Berkeley Energy Assurance Transformation (BEAT) Project

City of Berkeley

CASE STUDY

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Photo Credit: Roy Kaltschmidt, Lawrence Berkeley National Laboratory

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EXECUTIVE SUMMARY

Cities are at the forefront of the movement towards sustainability and resilience, and are looking for multi-benefit solutions that simultaneously enhance the safety and environmental quality of their communities. Microgrids, when powered by on-site renewable energy, can provide clean power for critical facilities even when the power grid fails. This Case Study summarizes the City of Berkeley's research on how to design a replicable, clean energy microgrid community in a dense urban area that contributes to both safety and sustainability.

The City of Berkeley received a grant from the California Energy Commission as part of its Electric Program Investment Charge program to conduct the Berkeley Energy Assurance Transformation (BEAT) project. The BEAT project explored how to design a clean energy microgrid community (CEMC) to serve key municipal buildings and to improve community resilience by maintaining essential City functions during a major, long-term power outage. 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. One of the main objectives of this project was to make the knowledge gained from this research accessible to the public and key decision makers to advance the development of CEMCs.

The BEAT project undertook regulatory, technical, and financial feasibility analyses with the purpose of producing a shovel-ready microgrid design for a microgrid in Downtown Berkeley. This Case Study consolidates findings from these analyses that are relevant to other jurisdictions, and presents outcomes, lessons learned, and recommendations for developing CEMCs in urban areas in California and beyond.

CLEAN ENERGY MICROGRID COMMUNITIES

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 the purposes of this report, a CEMC is a microgrid that connects multiple community-serving buildings together and uses clean energy like solar and battery storage to share energy across facilities during normal, or "blue sky" operations, and which can "island", or operate independently, from the grid in the event of an outage. The primary goal of a CEMC is to provide clean backup power to key facilities in order to provide critical services to the community in the event of a long-term power outage. The BEAT project envisioned developing a CEMC that would generate solar electricity to operate microgrid-connected key facilities. The microgrid's battery and smart controllers would balance solar energy generation and building demand, by distributing and storing the solar energy in real time.

Multi-facility, community-oriented, CEMCs are at an early stage of development. The majority of existing microgrid projects are located on private campuses or are located in remote settings at the end of a utility distribution line. In contrast, the BEAT project focused on designing a CEMC that could be integrated into the existing fabric of a dense urban city amid existing buildings and infrastructure.

BENEFITS OF CLEAN ENERGY MICROGRID COMMUNITIES:

The main goal and benefit of a CEMC is to provide community resilience through clean back-up power for critical facilities in case of a power outage. However, there are also many other co-benefits of CEMCs that can be realized by communities, including:

- ***Environmental benefits***: CEMCs can provide environmental benefits in both blue sky and island operation. During outages—especially long-term outages due to events such as natural hazards, the CEMC can reduce dependency on diesel generators. During blue sky conditions, optimizing energy use and on-site generation of renewable energy could reduce demand for conventional energy, resulting in GHG emission reductions.
- ***Cost savings***: CEMCs can allow for energy sharing and load management across multiple facilities, which can result in energy bill savings through a reduction in electric power demand and offset peak utility pricing.
- ***Advancing ZNE***: CEMCs can help buildings that could not otherwise achieve zero-net energy (ZNE) on their own become part of a ZNE or near-ZNE community by sharing energy across multiple properties. Sharing energy across the CEMC allows buildings that might not have space for solar generation to be powered by solar from another CEMC building.
- ***Reduced transmission & distribution demand***: CEMCs can reduce transmission and generation demand on the grid, which could benefit ratepayers by reducing the need for investment and maintenance of additional generation and transmission assets.
- ***Grid reliability***: CEMCs can help stabilize and optimize grid operations while integrating additional clean energy resources by allowing energy to be stored until it is needed.

LESSONS LEARNED

The BEAT project proved that CEMCs are technologically feasible, but found that some significant regulatory and financial barriers exist that can make them difficult to build.

The technical and financial performance of the CEMC and islandable solar + storage designs were modeled to measure their 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 energy consumption in blue sky operations by between 36 to 43 percent. During an outage, this combination of technologies reduces the need 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 single cost of the CEMC and prevents it from having a positive financial payback. However, when taking into account additional resilience benefits, payback improves. Additionally, the solar + storage option does have a positive financial return while providing similar resiliency benefits to a fully connected microgrid.

Most of the key findings and conclusions made throughout the BEAT project related to existing regulatory policy, implementation challenges that stem from utility requirements, and the financial implications of these regulatory and utility considerations. No federal or local regulatory barriers to CEMC development were identified. The main regulatory challenges to advancing CEMCs are at the State level under the California Public Utilities Commission (CPUC) code or as part of utility policies and practices.

BEAT PROJECT KEY FINDINGS:

- The technical viability of connecting buildings to form a CEMC depends on the physical proximity of each building, ability to use existing utility distribution lines and transformers, and the number of customers between each building. Discussing these items with the local utility early in the planning process is critical to understanding these existing conditions.
- For a CEMC with buildings that are not located directly adjacent to each other, a utility (either the local utility or a municipal utility) must own and operate distribution lines that cross a public right-of-way (per CPUC Rule 218(b)).
- In order to use existing utility distribution lines for an islandable microgrid, either all customers on that line must be part of the microgrid (such as at the end of a distribution line), or the utility must be willing and able to automatically shut-off any non-microgrid customers on the existing distribution lines in the case of a power outage. In addition, the utility would also require legal contracts with all customers not served by the microgrids that would be shut-off in the case of a power outage.
  - » For the BEAT project, there were hundreds of customers on the lines between the proposed CEMC buildings. Pacific Gas & Electric Company (PG&E), the local utility, did not have automatic switches or an interest in adding that technology to their distribution lines, nor a shut-off agreement with customers. Therefore, the BEAT project would require constructing new parallel distribution lines to connect microgrid buildings together.
- New distribution lines come at a significant cost. Costs include capital costs, installation costs, utility charges for operation and maintenance of the distribution lines, and the transfer tax of deeding assets to the utility. For example, some of the BEAT project costs for new distribution lines included:
  - » The construction of new distribution lines at around $1 million per mile.

  - PG&E would collect a one-time transfer tax per the Income Tax Component of Contributions (ITCC) Provision (to cover state and federal taxes) for deeding the new lines to PG&E. The ITCC is 24-34% of the capital costs.
  - PG&E would charge operation and maintenance of the new lines per PG&E Electric Rule No. 2 at a rate of 6.5% of the capital costs annually and indefinitely. This charge would equate to more than the total capital costs of the BEAT project after about 15 years.
- It is at the discretion of the utility to allow separate buildings within a microgrid to have a single meter at the point of interconnection and allow for aggregation of power during blue sky operations. Although all buildings proposed in the BEAT microgrid were owned by the same customer, the City of Berkeley, PG&E determined that the proposed CEMC could not have a single meter.
- There are currently no rate structures or tariffs 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 CEMC development.
- Utility rate structures play a significant role in defining the optimal battery size. Steep tariff structures strongly incentivize battery usage under blue sky conditions, while flat tariff structures limit cost-optimal battery usage.
- Current battery storage technologies have varying strengths and weaknesses. Lithium-ion batteries still lead the market over Flow/Zinc battery technology for small-scale microgrids. Lithium-ion batteries are considered optimal for providing ongoing charging and discharging of energy in faster intervals and are more compact, but more expensive than Flow/Zinc batteries, and have additional environmental implications. A project's optimal energy storage choice may vary based on available space for batteries, budget, and plans for charging and discharging of batteries.

SOLAR + STORAGE ALTERNATIVE

The cost of installing, operating and maintaining distribution infrastructure is the greatest single cost to the system and prevents the proposed BEAT CEMC from having a viable financial payback. Given this cost and other challenges noted above, the BEAT project also looked at developing islandable solar + storage systems at critical facilities as a first step towards enhancing the resilience of Berkeley's critical facilities.

Both CEMCs and islandable solar + storage projects can help cities advance community resilience by providing clean, reliable back-up power in the event of a disaster, reducing GHG emissions, and potentially reducing energy costs. Like a CEMC, a solar + storage system is comprised of solar panels and energy storage that would be able to isolate from the grid in the event of a power outage and provide clean back-up power. The solar + storage system is installed at individual facilities on a building-by-building basis and requires that each facility has adequate space for both the on-site solar generation and energy storage. A solar + storage option is a simplified and more cost-effective approach that has a positive financial return while providing similar resiliency benefits to a CEMC. The main difference is that an islandable solar + storage system would not physically connect buildings together as a CEMC would, and therefore buildings would not be able to share power in normal or outage conditions.

In the case of the BEAT project, because PG&E did not allow for a single meter in blue sky operations, the only difference between the CEMC and islandable solar + storage would be that power could not be shared across facilities in the event of an outage or disaster. Despite this limitation, an islandable solar + storage system can act as a first step toward a CEMC as it incorporates upgrades at the facility level that would support facility interconnection with new distribution lines in the future.

RECOMMENDATIONS

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 for the purpose of proving the effectiveness of their technology. While these approaches have been important for creating pilot or demonstration projects, commercial-scale deployment of CEMCs is still limited due to the regulatory and financial barriers that exist.

Moving from a project-by-project basis to commercial-scale deployment of CEMCs will require enhancing the availability of project financing, collaboration with the local utility, regulatory changes that enhance cost recovery during normal and outage conditions, and technical or market developments that reduce upfront capital requirements. The CPUC, utilities, the California Energy Commission and Community Choice Energy groups should keep CEMCs and solar + storage systems in mind when creating new rules related to advancing distributed energy resources.

Some future opportunities to advance CEMCs include the following:

- ***Greater coordination among the multiple federal and state agencies that develop building codes and standards***: Although local jurisdictions adopt and enforce the building 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 impact CEMC requirements, and these codes fall under the authority of two separate agencies: the Building Standards Commission and the Energy Commission.
- ***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 incentivize the adoption of specific technologies, such as solar photovoltaic (PV) and battery storage, which support California's goals related to 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, changes in this arena would be expected to have positive impacts on long-run feasibility of advancing CEMCs. Any new rate structures should be developed in an equitable fashion to ensure benefits can be accessed and costs are not unfairly incurred by low-income and more vulnerable populations.
- ***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.

- ***Utilization of existing distribution lines***: If utilities are able to find a way to utilize existing distribution lines for CEMCs, for example by virtually shutting off customers on the line which would still enable automatic islanding during outage mode, this would significantly reduce the cost of building a CEMC that requires new dedicated distribution lines.
- ***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, 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 customers, in both blue sky and outage conditions***: 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 are not co-located, and could be key for maximizing the potential energy savings for any CEMC. Currently there are no tariffs that would allow a CEMC to incorporate multiple facilities owned by different parties to share power or credits. If such a tariff were to exist, it could provide some cost benefits for these types of systems. However, there is currently limited CPUC guidance related to this, and it may be solely at the utility's discretion to allow for a more favorable metering arrangement.
- ***Reduced rate calculation for operation and maintenance of microgrid infrastructure or exception to PG&E's Electricity Rule No. 2***: The operation and maintenance for new distribution lines that are deeded over to PG&E as "special facilities" are subject to PG&E's Electricity Rule No. 2 (other utilities have similar rules). These annual fees for operation and maintenance of brand new lines — with few customers and less use compared to the overall portfolio — are prohibitively expensive at 6.5% of capital costs annually, indefinitely. If the rate was adjusted to better reflect the true cost of service it could encourage new microgrid development. Note that a rate found to be more reflective of a true to cost of operation and maintenance, based on research from Lawrence Berkeley National Laboratory and Stanford University, was found to be approximately 0.5% per year of capital costs.[1] Changing this rule would require either a negotiation with the utility or a requirement from the CPUC.
- ***Reduced cost of transmission and distribution costs***: During blue sky conditions, there are two sources of energy consumption – purchases from the utility and energy generated on site. Traditionally, utilities charge their customers transmission and distribution costs which capture both the capital costs and the costs to operate and maintain the distribution grid network within their service jurisdictions, and the transmission infrastructure necessary to transport electric power from where it is generated to its customers. Given that a CEMC may need to build its own distribution lines and will produce at least some of its own power through on-site solar, CEMCs should not be required to pay for the full transmission and distribution costs for energy produced on-site and should rather be charged a reduced fee for the operation and maintenance of the inter-facility distribution lines. This would require either a negotiation with the utility or a requirement from the CPUC.

1 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.

- ***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***: Given the costs and logistical challenges related to requirements 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.
- ***Bundling of utility installation***: In addition to the bundling of microgrids into a portfolio, bundling installation of distribution lines with other utility 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.

- ***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 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, as utilities shift customers to time-of-use rates with peak pricing in the evenings, 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 methodologies 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 methodology for measurement of 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 above 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 (i.e., CEC, CPUC, local utilities, CAISO, municipalities, etc.). Partnership and collaboration with a shared vision for enhanced community resilience, environmental benefits, and equity will be crucial for making the necessary changes to advance the commercialization of CEMCs, solar + storage systems, and other public-purpose microgrids.

CONCLUSION

Multi-facility clean energy microgrids can provide many resilience benefits to a community. Although they have been proven in campus and remote settings, there are many challenges for urban CEMCs that include multiple customers and connect multiple facilities across the public right-of-way. The BEAT project has contributed to the advancement of CEMCs by highlighting current barriers and potential policy solutions. In order to advance CEMCs, utilities will need to be required to change current policies and renegotiate rates and fees to enhance financial viability. State agencies will need to support new and change existing rules and policies to encourage advancement of CEMCs, which can provide benefits to ratepayers as well as overall grid reliability. Local jurisdictions and others interested in developing CEMCs will need to work together to share lessons learned and communicate the changes needed to utilities and other agencies to improve project feasibility. Seed funding will also be necessary to fund pilot projects until either the costs of these projects can be brought down or returns to projects improve. From an equity perspective, public-purpose, community-serving microgrids that provide back-up power to critical community facilities and vulnerable populations should be prioritized for funding.

The BEAT project continues to be committed to community resilience and advancing CEMCs. The City of Berkeley will continue to find ways to create cost-effective, multi-benefit energy assurance solutions for its critical facilities. Given the barriers identified for current CEMC development, the City has decided to improve community resilience by examining islandable solar + storage opportunities, which could later support CEMC development as well. Given this approach, the next step for the BEAT project is to identify which community-serving buildings in Berkeley are best suited for islandable solar + storage systems and find funding to install these systems.