levels. With a five-year payback period, it is assumed that the energy savings will accrue to the project in the 6th year of the implementation of energy retrofits.

<u>Energy Purchases</u>:

1. *Energy purchases from the utility:* All scenarios assume that CEMC participant buildings will continue to purchase electricity from the utility at the current applicable tariff E-19, which includes a charge for transmission and distribution (T&D).

<u>Energy Exports</u>:

1. *Tariff structure for energy exports:* For scenarios with a single generating site, financial returns from excess energy generated were modeled on the basis of utility-provided incentive programs of NEM and RES-BCT. However, for scenarios with multiple generating sites, financial returns from excess generation were modeled only on the basis of NEM because to be eligible for participation in the RES-BCT program, there can be only one generating site per arrangement. In addition to modeling on the basis of available utility-provided incentive programs, a potential aggregated or "single meter" condition was also analyzed. With "single metering," it was assumed that the city would be able to physically or virtually share renewable energy resources and thus offset coincident peak demand at multiple facilities.

    a. Scenario 1 was modeled to participate in the RES-BCT program. RES-BCT allows the city to receive only the generation component of the otherwise applicable retail rate (E-19) for surplus generation, which can be used toward offsetting use charges at the Public Safety Building, the Civic Center and the Civic Center Annex. Battery storage at the Civic Center would be used to offset demand only at the Civic Center.

    a. Scenarios 2, 3, and 6 were modeled to participate in NEM, which allows the generating accounts to receive the otherwise applicable retail rate (E-19). Credits that exceed the generating account's total annual demand would be reimbursed at a nominal wholesale rate at the end of the billing year. Each generating site would participate in NEM independently. Battery storage at the Civic Center would be used to offset demand only at the Civic Center, and battery storage at the Public Safety Building would be used to offset demand only at the Public Safety Building.

    b. Scenarios 4 and 5 were modeled to participate in NEM as well as allowed the "single meter" billing by the utility. Excess generated energy would be exported back to the grid to receive the otherwise applicable retail rate (E-19) or used to offset demand at other buildings. The battery storage at the Civic Center could also be used to offset demand at other buildings.

<u>O&M for Distribution</u>:

1. *O&M charges for distribution:* As the utility is assumed to take on the long-term responsibility of operating and maintaining the inter-facility distribution lines, appropriate O&M charges for this purpose were assumed. Operations and maintenance costs for transmission and distribution have been considered separately (consistent with industry practice) as well as for the purposes of energy purchases and energy exports.

    a. For energy purchases from the grid, T&D are covered under the otherwise applicable tariff (E-19).

    b. For energy exports to the grid/other facilities, no transmission infrastructure is required, and therefore O&M for transmission has been excluded from the analysis. Operations and maintenance for the inter-facility distribution infrastructure is assumed to be as follows:

i. Scenario 1 with RES-BCT tariff assumes that O&M for distribution lines is equivalent to the T&D charges for energy exports (as only generation charges are credited for excess energy).

ii. Scenarios 2 through 5 assume O&M for distribution lines to be equivalent to 0.5 percent of capital costs in the first year, and with 5 percent annual growth rate, consistent with LBNL research and FERC/U.S. Energy Information Administration guidance.[25, 26]

iii. Scenario 6 is assumed to have no inter-facility distribution lines.

4.5.2.2. Results

Overall, the IRR for the project is negative for all CEMC scenarios with inter-facility distribution infrastructure without external funding, and the financing gap is roughly equivalent to the capital cost of the inter-facility distribution infrastructure. This highlights the mismatch between the costs and the financial returns of the inter-facility distribution lines, as there is no regulatory guidance or utility tariff that encapsulates the operational resilience that these lines can provide to city buildings during an outage.

The project operations are revenue neutral if O&M charges could be capped at a rate of 0.5 percent per year on new distribution lines. However, currently under Rule 2, the O&M charges can be as high as 0.53 percent per month on new special facility infrastructure. The small net operating revenues will provide Berkeley with some buffer for operational risk and internal capacity building to learn how to successful govern and manage this project, which will be particularly important during the initial years of the project.

Prototype 3, the islandable solar + storage system, provides a positive return on investment, as this design alternative does not consist of the inter-facility distribution lines. Without the distribution lines, the overall capital and O&M requirements for the project are significantly reduced. Table 11 summarizes these results.

Table 11: Summary of Financial Performance

Scenario #	1	2	3	4	5	6
Prototype	Prototype 1	Prototype 1	N/A	Prototype 1	N/A	Prototype 3
Scenario Name	318 kW w/ RES-BCT	318 kW w/ NEM	436 kW w/ NEM	318 kW w/ NEM & Single Meter	436 kW w/ NEM & Single Meter	Solar + Storage only
System Configuration						

25 Source: Peter H. Larson. 2016. A Method to Estimate the Costs and Benefits of Undergrounding Electricity Transmission and Distribution Lines. Lawrence Berkeley National Laboratory and Stanford University. October 2016.

26 Note that this is not the current rate structure for Electric Rule 2.

Scenario #	1	2	3	4	5	6
Solar						
Solar Location	Center Street Garage	Center Street Garage	Center Street Garage, Civic Center, and Public Safety Building	Center Street Garage	Center Street Garage, Civic Center, and Public Safety Building	Center Street Garage, Civic Center, and Public Safety Building
Total Solar Capacity	318 kW	318 kW	436 kW	318 kW	436 kW	436 kW
Distribution						
Distribution	Yes	Yes	Yes	Yes	Yes	No
Distribution Operator	PG&E	PG&E	PG&E	PG&E	PG&E	N/A
Battery Storage						
Battery Capacity	300 kWh	300 kWh	300 kWh	300 kWh	300 kWh	300 kWh
Other						
Energy Efficiency Retrofits	Yes	Yes	Yes	Yes	Yes	Yes
Energy Purchases						
Rate	E-19	E-19	E-19	E-19	E-19	E-19
T&D Charges for Electricity Purchased from Utility	E-19 includes T&D charges	E-19 includes T&D charges	E-19 includes T&D charges	E-19 includes T&D charges	E-19 includes T&D charges	E-19 includes T&D charges
Energy Exports						
Tariff Structure	RES-BCT	NEM at Center Street Garage	NEM at Center Street Garage, Civic Center, and Public Safety Building	Single meter with NEM at Center Street Garage	Single meter with NEM at Center Street Garage, Civic Center, and Public Safety Building	NEM at Center Street Garage, Civic Center, and Public Safety Building
Distribution O&M (current assumption)	Equivalent to T&D charges per kWh of excess energy exported	0.5% of capital first year; 5% growth annually	0.5% of capital first year; 5% growth annually	0.5% of capital first year; 5% growth annually	0.5% of capital first year; 5% growth annually	N/A
Financial Results						

Scenario #	1	2	3	4	5	6
IRR before financing	–8.8%	–9.9%	–9.5%	–9.1%	–8.7%	0.9%
Net Operating Revenues (NPV)	$2.2 M	$1.5 M	$2.0 M	$1.8 M	$2.3 M	$2.7 M
Capital Costs[27]	$13.0 M	$13.0 M	$14.6 M	$13.0 M	$14.6 M	$4.0 M

Acronyms and Abbreviations: IRR = internal rate of return; kWh = kilowatt hour(s); kW = kilowatt(s); M = million; N/A = not applicable; NEM = Net Energy Metering ;O&M = operations and maintenance ;NPV = net present value; PG&E = Pacific Gas and Electric Company; RES-BCT = Renewable Energy Self-Generation Bill Credit Transfer program; T&D = transmission and distributionh

4.5.2.3. Sustainable Return on Investment

While the CEMC with distribution infrastructure provides a negative net-present value (NPV) to the city from a strictly financial perspective, the project is anticipated to support a range of social and environmental benefits, from greater community resiliency to reductions in GHG emissions. To measure these broader benefits of the Berkeley CEMC, a Sustainable Return of Investment (SROI) analysis was conducted to accounts for additional environmental and social benefits. The SROI benefit-cost analysis for the Berkeley CEMC consists of the following:

1. *Financial benefit*: With inputs from the financial model, the SROI accounts for project expenses (capital and operations and maintenance) as well as the financial savings.
2. *Environmental benefit*: Environmental benefit is calculated using the value of mitigated emissions from the use of renewable energy. Emission reductions from renewable energy use and their respective monetized values were calculated using U.S. Department of Transportation (DOT) and U.S. Environmental Protection Agency (EPA) standard values for CO2, CH4, N2O, SOx, and NOx.[28, 29, 30]
3. *Social benefit*: The social values for the SROI analysis consist of value of services provided during a grid outage due to the presence of the CEMC. The social value of services is calculated by measuring the value of the average energy demand during an outage[31] and adjusting this value with a continuity premium[32] to account for city services being more valuable to the community during a grid outage.[33]

27 Note: Capital costs may differ from the Conceptual Cost Estimate due to differences in modeling assumptions.

28 U.S. EPA. (2016). The Social Cost of Carbon.

29 U.S. EPA. (2010). Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis.

30 U.S. DOT. (2017). Benefit-Cost Analysis Guidance for TIGER and INFRA Applications.

31 This value was calculated using average price per kWh that City of Berkeley would pay to the utility and the annual average duration of an outage.

32 FEMA. (2009). BCA Reference Guide. https://www.fema.gov/media-library-data/1396550224865-548160e5f22dabb793d8a045fa89f5fe/bca_reference_guide_508_final.pdf/.

33 Continuity premium is a multiplier or adjustment that places a higher dollar value on critical services. Critical services such as fire, police and medical that are essential to the post-disaster response and recovery are worth more to the community in the immediate post-disaster period. Such services are valued more highly by adding a continuity premium or a multiplier on the normal daily cost of operations. A continuity premium of up to 5 may be assumed for

When these additional benefits are monetized, they contribute up to $11.3 million (NPV) over a 20-year analysis period for a single three-day outage event, resulting in a positive IRR.

This makes the case for developing standardized methodologies and values for evaluating the community benefits of microgrids, including resilience and environmental benefits. Evaluating these benefits would help build the case for microgrids and allow them to compete more effectively with other projects in the market. Standardized methodologies and values would support the ability of local governments to finance such investments and reduce dependence on external funding. In addition, standardizing a method for the measurement of resilience benefits, for example, could also support adoption of a community-wide resilience fee that encapsulates the resilience benefit provided by the CEMC to the wider community. This fee could result in a new financial revenue stream for the CEMC, enhancing the overall financial performance of the CEMC.

For Prototype 3, a detailed SROI analysis was not conducted, but general differences from the Prototype 1 SROI analysis include the following. Broadly, the similar level of benefits paired with the significant reduction in project expenses makes Prototype 3 a potentially more attractive option under current regulatory and policy conditions.

1. *Financial benefit*: Prototype 3 has much lower project expenses due to the lack of distribution infrastructure. Financial savings are slightly lower because peak demand charges are not able to be aggregated.
2. *Environmental benefit*: Mitigated emissions for Prototype 3 are slightly lower, because PV generation at the Center Street Garage may be limited to annual consumption per NEM requirements (this will depend on real-world electricity demand from the EV charging stations, which may be great enough for the electricity meter to exceed annual PV generation).
3. *Social benefit*: For Prototype 3, the city has a reduced capacity to serve the community during an outage compared to Prototype 1, because the four municipal buildings would not be able to share distributed energy resources (DER). The Civic Center Annex will remain unpowered during an outage because it lacks on-site energy resources, and the Civic Center will not be able to endure as long of an outage because its small on-site PV generation capacity existing on-site diesel storage. However, the Public Safety Building, which houses the majority of community services (especially emergency response), will have the same or greater performance during an outage for Prototype 3.

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emergency services in the event of a disaster event such as earthquakes or hurricanes. As the Berkeley CEMC may provide a combination of emergency and non-emergency services during a grid outage, a conservative continuity premium of 2.5 is used.

CHAPTER 5: Key Considerations for Other Communities

Municipally owned, community-oriented, clean energy microgrids are in an early stage of development, which results in ambiguity and a lack of a clear regulatory, technical, and financial path for their successful development, implementation, and operation. A major goal of the Berkeley CEMC analyses was to identify the barriers and address these questions in a way that supports development of a CEMC not only in Berkeley but in cities throughout California. This chapter outlines the most significant considerations and challenges for CEMC development, and offers recommendations for addressing these in CEMC development from regulatory, technical, and financial perspectives. Although the BEAT project also focused on solar + storage as a first-step towards CEMC development, this section is about advancing fully-connected CEMCs. Although the concepts discussed are most applicable to jurisdictions within California, there may be relevant process-related lessons learned for those outside of California.

5.1. Regulatory Consideration for CEMC Implementation

No federal or local regulatory barriers to CEMC development were identified, but there are State of California regulations and utility rules or business practices that present challenges for multi-facility and multi-owner CEMCs. The main regulatory challenges to advancing CEMCs are at the State level under the CPUC code or as part of utility policies and practices. This section includes considerations and lessons learned for communities interested in pursuing CEMCs.

State Regulations:

1. *Operation across the PROW:* A multi-facility microgrid or CEMC that crosses the PROW must be owned and operated by a utility—either an IOU or a municipal utility (per CPUC Rule 218(b)). Therefore, a city-developed microgrid that crosses the PROW would need to either negotiate an arrangement with the local utility to use existing distribution lines that are already owned and operated by the utility or would need to construct new distribution lines and then have the local utility take on the long-term responsibility for owning and operating the inter-facility distribution lines. Alternatively, if a city is a municipally-owned utility district or chooses to become one, it could own and operate microgrid inter-facility lines.
2. *Regulations related to tariffs and interconnection:* The CPUC sets tariff rules, such as NEM, or RES-BCT for governments, to ensure utilities offer financial credit to customers who generate excess renewable energy power for their individual buildings. These tariffs allow individual buildings to receive some utility credit for blue sky operations. However, there is no CPUC guidance or utility rate structures to support a microgrid tariff for power generated within the microgrid during a grid outage.
3. *Additional tax for new infrastructure projects deeded to the utility:* When new infrastructure is installed and deeded to the utility to own and operate, such as new

distribution lines for a microgrid, there is a one-time federal and state tax called the Income Tax Component of Contributions (ITCC) Provision that applies. This is a charge to cover the local utility's resulting estimated liability for federal and state income tax, and is passed through to the entity that deeds over those assets. For PG&E territory, the amount of this tax is 24 percent of the gifted amount for contributions received by PG&E in 2018, 27 percent for contributions received in 2019, and 34 percent for contributions received in or after 2020. This can be a significant additional cost to an expensive capital project to install new distribution lines, and should be included in the financial analysis for any projects that require new infrastructure that will be gifted to the local utility.

Utility Policies and Discretion:

1. *Use of existing distribution lines:* For microgrids in dense urban areas, existing distribution lines can have thousands of customers, and there can be hundreds of customers between microgrid buildings even if those buildings are in close proximity. Through conversations with the local utility, the BEAT team understands that during an outage all non-microgrid customers would need to be individually shut off, and the utility would require a contract agreement with those customers for the microgrid to isolate. When many customers are impacted, this approach will be infeasible. Therefore, to isolate microgrid-connected buildings from the rest of the grid, the microgrid must either construct new, separate distribution lines specifically for the microgrid, or have an agreement with the utility to install smart technologies and automatic shutoffs on the existing distribution lines that would allow the microgrid buildings to island from the grid. Because of the cost of trenching, constructing new distribution lines may be infeasible for many projects. If existing distribution lines could be used, this would significantly reduce the capital costs of CEMC projects. The technology to virtually turn customers off on a distribution line may be available, but would need to be adopted by local utilities.

2. *Sharing power within the microgrid across multiple meters and multiple accounts:* The utility has the discretion to allow multiple buildings participating in a microgrid to aggregate power similar to a single meter or master meter at the point of interconnection. There is no tariff that would allow a CEMC that incorporates multiple facilities either owned by a single party or different parties to share power or credits in blue sky or outage operations. If such a tariff were to exist, this could provide some cost benefits for these systems and would be a financing mechanism to support the development of CEMCs. This type of tariff would also enable microgrids to maximize the use of building automation controls and distributed energy resources to optimize the microgrid's benefits.

3. *Cost of O&M for new distribution lines:* Utilities have the discretion to develop distribution O&M rate structures for the microgrid distribution infrastructure that are based on the actual costs of operating the microgrid rather than standard utility practices, such as those that relate to the use of standard tariffs (which include full

transmission and distribution costs) and special facilities. Current O&M costs for the distribution of power from new distribution lines are subject to Rule 2, which is 0.53 percent per month of the cost of ownership or the "estimated installed cost of that portion of the existing facilities which is allocated to the customer."[34] This can be an extremely high cost, as new distribution lines are very expensive. These costs are at the discretion of the utility unless the rules are clarified with a CPUC ruling to specifically allow special projects that serve the public good, such as microgrids, to not be burdened with these fees.

Possible Future Tariff Options: There are several future opportunities that may result in more tariff financially beneficial options for a CEMC. Some options, which could potentially enhance the financial performance of multi-facility CEMCs, include:

1. *Single meter arrangement*: A single meter (or master meter) would address the limitations of existing tariffs, as it would allow for energy resources to offset coincident peak demand at multiple facilities.
2. *Community Choice Energy (CCE)*: As CCE's typically engage in advancing energy resilience through microgrids and other renewable energy solutions, they may offer more competitive rates for renewable energy exports. CCE's cannot own transmission and distribution infrastructure, but they may own generation and ancillary services equipment. East Bay Clean Energy (EBCE), a forthcoming CCE that will provide retail electricity service in Alameda County, could potentially own and operate the Berkeley CEMC generation and storage assets, but leave the distribution infrastructure to be owned by the utility.
3. *Formation of a municipal utility*: As a municipal utility, local governments would have more flexibility in setting their own tariffs and fees for customers. Municipal utilities' tariff rate offerings have been observed to be more competitive and some have more innovative rate designs (as compared to their IOU counterparts) to promote resilience, energy security, and energy diversification within their service areas.[35] However, municipalization is a complex and time-consuming process, and may not be feasible for some jurisdictions.
4. *Resilience fee:* Another possible future opportunity to advance deployment of CEMCs would be for local governments to work with their local utility to develop a community-wide resilience fee that encapsulates the value of resilience benefits provided by the microgrid to ratepayers within the CEMC's service area. This would result in a new revenue stream for the microgrid, enhancing its overall financial performance.

34 Pacific Gas and Electric Company, Electric Rule No.2 Description of Service, 1990. Accessed March 29, 2018, https://www.pge.com/tariffs/tm2/pdf/ELEC_RULES_2.pdf.

35 Value of Solar Tariff is an example of an innovative rate design that has been implemented in several municipalities of Texas, Arizona, and Minnesota to appropriately compensate residential and commercial solar power generators.

5.2. Operational and Design Considerations

When designing a CEMC, there are several considerations, including who should be involved, and how the design could be optimized.

CEMC participants: A variety of partnerships can play an important role in the successful implementation of CEMCs. They include the following:

1. *Local governments:* Local governments are concerned with a broad range of societal benefits. Even if local governments do not have direct ownership of the project, they can play a critical role in establishing community priorities in relation to the CEMC, facilitating CEMC development and fundraising for the project.
2. *Local utility:* The local utility should be engaged early in the development process to ensure successful implementation of the CEMC. Utilities have information about the existing distribution infrastructure that can help determine the optimal CEMC configurations. In addition, negotiation with the utility may be required to determine investment, ownership, and operation rights over either new or existing distribution infrastructure for the CEMC, particularly as only a utility entity may own/operate inter-facility distribution infrastructure.
3. *Private energy service providers:* Because of the technical expertise required to plan, build, and operate microgrids, partnerships with private energy service providers are important, particularly for municipalities with little technical expertise in the area. Energy service companies also have expertise in emerging technologies and innovative financing techniques, and can play a key role in securing funding for the project.
4. *Third-party microgrid customers:* The inclusion of third-party microgrid customers has the potential to enhance CEMC benefits and project economics, as new sources of revenue such as resiliency fees or mobile storage options become more viable. Third-party customers may include major businesses that require uninterruptable power, hospitals, medical facilities (including pharmacies), supermarkets, key transit agencies, and other community amenities.

Operational and Governance considerations: State regulations limit who can own and operate electrical distribution networks that cross the PROW. Opportunities to navigate these regulations as they pertain to CEMC components include:

1. *Governance considerations:* Municipal ownership of the generation and storage assets would be the most beneficial option for local governments interested in CEMC development and is not prohibited by State regulation. CPUC regulations require the CEMC distribution network to be owned by a utility. If a utility is not building the microgrid, then the ownership of any distribution lines and other equipment necessary for the CEMC would need to be transferred to the utility. Alternatively, if the local government became a municipal utility, it could own the microgrid distribution lines. However, as discussed, this may not be feasible for many jurisdictions.

2. *CEMC operation*: As current regulations restrict the distribution of power by a non-utility entity, operation of the CEMC's distribution network would have to be the responsibility of a utility during blue sky conditions. There is greater flexibility in the operation of the generation and storage assets, and both municipal and private operation of these assets would be permitted. Private or joint operation is recommended, particularly for local governments with little experience in operating energy systems.

Coordination with local utility: Recommendations for collaboration with the local utility regarding their participation in the ownership/operation of the CEMC are as follows:

1. *Utility expertise*: The utility's expertise should be leveraged in CEMC development as utilities have information on existing electrical infrastructure and preferred specifications for equipment, interconnection requirements, and can provide high-level cost estimates.
2. *Regulatory or tariff changes*: Explore possible avenues for advancing CEMCs for municipal use by supporting regulatory or tariff/pricing changes in collaboration with the utility.
3. *Use of existing distribution lines*: Explore the possibility of using existing distribution lines to connect CEMC buildings, as opposed to trenching new lines. If utilities are able to find a way to virtually shut off customers on an existing distribution line in a manner that would still enable automatic islanding during outage mode, this would significantly reduce the cost of building a CEMC.
4. *Alternative metering configurations*: Explore different metering configurations that allow a CEMC to share energy resources across multiple facilities and owners. This could enhance the financial performance for a multi-facility CEMC.
5. *Ownership and operation of distribution lines*: Negotiate ownership/operation of the inter-facility distribution infrastructure. Unless a local government is a municipal utility, it is likely that the local utility would take on the long-term responsibility for maintaining and operating the inter-facility distribution network. This would require resolving questions such as responsibility for operations during blue sky, island, and transitional phases as well as the appropriate charges for O&M.
6. *Clarify CPUC guidance of CEMC operation*: In general, there is limited CPUC guidance related to several aspects of CEMC operation. These aspects include aggregated billing, T&D, and O&M charges for new inter-facility distribution lines deeded to the utility, operation of CEMCs during grid outages, and tariffs for power generated during a grid outage. As such, utilities do not have clear direction on how to work with local microgrids even though microgrids provide back-up support to the main utility grid and greater resilience for critical needs. It is usually at the local IOUs discretion to provide accommodations on a case-by-case basis. This creates uncertainty, slows the deployment of local CEMCs, and ultimately makes microgrids more expensive.

Considerations for CEMC design: A CEMC consists of many components that together comprise a complex electrical system. Design considerations vary by system component and include the following:

1. *Solar and storage:* Solar generation assets have been observed to have strong financial performance, and as result, the approach to PV sizing is to maximize PV located on site. Energy storage assets can have varying degrees of contribution to the overall financial performance based on a variety of factors, including time-of-use tariffs and variability between energy generation and building demand. This could result in a cost-optimal battery storage being sized to be significantly smaller than would be able to withstand a multi-day outage. As such, the sizing of storage in CEMC design may be influenced by factors in addition to financial performance, such as CEMC objectives and system performance objectives. For example, for resilience-oriented CEMCs, battery storage sizing may be guided by duration targets to maintain operations without reliance on back-up diesel generators and the associated on-site fuel supply.
2. *Inter-facility distribution lines:* In current conditions, while inter-facility distribution lines do not provide any direct financial returns to CEMCs, they do provide substantial resilience benefits, such as facilitating transfer of energy to critical uses during grid outage events. However, they are a substantially more expensive investment than solar and storage alone. As such, the decision to include inter-facility distribution lines in CEMC design will depend on the ability to finance them and/or the availability of alternative design options that achieve similar resilience outcomes. An alternative approach is solar + storage, which is more cost-efficient because it does not require new distribution infrastructure; however, this approach does not allow the aggregation of power in blue sky or outage conditions.
3. *Energy efficiency and BAS:* Energy efficiency retrofits and BAS are considered to be complimentary to renewable energy projects, as every unit of energy consumption reduced means a greater proportion of total demand can be served by on-site energy resources. Low-cost energy upgrades, such as lighting and BAS, can result in substantial energy demand reductions and have payback periods of typically less than 5 years.
4. *Physical constraints:* Within a microgrid configuration, some buildings may have roof capacity for solar and some may have capacity for storage, while others may be critical facilities that serve a public benefit in the event of a power outage. Such physical constraints may mean that the solar and storage cannot be co-located and/or may require inter-facility distribution to provide energy to critical facilities from solar generators at other facilities. These physical constraints can have significant implications for the technical, regulatory, and financial design of the project, and are more likely to arise for CEMCs that are being integrated into existing buildings and infrastructure.
5. *Design approach for future expansion:* CEMCs are in their emergent phase. The roles of utility companies, consumers, and energy producers are still developing, as is the

microgrid technology. To take advantage of a changing environment, it is critical to design plans to be as flexible as possible. It also may make sense to start with a more basic modular microgrid that is designed to be able to grow. If and when more facilities or renewable energy resources are brought online, a modular approach will make it easier to expand the generation and storage capacity and other factors appropriately. Designing to accommodate future expansion should include considerations for spare capacity in distribution infrastructure (e.g., provision of spare conduits and spare connectors for selector switches, equipment sizing for future load increases) and allocation of additional space for system components such as PV and batteries.

5.3. Business Model Considerations

Although no preferred business model for California's local governments interested in using a CEMC, many cities will share priorities regarding CEMC operations and government funding approaches, and will face the same state of financial markets. Some considerations include:

1. Funding *support*: Government or other types of seed funding will continue to be necessary to advance the deployment of CEMC projects until such projects are considered to be mainstream investments with standardized methods for evaluating their benefits and performance. As a result, nearly all existing CEMCs have secured direct financial support from state or federal governments to cover part of the transaction and development costs.

2. *Project scale*: Multi-user microgrids can enhance project economics with the aggregation of multiple, complimentary loads. The inclusion of third-party customers, in particular, has the potential to enhance CEMC benefits by supporting the operations of key community amenities, such as medical centers, supermarkets, pharmacies, and gas stations. Inclusion of third-party users also has the potential to enhance project economics through tariff mechanisms (as they become available) that would allow for use fees to be charged to other third-party customers.

3. *Managing profitability*: Profitability may be limited for CEMC projects when resilience has guided their development, which results in decisions related to sizing or inclusion of microgrid components such as storage and inter-facility distribution lines to be motivated by community resilience benefits rather than by cost optimization. For example, inclusion of inter-facility distribution lines and sizing of the battery storage for the worst-case outage condition (for example a multi-day outage caused by a major disaster) may result in higher capital costs than could be recovered solely from project-generated revenues in current regulatory and market conditions. From a purely financial perspective, such projects would result in negative returns on investment. Instead, alternative measures of performance (such as SROI or TBL analyses), which include a wider range of community benefits in their measurement of project performance, may be used to more effectively represent the value proposition of such projects to stakeholders and potential project financiers until these benefits are able

to be monetized through regulatory changes. For example, the inclusion of monetized resilience and environmental benefits in a SROI analysis may result in a positive return on investment on a project that may have a negative return on investment in a traditional financial analysis.

CHAPTER 6: Recommendations to Advance Development of CEMCs

Further development of the microgrid market is critical to advancing deployment of community microgrids in California and beyond. A majority of microgrid projects, especially those providing community resilience benefits, have been realized through seed investments provided by state and federal government entities or by vendors and project developers proving the effectiveness of their technology. While these approaches have been important for creating pilot or demonstration projects, they have limited the commercial-scale use of CEMCs.

Moving from a project-by-project basis to commercial-scale use of CEMCs will require enhancing the availability of project financing, regulatory changes that enhance cost recovery during normal demand conditions, and technical or market developments that reduce upfront capital requirements. Some future opportunities lie in the following:

- *Clarification of Rule 218(b) or a new CPUC Rule:* If the CPUC were to allow commonly-owned buildings participating in a microgrid to aggregate power across the public right-of-way, then this would eliminate the barriers caused by CPUC Rule 218(b) and allow cities to develop CEMCs without having to become a municipal utility.
- *Clarification of Rule 21 interconnection and tariff rules for the islanded operation of systems*: None of the existing tariffs under Rule 21 clarify the governance of CEMC operation in islanded mode. While back-up generation may be allowed to operate during a grid outage, there is no guidance to support a utility tariff for microgrid-generated power during the outage or regarding non-utility operation of inter-facility distribution lines during the outage. This limits the ability of multi-facility CEMCs to recover project costs and/ or distribute power to third-party customers. Clarification of this rule would help to advance CEMCs.
- *Development of tariff and agreement by utilities to allow energy to be shared across multiple meters and multiple accounts, in blue sky and outage conditions*: Currently there is no tariff that would allow a CEMC that incorporates multiple facilities owned by different parties to share power or credits, and such agreements would be at the discretion of the utility. If such a tariff were to exist, it could provide some cost benefits for these types of systems and would be a financing mechanism to support the development of new inter-facility distribution lines that may be critical to CEMC operation during a power outage.
- *Reduced rate calculation or exception to Rule 2 for O&M costs of microgrid infrastructure:* The application of Rule 2 to microgrids is currently performed on a case-by-case basis. However, if the O&M for new distribution lines are subject to Rule 2, then the costs to

build and operate a CEMC become prohibitively expensive. If the rate was adjusted to better reflect the true cost of service it could encourage new microgrid development.

- *Rate structures:* Rates for electric power in California are regulated through the CPUC. The development of new rates and tariffs in California requires a comprehensive rate setting process and associated study of impacts. New tariffs and other financial mechanisms have been developed to provide incentives to adopt specific technologies, such as PV and battery storage, which support State interests around renewable energy and climate change. Assuming certain types of microgrids can provide benefits that support the State's goals as well as community resilience benefits, a microgrid-specific rate structure could eventually be developed and adopted. Additionally, because rate structures and associated regulations related to the ability of multiple legal entities to share on-site power play key roles in determining the feasibility of urban microgrids, these changes would be expected to have positive impacts on long-run feasibility of advancing CEMCs.
- *Rule development:* The CPUC, IOUs, and CCEs could keep microgrids, CEMCs, and solar + storage systems in mind when putting together new rules related to storage.
- *Greater coordination among the multiple federal and State agencies that develop building codes and standards:* Although local jurisdictions adopt and enforce the code, federal and State agencies should take active steps to harmonize the code requirements for CEMC-enabling technologies, systems, and related building practices. For example, in California multiple Building Code sections, including Electrical, Mechanical, Energy, and Fire codes will affect CEMC requirements, and these codes fall under the authority of two separate agencies, the Building Standards Commission and the Energy Commission.
- *Increased understanding of opportunities and best practices for local jurisdictions to amend and revise existing franchise agreements to require terms that are favorable to CEMC deployment*: Although this recommendation is not necessarily a regulatory change, it does present a potential strategy that local governments may be more likely to pursue with the proper information and support. Given the costs and logistical challenges related to any requirement to run new distribution lines for a CEMC, if existing distribution lines can technically support proposed projects, then local jurisdictions should have the tools necessary to evaluate all opportunities to secure the cooperation of existing utility providers to access existing lines. Tools could include template language for CEMC-friendly franchise agreements and best practices for the negotiation of existing and new/reissued franchise rights.
- *Project aggregation:* As small community microgrids on a stand-alone basis are likely to have limited revenue potential, they could be bundled together to create a more attractive portfolio of assets with a larger scale. The aggregated scale of the assets' value may then be sufficient to justify a financiers' consideration through reducing transaction costs, diversifying cash flows, and standardizing collateral. This method has proven successful in a number of industries. While there is potential in aggregating

microgrid projects, putting this concept into practice is likely some years off in the future, and will require regulatory support to minimize the adverse exposure to both asset owners and financiers that may occur in markets with insufficient regulation to identify, define, and mitigate risk.[36]

- *Bundling of utility installation*: In addition to the bundling of microgrids into a portfolio, bundling installation of distribution lines with other services that also require similar installation processes can help to reduce the financial burden of CEMC development. Note that this would be of benefit only to CEMCs with multiple facilities requiring the installation of a new distribution network. By bundling the installation of services such as fiber and inter-facility distribution lines for CEMCs, the installation costs (e.g., trenching costs) can be distributed among different entities, reducing the cost to any single party. This would substantially reduce the upfront capital costs.
- *Reduced insurance premiums*: For microgrids that offer back-up power capacity, the uninterrupted supply of energy would reduce impacts from extreme weather events, such as interruption of critical government services or business operations, and as a result, would have the potential to reduce insurance premiums in the future that relate to risks to these activities. Advancement of this value stream is likely to require further market maturity of CEMCs and collaboration with insurance companies, reinsurance companies, and other entities that are knowledgeable and willing to underwrite the performance risk of CEMCs. CEMCs and their value stream could be supported by the use and further development of insurance products that target catastrophic risk reduction.
- *Inter-facility distribution lines*: In the current regulatory environment, inter-facility distribution lines do not provide direct revenues but still account for a large portion of the capital expenses related to the project. In the case of the Berkeley CEMC, the inclusion of inter-facility distribution lines results in a negative return on investment for the project as a whole, while solar + storage alone would result in a positive return on investment. However, inter-facility distribution lines are key to creating a CEMC designed for resilience under current conditions. They enable facilities to transfer energy to critical uses during grid outage events. As such, during major outage events with outages lasting multiple days, the project benefits (when resilience benefits are monetized) tend to exceed the project costs. Thus, to advance the market for microgrids, it will be necessary to create incentives, such as utility fee structures targeted for physical inter-facility infrastructure, or find a way to utilize existing distribution lines.
- *Time-of-use rates:* There is less financial benefit from energy storage systems when solar output and building demand overlap. The greater the difference between the time when solar power is generated and the time when energy is consumed, the greater the

36 Strahl, J., Vogel, L., and E. Paris. 2016 (May). The bankable microgrid. Decentralized Energy. Retrieved from http://www.decentralized-energy.com/articles/print/volume-17/issue-3/features/the-bankable-microgrid.html.

financial benefit of the battery storage during blue sky conditions. This is because batteries generate revenue from storing generated energy until demand is more expensive. As such, energy storage solutions have been seen to be most financially attractive for buildings or customers with high demand in the evening and nights. However, for buildings or customers that consume energy during the day (as most municipal buildings do), which coincides with the time when solar energy is produced, the need for the battery to store the energy for later use is reduced, as is the financial benefit. Changes in time-of-use rates could change these results. Currently, peak demand charges occur during mid-day, during peak solar output. This means that solar output during the day should be used toward building demand to reduce purchases of peak-charge electricity from the utility. However, in the future, if peak demand charges occur in the evening, the battery storage may play a more substantial role in supporting the financial returns of PV. For instance, during the day, solar generation may be used toward energy storage, which could be used to offset the higher price of energy in the evening.

- *Standardized methodologies for alternative measures of performance:* The development of standardized methods and values for evaluating the wider community benefits of microgrids, including resilience and environmental benefits, would help build the case for microgrids and allow microgrids to compete more effectively with other projects in traditional financial markets. This would support the ability for local governments to finance such investments and reduce dependence on state funding. In addition, standardizing a method for measuring resilience benefits could also support adoption of a community-wide resilience fee that encapsulates the resilience benefit provided by the CEMC to the wider community. This fee could provide a new financial revenue stream, enhancing the overall financial performance of the CEMC.

The list of recommendations represents just a few of the many opportunities available in overcoming policy, regulation, and finance obstacles. Many of these opportunities are multidisciplinary and cross-jurisdictional in nature, highlighting the need for ongoing partnerships between the myriad agencies and stakeholders involved in CEMC development (. Energy Commission, CPUC, local utilities, municipalities, etc.). Partnership and collaboration, with a shared vision for enhanced community resilience and environmental benefits, will be crucial for making the necessary changes to advance the commercialization of CEMCs, solar + storage systems, and other public-purpose microgrids.

GLOSSARY

Term	Definition
ABAG (Association of Bay Area Governments)	A regional planning agency that incorporates local governments in the San Francisco Bay Area in California.
ATS (Automatic Transfer Switch)	An electrical switch that switches a load between two sources, such as switching serving a building load from the utility grid to an alternative generation source.
AUP (Administrative Use Permit)	A discretionary permit that, depending on the type and size of the enclosure, may take several months to obtain.
BAS (Building Automation System)	A digital control system installed in buildings that controls and monitors the building's mechanical and electrical equipment, such as ventilation, lighting, power, fire, and security systems.
BayREN (Bay Area Regional Energy Network)	A collaboration led by ABAG that implements energy savings programs at the regional level.
BEAT (Berkeley Energy Assurance Transformation)	A project to explore opportunities for cities to create innovative approaches for increasing energy resilience for critical facilities while reducing greenhouse gas emissions.
battery storage	An electrochemical system used to store electrical energy.
BSC (California Building Standards Commission)	A commission established to manage processes relating to the development, adoption, publication, and implementation of California's building codes.
California ISO (California Independent System Operator)	An agency that oversees the operation of California's electric power system, transmission lines, and electricity market.
CCE (Community Choice Energy)	An alternative to the investor owned utility energy supply system in which local entities pool the electric load of their residents and businesses and purchase electricity on their behalf. The existing energy utility remains responsible for transmission, distribution, and billing.

Term	Definition
CEMC (Clean Energy Microgrid Community	A microgrid that uses clean energy generation sources like solar and energy storage in addition to, or in replacement of, fossil-fuel generation sources like diesel. CEMCs generate substantial value for the communities within their service area.
CEQA (California Environmental Quality Act)	A California statute passed to require State and local agencies within California to follow a protocol of analysis and public disclosure of environmental impacts of proposed projects, and to adopt all feasible measures to mitigate those impacts
CIP (Critical Infrastructure Protection)	A concept related to preparedness and response to serious incidents involving the critical infrastructure of a region.
city	The governing entity of the City of Berkeley, California.
CPUC (California Public Utilities Commission)	An agency that regulates privately owned public utilities in the state of California, including electric power, natural gas, telecommunications, and water.
cybersecurity	The protection of computer systems from the damage or theft of their hardware, software or information.
DER (Distributed Energy Resource(s))	Electrical generation and storage performed by a variety of small, grid-connected devices.
Distribution Infrastructure	The collection of equipment and other infrastructure that delivers electric power from the utility transmission system to individual customers. Primary distribution delivers medium-voltage (2 kV to 35 kV) power to transformers, and secondary distribution delivers the power at utilization voltage to individual customers.
California Energy Commission	An energy policy and planning agency established to reduce the costs and environmental impacts associated with energy use.
EPIC (Electric Program Investment Charge)	Created by the California Public Utilities Commission in December 2011, it supports investments in clean energy technologies that benefit electricity ratepayers of PG&E, Southern California Edison Company, and San Diego Gas & Electric Company.
EV (Electric vehicle)	A vehicle that uses electric motors for propulsion.
FERC (Federal Energy Regulatory Commission)	United States federal agency that regulates the transmission and wholesale sale of electricity and natural gas in interstate commerce.

Term	Definition
GHG (Greenhouse gas) emissions	Gasses, such as carbon-dioxide and methane, that, when released into the atmosphere, absorb and emit radiant energy within the thermal infrared range, causing the atmospheric greenhouse effect.
HMI (Human Machine Interface)	The space where interactions between humans and machines occur to allow effective operation and control of the machine from the human end.
IEEE (Institute of Electrical and Electronics Engineers)	A professional association that works for the educational and technical advancement of electrical and electronic engineering, telecommunications, computer engineering, and other related disciplines.
IOU (Investor-owned utility)	A business that provides a product or service regarded as a utility (such as electricity) and is a private enterprise rather than a public agency.
IRR (Internal rate of return)	A metric used to estimate the profitability of potential investments.
ISO (International Organization for Standardization)	An international standard-setting body that promotes worldwide proprietary, industrial and commercial standards. It is the world's largest developer of voluntary international standards.
ITC (Business Energy Investment Tax Credit)	A United States federal corporate tax credit that is applicable to commercial, industrial, utility, and agricultural sectors for expenditures related to the installation of certain energy technologies, including solar.
ITCC (Income Tax Component of Contributions)	When new infrastructure is installed and deeded over to a utility to own and operate, such as new distribution lines for a microgrid, there is a charge to cover the local utility's resulting estimated liability for federal and State income tax, and this charge is often passed through to the entity that deeds over those assets.
JPA (Joint power authority)	An entity in which two or more public authorities (e.g. local governments or utility districts) may jointly exercise any power common to all of them.

Term	Definition
Microgrid	"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."[37]
MSB (Main switchboard)	The component of an electrical installation where the main electricity supply current is divided into smaller currents for further distribution into the facility.
MUD (Municipal utility district)	A special-purpose district that provides utility services (e.g., electricity, natural gas, sewage treatment, waste collection/management, water) to district residents.
NEM (Net Energy Metering)	A policy that allows consumers who generate their own electricity to use that electricity anytime, rather than when generated. This allows, for example, excess summertime solar generation to offset electricity costs in the winter.
NEMA (National Electrical Manufacturers Association)	A trade association of electrical equipment manufacturers in the United States.
NERC (North American Electric Reliability Corporation)	A nonprofit corporation formed by the electric utility industry to promote reliable and adequate bulk power transmission in the electric utility systems of North America.
NIST (National Institute of Standards)	A measurement standards laboratory established to advance measurement science, standards, and technology.
O&M (Operations and maintenance)	Services including inspection, cleaning, servicing, lubrication, recalibration, etc., to extend the service life and efficacy of the equipment.
PG&E (Pacific Gas and Electric Company)	The investor-owned electric utility with jurisdictional authority in the City of Berkeley, California.
POU (Publicly owned utility)	A utility collectively owned by citizens of the area served by the utility.

37 Working definition from the U.S. Department of Energy Microgrid Exchange Group.

Term	Definition
PPA (Power purchase agreement)	A long-term financial arrangement in which a third-party developer owns, operates, and maintains the renewable energy system, and the buyer agrees to purchase the system's electric output at a predetermined rate for predetermined period.
PROW (Public right-of-way)	A type of easement granted or reserved over the land for transportation purposes, including vehicle, pedestrian, or rail, as well as electrical transmission lines, oil and gas pipelines.
PV (Photovoltaic)	A type of solar energy technology that converts solar radiation (i.e. light) into electricity using semiconducting materials that exhibit the photovoltaic effect, the creation of voltage and electric current in a material upon exposure to light.
RES-BCT (Renewable Energy Self-Generation Bill Credit Transfer)	A program for local governments or campuses that allows participants to transfer excess bill credits earned through on-site renewable energy self-generation to other eligible accounts within the organization.
RPS (Renewable Portfolio Standard)	A statewide regulation in California that requires the increased production of energy from renewable energy sources.
Electric Rule 21	A tariff that describes the interconnection, operating, and metering requirements for generation facilities to be connected to a utility's distribution system.
SCADA (Supervisory Control and Data Acquisition System)	A control system architecture that uses computers, networked data communications and graphical user interfaces for high-level process supervisory management of process plant or machinery controls.
SGIP (Self-Generation Incentive Program)	An incentive program to support existing, new, and emerging distributed energy resources.
SLD (Single Line Drawing)	A simplified notation for representing a three-phase power system, such as in power flow systems.
Solar + Storage	An alternative to the Clean Energy Microgrid Community (CEMC) design that includes clean distributed energy resources (DERs) at individual facilities to make them islandable from the electric grid during an outage without being interconnected with distribution infrastructure.
SROI (Sustainable return on investment)	An approach to identifying and quantifying environmental, societal, and economic impacts of investment in projects.

Term	Definition
SSIMde (Sustainable Systems Integration Model for District Energy)	A tool developed by URS Corporation and used to perform an initial technical feasibility assessment of potential building sites.
State	The State of California.
TBL (Triple Bottom Line) analysis	An accounting framework with three parts – social, environmental and financial –adopted to evaluate the performance of a business model from a broader perspective.
Transformer	A static electrical device that transfers electrical energy between two or more circuits through electromagnetic induction. In electric power applications, transformers are used to increase or decrease the voltages of connected circuits.
US EPA (United States Environmental Protection Agency)	An agency created to protect human health and the environment by writing and enforcing regulations based on laws passed by Congress.
US DOT (United States Department of Transportation)	A federal department concerned with providing an efficient and economic national transportation system.
ZNE (Zero Net Energy)	A title applied to buildings for which the annual amount of energy consumed by the building is roughly equal to the annual amount of renewable energy generated on-site.

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APPENDIX A: BEAT CEMC Prototypes and Building Information

This appendix provides additional information on the buildings being considered in the Berkeley CEMC Prototypes 1, 2 and 3. Table A-1 presents building information on the prototypes. Figure A-1 shows the building locations, and Figure A-2is a diagram of BEAT Clean Energy Microgrid Community (CEMC) Prototypes 1 and 2.

Table A-1: BEAT CEMC Prototypes – Building Information

Prototype	Building	Address	Owner	Critical Function	Existing PV Generation	Existing Diesel Generation
1, 2, 3	Center Street Garage	2025 Center Street	City of Berkeley	N/A	Yes, with future potential expansion	Yes
1, 2, 3	Civic Center	2180 Milvia Street	City of Berkeley	Housing Department, Department of Parks, Recreation & Waterfront, Department of Human Resources, Department of Health, Housing & Community Services, Department of Public Works, Department of Information Technology, Office of the City Manager, Office of the City Clerk, City Council Offices, Mayor's Office, Auditor's Office, Finance Department, Office of the City Attorney, Office of Economic Development	No, but future potential	Yes

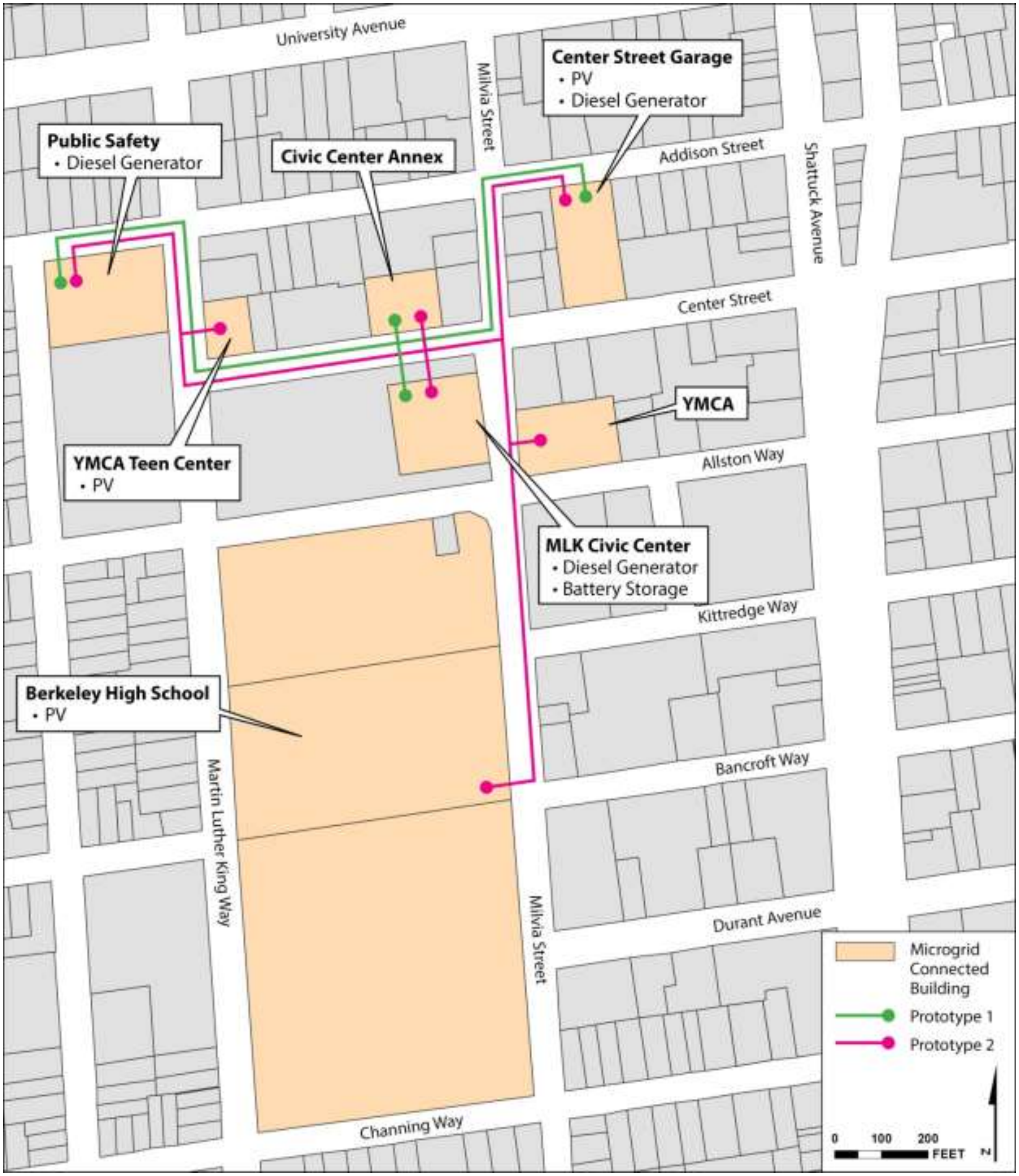
Prototype	Building	Address	Owner	Critical Function	Existing PV Generation	Existing Diesel Generation
1, 2	Civic Center Annex	1947 Center Street	City of Berkeley	Department of Planning & Development, Department of Public Works, Department of Health, Housing & Community Services, Finance Department, Police Review Commission	No	No
1, 2, 3	Public Safety	2100 Martin Luther King Jr. Way	City of Berkeley	Emergency Operations Center, 911 Call Center, Fire Department, Police Department.	No, but future potential	Yes
2	YMCA	2001 Allston Street	YMCA	Potential Care and Shelter Site	No, but future potential	No
2	YMCA Teen Center	2111 Martin Luther King Jr. Way	YMCA	Administrative Services	Yes, with potential future expansion	No
2	Berkeley High School	1980 Allston Way	Berkeley Unified School District	Potential Care and Shelter Site (gyms only)	Yes, with future potential expansion	No

Acronyms and Abbreviations:
CEMC = Clean Energy Microgrid Community
N/A =Not Applicable
PV = photovoltaic

Figure A-1: BEAT Building Locations

Source: Google Earth, March 2017

Figure A-2: Diagrammatic Representation of BEAT CEMC Prototypes 1 and 2



APPENDIX B:
Potential Business Models

This appendix provides a summary of business models and considerations for business model selection related to the ownership/operation of generation, storage, and microgrid control assets. (See Appendix C for considerations related to ownership/operation of distribution assets.) Table B-1 presents the summary of business model options, and Table B-2 presents the Strength/Opportunity/Weakness/Threat (SWOT) Model for each business model option.

Table B-1: Summary of Business Model Options

	1. Municipally Owned CEMC	2. Privately/Municipally Owned CEMC	3. Utility/Municipally Owned CEMC
Owned by	Municipal entity	Joint ownership by municipal entity and private energy developer	Joint ownership by municipal entity and utility/CCE
Operated by	Owner-operated with limited third-party assistance	Private-energy-developer-operated	Utility-operated
Financed By	Owner-financed	Joint financing	Joint financing
Financing Mechanisms	Owner may finance using a combination of internal financing, grants, bonds and/or private investment	Private energy developer may finance using grants, federal tax credits, and private capital to supplement municipal financing	Utility may finance using grants, federal tax credits and DER pilot funding to supplement municipal financing
Planned Contractual Agreements	Routine maintenance agreement	PPA	Joint-ownership and revenue-sharing agreement and PPA
Potential Revenue Streams	Load management, net energy metering (or virtual net metering for affiliated facilities), ancillary grid services, self-generation incentive, fees		
Potential Project Use and Benefits	Project benefits could include resilience (emergency back-up power), energy cost savings, energy source diversification, environmental benefits (GHG reductions)		
Pricing	Determined by applicable PG&E rate schedule(s)	Determined by terms of the PPA	Determined by terms of the PPA
Role of Utility	Interconnection with local utility; may include infrastructure support for inter-facility connections	Interconnection with local utility; may include infrastructure support for inter-facility connections	Utility may partly own generation and storage assets and will operate the system

	1. Municipally Owned CEMC	2. Privately/Municipally Owned CEMC	3. Utility/Municipally Owned CEMC
Possible Modifications to Business Model	Operations and maintenance (O&M) contract that extends beyond routine and preventative maintenance to a more engaged operations partnership with a specialized energy service provider	The municipal entity could increase or decrease its portion of financing of the CEMC in order to increase its autonomy or control of project outcomes	The municipal entity could increase or decrease its portion of financing of the CEMC, in order to increase its autonomy or control of project outcomes

Acronyms and Abbreviations:
CCE = Community Choice Energy
CEMC = clean energy microgrid community
GHG = greenhouse gas
PG&E = Pacific Gas and Electric

Table B-2: Business Model Strength/Opportunity/Weakness/Threat (SWOT) Model

Business Model	Strengths/Opportunities	Weaknesses/Threats
Municipally Owned CEMC	Municipal entity has full autonomy and flexibility in configuring/operating CEMC to meet desired objectives, e.g., prioritizing resilience. Municipal entity receives all financial returns from CEMC and can use these to fund a routine service agreement for maintenance of the CEMC. Municipal entity could develop expertise in CEMC O&M, and provide this service to other CEMCs.	Municipal entity takes on the entire burden for raising capital and the associated risk. Municipal entity may be responsible for CEMC operation, and takes on associated operating risk. This may require additional investment in staff training and/or hiring to develop the appropriate expertise for this task. CEMC operation may reduce capacity to provide other critical City services.
Private/Municipally Owned CEMC	Reduces burden on municipal entity of raising capital and reduces associated financial exposure. System performance risk is passed on to private energy developer/operator; system may perform more efficiently. Greater confidence in the ability of the CEMC to meet financial and operational targets with a specialized partner may enhance access to third-party/private capital. Has complementary strategic objectives, as municipal entities prioritize resilience while private microgrid developers would prioritize advancing the microgrid market and	Municipal entity may need to consider strategic objectives of private partner (e.g., financial returns, technology testing), which may need to be incorporated in CEMC configuration/operation to attract the partner. This may result in loss of full project autonomy. Municipal entity is likely to receive a smaller share of the financial return from the CEMC. Municipal entity would not develop in-house expertise in CEMC O&M, and would rely on a third-party developer/operator for CEMC operation. Performance and lifetime of new

Business Model	Strengths/Opportunities	Weaknesses/Threats
	demonstrating value of microgrids. Provides access to the latest technology from third-party developer/operator and potential for favourable financing terms to support new technology deployment.	technology may be less well established.
Utility/Municipal Owned CEMC	Utility expertise is leveraged in CEMC development, operation, and maintenance. Reduces burden on municipal entity of raising capital and reduces associated risk. Utility may be able/willing to develop rates to support CEMC objectives like resilience. Utility may be able/willing to support regulatory changes required to advance CEMCs for municipal use.	Loss of full project autonomy, as joint ownership would require compromising on project operations and outcomes. Strategic objectives of the two entities may be less aligned for small-scale CEMCs, as they do not significantly reduce utility infrastructure burden. Process for determining the legal and financial aspects of setting up a joint-ownership entity may be a lengthy process and require additional soft costs. Utilities may require longer time frames compared to private entities to engage in and commit to new business approaches. Utility capacity to operate CEMC during outage conditions may be limited.

Acronyms and Abbreviations:
CEMC = clean energy microgrid community

APPENDIX C:
Comparison of Ownership/Operation Options for Distribution

As current regulations restrict the distribution of power by a non-utility entity, operation of the CEMC's distribution network would have to be the responsibility of a utility (either an investor-owned-utility [IOU] or municipal utility) during blue sky conditions. While it would be consistent with past practice to transfer ownership of any distribution lines and other equipment to the IOU, a local government could also own the distribution lines, especially if it were paying for the asset. Another option available to the local government would be partnering with another existing municipal utility district (MUD). The key considerations related to these different options for ownership/operation of distribution assets are presented in Table C-1.

Table C-1: Comparison of Ownership/Operation Options for Distribution

Ownership/ Operation of Distribution Assets	Strengths/Opportunities	Weaknesses/Threats
Investor-Owned-Utility (IOU) Ownership/ Operation of Distribution	If the clean energy microgrid community (CEMC) lies within the existing service territory of the established incumbent IOU, no regulatory changes required for the IOU to assume operation of the assets. Established tariff structures for use charges as well as excess generation. Most clearly defined ownership/operation model and as such, most commonly adopted. Least uncertainty related to CEMC operation and financial performance in this model. Replicable model for other jurisdictions in IOU territory.	The CEMC's financial performance is subject to IOU provided tariffs and incentive programs. Distribution assets are operated as any other IOU asset and would not generate any additional revenue for the CEMC during blue sky conditions. Negotiation related to favorable tariff structures may occur at the sole discretion of the IOU. May require renegotiation of tariff arrangement as more energy resources or participants are added to the CEMC. No substantial reduction in City/ owner financial liability, as the City/ owner would still be expected to finance the distribution assets.
IOU Ownership/ Operation of Distribution with Community Choice Energy (CCE) Participation	Continued partnership with IOU under this model. IOU would be expected to operate all transmission and distribution (T&D) within CCE service territory, including the CEMC distribution. Potentially more favorable tariff structures for both use charges as well as credits for renewable and/or excess generation, subject to negotiation. CCEs typically have	As T&D remains within the purview of the IOU, similar restrictions may apply to the operation of distribution assets during blue sky conditions. No substantial reduction in City/owner financial liability, as the City/ owner would still be expected to finance the distribution assets.

	more competitive use rates for their customers. CCEs may have enhanced ability to negotiate single or upstream metering with IOU on behalf of the City/ owner.	The City/owner would still be constrained by the regulations governing CCEs, and any new rates or incentive programs would be at the discretion of the CCE and its governing body. No assurance that the rate design with the CCE would be more favorable (than current tariffs provided by IOU) for the CEMC.
City Forms Municipal Utility	City/owner would have full autonomy and flexibility in configuring/operating CEMC to meet desired objectives, including with respect to T&D and rate design. Ability to design and/or adopt innovative rate design that could be more favorable to the CEMC but also for other small community microgrid projects in the municipal utility service jurisdiction. Potential to partner with an existing joint power authority (JPA) for the purposes of energy procurement. This could result in lower electricity costs and as such, lower use charges for its customers/CEMC participants. Access to additional sources of financing, particularly if it joins a JPA, such as tax-exempt bonds and revenue bonds for certain energy generation and transmission projects. Greater flexibility to expand the CEMC with respect to both energy resources and participants. In particular, additional participants may not be limited to municipal users and may include commercial or residential customers as well.	A municipal utility can take several years (approximately 2-5 years) to form, as the City/owner would be required to complete a feasibility study, legal and regulatory analyses, and financial analyses including development of a tariff structure. [38] City/owner takes on additional financial burden generated by legal expenses, feasibility studies, exit fees for IOU, and other costs related to setting up a publicly operated utility (POU). Although, this may be only a small percentage of total project costs. City/owner may not be experienced in managing its own utility and may take on some additional operating risk. This would require additional investment in staff training and/or hiring to develop the appropriate expertise in-house, or contracting out operations and management to a private energy service provider. Adverse impacts for community from potential political opposition from existing IOU. Precludes partnership with CCE as community choice aggregators may only provide electric to service to customers within IOU service territory. Increased regulatory requirements that would become the City/owner's responsibility, e.g., load forecasting, Renewable Portfolio Standard (RPS) requirements.
CEMC Distribution Annexed by Existing Municipal Utility District	Potential to benefit from an existing entity that has experience/expertise in operating as a publicly owned utility.	It is possible the Municipal Utility District still partners with an IOU to operate T&D infrastructure, in which case City/owner

38 Municipal utilities can be formed with a majority vote from the City Council. Through a public vote, Charter Cities also have the authority to amend their charter and establish a separate municipal entity. The more common approach, however, is for the City Council to retain ultimate authority and establish a commission that serves an advisory role to the Council (see California Municipal Utilities Association "Handbook on Public Agency Power Options" for more information).

	Would not require the formation of a new public agency by a city. Potential for more favorable terms for tariff structures and CEMC operation during blue sky conditions.	would not have control over CEMC operations under blue sky conditions. Annexation has its own regulatory processes, such as requiring approvals from the Local Agency Formation Commission (LAFCO). Would require renegotiation if CEMC is expanded in terms of additional generation or additional participants. City/owner would need to partner with an existing municipal utility district (MUD) that provides electric service or that has an interest in expanding to the electric service sector. In addition, such an expansion in service territory or service portfolio should be compatible with organization's charter and strategy. However, transaction costs may far exceed benefit for a small CEMC. Adverse impacts for community from potential political opposition from existing IOU. The City/owner would still be constrained by the regulations governing the MUD, and any new rates or incentive programs would be at the discretion of the MUD and its governing body. No assurance that the rate design with the MUD would be more favorable for the CEMC.