# Keeping the lights on: the Oakland EcoBlock community electrification and microgrid improves health, comfort and resilience in an urban neighborhood

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**ABSTRACT**

How can cities efficiently and affordably undergo effective and dramatic decarbonization of buildings and vehicles? Can these strategies promote equity and scale across the urban environment worldwide? The EcoBlock in Oakland, California seeks to answer this urgent environmental, social, and technical question by designing, testing, and deploying community-scale energy and water systems. These innovative systems combine energy and water efficiency and electrification at the building scale with an electrical system that integrates rooftop solar, block-scale storage, electric vehicle (EV) charging, and a smart microgrid that optimizes supply and demand at the block-scale.

This paper presents the approach and strategies when moving from design to implementation deploying this novel prototype toward industrializing city-wide, residential microgrids that generate their own clean, renewable power for homes and EVs. Scaling retrofits requires coordination from evaluation, product selection, permitting and installation involving contractors, utilities, consultants and various Authorit(ies) Having Jurisdiction (AHJ). Improvements at homes interconnect with block scale microgrid and EV charging in an existing block and social dynamic. This paper will discuss opportunities and pitfalls to implementing block scale electrification and microgrid to achieve environmental benefits of emission savings and resiliency, utility cost benefits, social benefits of neighborhood network, and comfort and health benefits in each home.

## Introduction

Worldwide consensus invites action to rapidly and cost-effectively reduce carbon emissions from energy generation and transportation to achieve a clean, reliable future. Progress toward these goals is exacerbated by trends in urbanization and income inequality, as well as the growing impacts of climate change.

The world is experiencing the largest wave of urban growth in human history, with more than half of global population living in urban areas. By 2060, two thirds of the expected population of 10 billion will live in cities (United Nations Department of Economic and Social Affairs (UN DESA), 2018) and require housing and services. Energy consumed by buildings generate nearly 40% of greenhouse gas emissions, and two-thirds of existing buildings will still exist in

2050 (Architecture 2030, 2021). Only 0.5-1% buildings are renovated every year (Architecture 2030, 2021). Thus, effective climate change mitigation must focus on renovating existing building stock to achieve these goals. Urbanization affects transportation and mobility. In California, passenger vehicles produce 28% of greenhouse gas emissions (California Air Resources Board, 2017); 88% of trips are less than 20 miles (US Department of Transportation, 2011). Driven by aging infrastructure and wildfires, power outages in California are increasing in number and duration, and increasingly occurring in urban areas, affecting more people and costing billions of dollars (Bloom Energy, 2019).

Personal carbon footprint reduction through electrification or fuel switching from fossil fuels (natural gas, gasoline) is expensive. Residential adopters of solar photovoltaic (PV) electricity generation have a significant higher median household income than the national average household (Barbose et al., 2018). Electric vehicle (EV) adoption is still primarily led by higher income households (Soltani-Sobh et al., 2017). Low income populations are increasingly vulnerable to heat waves as these communities often lie in areas disproportionately warmer than wealthier communities (Anderson & McMinn, 2019), their houses tend to be less efficient (Berelson, 2014), and they pay more of their income for energy (Alamo et al., 2015). Energy-intensive cooling through air conditioning has become a necessity in many climate zones: extreme heat events kill more Americans every year than any other weather-related disaster (US Department of Homeland Security, 2020), and as climate change progresses, heat waves are increasing in intensity and frequency (Center for Climate and Energy Solutions, 2017). Another unfortunate confluence of urbanization and income inequality is pollution inequality. Poor air quality in urban areas disproportionally affects the health of people of low income (Creasy, 2020). This is aggravated by trends in income inequality. The past four decades have seen an increase in global economic inequality; in the US during this period, the share of national income by the bottom 50% plummeted from 21% to 13% while the top 1%'s share of grew from 11% to 20% (WID.world, 2018).

Current endeavors for building energy efficient retrofits, solar panel installations, and decarbonizing transportation are piecemeal—one building, one car at a time—at much too slow a pace, and are largely enjoyed by households with the highest incomes. Several factors are hindering the adoption of these clean-energy technologies: 1) transaction costs inherent in the one-house-at-a-time deployment model, 2) limited access to capital to finance the large capital investments needed for deep energy retrofits with solar and energy storage systems, 3) lack of awareness of the benefits of these technologies, particularly in hard-to-reach market segments, and (4) lack of time and capacity to undertake and navigate systems. That said, in California there are several policies and programs directing funding to bring benefits to more vulnerable populations.

The transition to a low-carbon energy future requires moving beyond technical innovations to fundamental shifts in social, legal, business, and financial constructs. Community renewable energy microgrids provide a canvas to test new approaches. The Oakland EcoBlock is an urban sustainability project that aims to prototype a pathway to rapidly, equitably and affordably reduce greenhouse gases, increase resilience to power outages, and build community. The project will conduct energy and water efficiency retrofits in a neighborhood of houses and develop a standalone "microgrid" of electrical generation (solar electric rooftop panels) and storage (batteries) with curbside Electric Vehicle (EV) charging and EV carsharing, and a new approach for coordinating these. This is not a home-by-home approach and not a community development. To scale requires adaptation of delivery and service models of contractors, utilities, authority having jurisdiction to accommodate a diverse building stock under the umbrella of one project.

This paper describes the social and business elements to recruiting a block, engaging the community, and designing and planning a block-scale energy retrofit and microgrid. The project explores how institutions and legal instruments frame energy behaviors, and how a community-led "prosumer" can shift thinking about energy from a commodity to a "commons" that is self-generated and shared. A neighborhood block seems to provide an appropriate technical, economic and social scale that may prove more impactful than individual sustainability efforts and more nimble than state/city-wide efforts to achieve a low carbon future while creating stronger community networks.

## Project Background and Approach

The project has eight overlapping disciplines or teams, each with a team lead. UC Berkeley is leading the project with a team of researchers across campus and at a national lab, City of Oakland officials, professionals such as architects, urban planners, legal experts, business and finance experts, water efficiency experts, energy and electrification upgrade professionals, electrical and civil engineering firms, and contractors for the microgrid and for the building retrofits. The combination of researchers and practitioners across the different fields created a necessary push and pull dynamic to successfully undertake this challenge.

Building off Phase 1 planning efforts, the multidisciplinary team engaged in implementation. In Phase 1, three key considerations were identified: (1) social, legal, and governance barriers are likely to outweigh technical limitations; (2) cost considerations relative to technology, implementation, and scalability effect critical decision-making points during a project; and (3) a variety of approaches must be used to verify benefits through implementation, measurement, and communication

The initial goals of the Ecoblock project were defined as providing resiliency through:

- Affordable energy retrofits (e.g., insulation, air sealing, efficient electric equipment and appliances)
- Water efficiency upgrades (e.g., efficient fixtures and appliances, greywater)
- Shared electrical assets (e.g., photovoltaic array and battery storage)
- Mobility improvements (e.g., shared electric vehicle with curbside charging)

## Technological Solutions

The technical aspects of the EcoBlock development include urban planning, building retrofits: electrification, energy and water efficiency upgrades; water: stormwater and wastewater mitigation, microgrid design, and transportation/mobility.

**Building Retrofits.** In Phase 2, the team conducted on-site building audits, utility bill analysis, and energy consumption modeling on the selected block to produce construction work scopes and bid specifications. The audit was equivalent to an ASHRAE Level 2 audit (Baechler, 2011), which identifies no-cost and low-cost opportunities. The audit also included interviews and surveys with the tenants and owners and included an evaluation to identify any deficiencies that could result in health and safety hazards to residents, code violations, and/or degradation of building systems. The assessment includes documentation of type, condition, area, location, efficiency for the following: space and water heating systems, appliances and fixtures, the building envelope, electrical and gas infrastructure, and EV charging. The assessments also captured building and lot layout, drainage, landscape and paving.

Initially the team collected energy bills from residents to analyze, and then partnered with UtilityAPI to collect the energy consumption and costs directly. The intention was to model expected electrical consumption after the retrofit and combine with existing baseload consumption to produce a total home consumption estimate to understand change in usage and inform PV sizing. This load analysis was also used to estimate expected energy costs to inform contribution to the ongoing cost of operating the microgrid.

The main criteria for the retrofits were to eliminate natural gas, improve building envelope efficiency to better support heat pump HVAC, improve ventilation, and address critical electrical infrastructure to support electrification of end uses. The challenges faced at the individual home level, may not be novel, yet are critical when considering the cost and scale question. While each home was receiving heat pump HVAC and water heating, the equipment selection, location, and feasibility varied from building to building. The energy efficiency measures and appliance upgrades also varied from building to building. Residents had limited choice on HVAC and water heating equipment and greater choice over appliances such as dryers, ranges, and refrigerators. Providing choice and achieving cost efficiency with "bulk purchasing" resulted in a partnership with a local appliance store where residents would be able to select high efficiency appliances to replace selected existing appliances. Electrical infrastructure and the necessary electrical upgrades were unique to each building and in completing whole home electrification, the team was challenged to minimize triggering whole home code compliance which would not be financially feasible. In addition, approximately 50 square feet of space was needed at each home to accommodate all the electrical infrastructure for main panel, load centers, inverters and controls for the microgrid. The approach to the recommendations were not constrained by a per home or per unit budget or technical parameters bounded by infrastructure constraints as the intent was to cover comprehensive scopes of work. The project ultimately required prioritizing upgrades to reduce budget pressures while ensuring electrification and improved comfort was achieved. Owners still received the comprehensive assessments.

**Water.** Water supplies in most of California by 2050 are expected to be at "high" or "extreme" risk, according to the Water Supply Sustainability Risk Index developed by (Roy et al., 2012). Thus the water team explored water efficiency, drought tolerant landscaping, rainwater harvesting, waterwaste reuse, and stormwater mitigation, exploring building-level and block-level interventions (Chapter 4 in (Barr et al., 2019a)). The initial model in Phase 1 assume water usage of 55 gallons per capita per day (gpcd) and efficiency (e.g., new efficient fixtures and appliances) would reduce this to 29 gpcd, saving approximately $80 savings per year. The Net Present Value analysis indicated that the benefits are greater than costs for the faucet interventions, and for toilet and shower replacements. Greywater diversion (laundry-to-landscape irrigation) is relatively inexpensive and quite simple to apply in specific conditions. However, costs exceed benefits for dishwasher and laundry replacements. The water team is reviewing the assessed buildings for downspouts discharging to grade that indicate raingarden/catchment potential, addressing water flow issues (such as ponding, basement water damage), and potential for street tree and other plantings and reclaiming paved planting strips.

**Microgrid.** The goal for the microgrid Energy team was to design, deploy, and test a cost-effective and reliable community-scale microgrid platform that can be replicated easily across city districts. The microgrid has multiple ratepayers aggregated at the point of interconnection to the utility grid. The hypothesis is that substantial benefits accrue from this community-scale approach, namely: (1) improved utilization of assets through shared solar, storage, and EV charging systems; (2) enhanced load shape, demand response, and power resilience through optimized and coordinated control of the microgrid's assets; and (3) business and financial economies of scale through larger-size development projects and modular, scalable designs, and greater access to capital markets that result in lower ratepayer costs.

The design of the microgrid evolved as a result of CPUC policy, the utility's interest in microgrids after wildfires caused power outages, and personnel changes at these agencies. While the DC microgrid design was desirable in its efficiency, it represents a new technical model with regulatory and governance issues. The energy team decided on the AC solar/storage microgrid with the electrical generation (PV) owned by the home owners and distribution provided by the utility PG&E's existing cables. This block-scale AC microgrid would receive power from the PV arrays, store it in a shared battery storage system, and distribute it back to the homes, and would operate during utility power outages. The advantages of this scenario include: reducing the cost of PV by purchasing in bulk, reducing the cost of materials by reusing existing high-voltage cables, reducing the cost of storage by using a block-scale approach, and allowing the existing AC circuits in the homes to remain unchanged.

The EcoBlock microgrid concept includes five distributed energy resources (DERs) applied in the California loading order and are estimated to reduce $CO_2$ emissions against the block-level baseline (i.e., a house's utilities and one vehicle per household emit 450 metric tons of $CO_2$ per year): (1) energy efficiency retrofits and electrification of major home equipment (reduce home energy use by 50-60 percent); (2) controllable/deferrable loads for demand response; (3) electrification of transportation using EV's (electrifying approximately 33 percent of vehicle miles); (4) serving remaining load with a block-scale microgrid system powered by communal rooftop PV; and (5) a central energy storage system (meeting about 75 percent of the remaining electricity use).

The sum of these steps are estimated to reduce blockwide $CO_2$ emissions by about 65 percent, with close to a zero net energy (95 percent) reduction at the house scale

**Mobility.** The goal of the Mobility team was to reduce carbon emissions as well as learn the travel pattern of residents and provide scenarios to reduce gasoline-powered Vehicle Miles Traveled (VMT). Measures include providing curbside EV chargers as part of the microgrid, an EV carshare service, and other electric mobility, such as e-scooters or e-bikes that provide the last mile of travel between home and public transportation. Residents were surveyed to understand transportation patterns and interest in electric vehicles. Responses indicated a great interest in personal EVs, shared EVs as well as a mixed response over having 1-2 EV chargers displace street parking. Curb and parking space on the block limited options for both scooters and EV charging. The scale for scooters may be larger than a block whereas 1-2 EV cars are more right-sized.

## Scaling Implementation

The aspect of scaling technological implementation must be considered in the two key processes to find cost effectiveness (1) submission for approval and permit from utilities and authority having jurisdiction and (2) execution of upgrades.

First the process for both utility and authority having jurisdiction are designed for individual submission based on meter, utility account and/or parcel number.

The team has worked with the utility to understand the process for approval for main panel upgrades, individual interconnection agreements, community storage and transformer upgrades, none of which are designed for multiple submissions (i.e 15 existing buildings on a block) but rather a cumbersome single application process. A modified review process was developed in order to "group" the individual applications and assign to one reviewer. This was an important incremental step to support a more efficient whole project review process rather than individual application review by different utility review staff. In addition to the process, the information required and the process for submission must be streamlined to enable scale.

At the jurisdiction level, the project has been assigned one inspector to again facilitate a whole project review and engagement rather than separate plan checkers and building inspectors being assigned to different homes. In addition, this designated inspector has been important to engage in questions on permitting requirements in particularly as related to newer technologies, community storage and stormwater management to reduce permitting barriers or delays.

The scheduling of the upgrades themselves is currently underway. Contractors are more familiar with service delivery for one off service delivery or more uniform delivery for a community development or multifamily building. It is critical to identify critical path activities and trades required to determine how to approach project most efficiently and effectively. At this time, the order of operations will be to complete electrical upgrades including main panel and new circuits at each home, prioritizing less complicated scopes first, while simultaneously initiating building envelope scopes of work that will not interfere with installation of HVAC or water heating equipment. Installation of HVAC and water heating will follow and finally new appliances will be installed. In executing the upgrades, the construction team could do each trade at all the homes and then move to the next stage or deliver this process and complete the work in 4 of the homes and then move on to the next set. It has yet to be determined the best approach for both efficiency and effectiveness and minimized resident impact.

## People and Policy Solutions

The technical solutions above are wrapped in a framework of social and community engagement, legal and regulatory conditions, and the business case. These are the most critical aspects of the Ecoblock and the most challenging.

**Social and Community Engagement.** One of the most complicated challenges in the project is social: to recruit a neighborhood and work with 15-70 people to upgrade their homes, develop a governance structure to co-own a microgrid and figure out an equitable distribution of fees, and educate and engage them in energy-saving behaviors to optimize microgrid performance. There are also social challenges in working across multiple disciplines within the team and working with stakeholders outside the team. Some key questions were: What characteristics of a neighborhood block would lead to a successful project? How will we identify and recruit that block? How do we build trust and develop a relationship with the participating neighbors? What is the process of community engagement throughout the project to understand the needs and concerns of the participating neighbors and other stakeholders?

At the outset the project team established a recruitment and selection plan. Selection criteria stemmed from interviews with and lessons learned from residents in Phase 1, meetings with the City of Oakland, interviews with key researchers, and a meeting of the broader research team to discuss and prioritize criteria. The team developed an initial set of criteria, ranked according to priority, reviewed and modified based on further discussion, leading to the final selection criteria. A critical selection factor was the estimated ability of each block to afford costs for ongoing operation, maintenance and insurance after the end of the research project, originally estimated at US$38,000 per year. The intention was that these costs would be offset by the reduction in energy and water bills, and for some, reduced cost of transportation by eliminating a second car given available EV car-share on the block.

The finalist block stood out as having enthusiastic block leads who were very responsive to the project team's request for information, and a block community who had gathered previously for block parties. The block was diverse in races, cultures, age, and household demographics. The people residing on the block are about a third homeowners and the rest renters; of those that answered the Initial survey, the median number of years lived on the block was 3.5. While the researchers felt that any of the top blocks would lead toward a successful project, given the high numbers of participating homeowners, the preferences of the City of Oakland towards their environmental justice goals, the enthusiasm of the Council Member, and the preference of PG&E, the research team selected the block adjacent to the creek.

The community engagement process included hiring a dedicated community engagement liaison at the beginning of the project, someone with deep ties in the community and experienced in canvassing and outreach. The team also developed an initial communication plan, identifying decision points and planning a series of in-person meetings, design charrettes, surveys, interviews and other methods of collecting data (e.g., building and energy use) throughout the project. The team discussed the type of participation (e.g., a single spokesperson, working groups, or advisory committee), the method of communication (e.g., online or email, in-person, telephone, individual vs. group), and frequency (e.g., how often to meet with participating homeowners versus all residents).In order to improve communication, the research team added a private page to the website (www.ecoblock.berkeley.edu) strictly for participating residents of the block and also started a monthly emailed and mailed newsletter for the residents of the block to introduce the team (especially during restrictions due to COVID -19) and engage them on various aspects of the project. In-person (outdoor and socially distanced) meetings were conducted to get to know the residents; the meetings began with music and provided food. The community liaison visits the project several times per month to deliver newsletters, gather data, and talk to the residents.

While the residents engaged with each other socially, the requirement for a governance structure required a change in their relationship with each other. This structure took longer than expected to define and a board was designated over a year into project. This was an important step to shape decision-making and authority for the community.

**Legal**. The legal team consisted of several specialties including real estate, energy regulations, and governance. One key factor affecting the choice of microgrid typology was the CPUC regulations regarding energy generation. Under the Public Utility Act, any public or private entity that provides utility service (such as electricity, gas, or water service) to any other person or group of people is considered a public utility, and is subject to regulation by the CPUC (Cal. Pub. Util. Code § 216). While the legal energy regulatory team concluded that a DC microgrid, where the DC distribution would be owned by the participating homeowners, would be allowable under the “own use” exception to the CPUC’s definition of electrical corporation including distribution for immediately adjacent properties (California Public Utility Commission (CPUC), 2009), the utility preferred that the project use the existing overhead ac lines.

Ownership was another key legal element of the project. One ownership option, a Public-Private Partnership (P3), is a long-term contractual arrangement between a public agency and a private-sector entity (Rizzo and Cruz 2017). Under the agreement, the private developer designs, builds, finances, operates, and maintains a fee-generating public improvement. P3s are often (but not always) built on public land and focus on public infrastructure that has a revenue stream to help secure and repay project costs. Other options include a Community Choice Aggregator or a municipal utility, and yet another model is collective ownership by the participating homeowners through a Home Owners Association or nonprofit Trust. The EcoBlock team hired a legal firm that specialized in the development of co-operatives to review relevant governance models and propose an appropriate one.

The legal team reviewed options for the governance of the shared microgrid assets; the requirements are:

1. It must provide for effective, democratic governance over the term of the project (20 years to 99 years).
2. The entity must enable the community of members to have continuous access to, and utilization of, other members’ roofs for the common benefit.
3. The entity must have recourse to address non-payment or other violations of a user agreement of some kind for the system.
4. The entity must limit the risk and liability that any individual member might otherwise face.

Three vehicles were considered: Planned Development Association governed by Davis-Stirling (e.g., Home Owners or commercial Association), individual long-term lease agreements with individual landowners (potentially tied to a master agreement), and land trust. The legal firm concluded that a nonprofit mutual benefit Association was the best option.

**Business Model.** The goal of the EcoBlock is not only to realize environmental benefits but also reduce costs of energy, water, gasoline and so on for residents over the long term. The appropriate business and financing models can take advantage of long-term savings on electricity, gas, and water bills that can be used as a “revenue” stream to help finance both upfront capital costs and long-term maintenance and operation. Since this first EcoBlock is a demonstration project, grant funds will cover the capital costs of procuring and developing the physical infrastructure; however, they will not cover long-term operation, maintenance, and insurance costs. The “best” business and/or financing model will depend on its specific circumstances and context, and will likely include several different tools that could be developed into a single model with the potential for market transformation. There is no single existing “model” for either the financing or the governance of the EcoBlock because the EcoBlock contains a mix of public assets (such as curbside EV chargers) and private ones (such as home appliances), includes both homeowners and tenants, requires funding for upfront capital costs as well as ongoing costs, and upgrades both energy and water infrastructure.

Public financing models generally rely on state laws enabling residents to agree collectively to direct property tax funds to the acquisition of communal assets and infrastructure, subject to public agency-based ownership and management. Private financing models rely on a range of fund sources to finance these acquisitions, with ownership and management remaining in the hands of private residents or a third party. Utility models are wholly directed by existing power and water utilities. The models would require a governance structure to coordinate resident actions and financing instruments.

The Business/Finance team recommended several models: Property Assessed Clean Energy (PACE) financing for private home upgrades and Community Facilities Districts (CFDs) for shared assets and managed through the governance structure of a nonprofit trust, and supported by the creation of a Joint Powers Authority (JPA) for ownership, insurance, and indemnification purposes. Through property taxes, a CFD could finance many of the project's higher-cost, community-wide installations, such as the proposed energy generation, storage resources, and the block-wide water treatment facilities. CFDs may be more attractive option for medium to high income areas due to exemptions for low income properties. For upfront capital costs of a future EcoBlock's microgrid solar and battery storage, the team continues to explore options, such as Private-Public Partnerships, including third-party "Microgrid as a Service" companies just beginning to emerge into the market. Ownership of some or all of the microgrid assets by utilities or electrical cooperatives is possible, but many important issues still need to be addressed, such as safety and tariff structures.

To finance in-home energy improvements for a future EcoBlock, either PACE or on-bill financing were evaluated as feasible structures. However, the interest rates of PACE are relatively high and the program has received increasing criticism due to poor customer protection and high risk (Harak & Saunders, 2016). The team is exploring various forms of on-bill financing (American Council for an Energy Efficient Economy, 2020; US Department of Energy Better Buildings Initiative, 2020), zero percent loans (backed by Federal funds), and other options.

As the governance vehicle for the project, an Association would oversee the operation and maintenance of the microgrid and would collect fees proportional to energy consumption to cover ongoing costs of the microgrid.

## New Social Paradigm

The technical aspects of the project are not particularly novel, but the social, legal, and business elements present interesting intersectional challenges. Interdisciplinary approaches are vital towards accelerating the energy transition towards a carbon-free future, but difficult; even for the research team has to learn each other's language (Wilhite, 2018). We recognize that residential energy consumption is not solely driven by individual behavior; people use energy in ways often conscribed by laws, regulations and norms (Sahakian & Wilhite, 2014; Shove et al., 2013). The EcoBlock legal team includes experts in property law, real estate, energy regulations, and co-operative formation, each of which affects how a community can work together to become more resource-efficient and resilient. Understanding how legal instruments can frame behavior, especially regarding shared resources such as a microgrid or energy efficiency retrofits in multi-owned properties, is needed to enable sustainability goals (McCarthy et al., 2018). This energy transition embodies new actors, such as community-led “prosumers”, and new thinking about energy as a “commons” that is self-generated and shared, rather than utility-produced, secured and commodified (Bridge et al., 2018): a “prosumerism” emanating out of neighborhoods (Campos, 2018).

The transition involves moving from individual to collective action at the same time as shifting from centralized to decentralized systems. A neighborhood of 20-40 households seems to mark the “sweet spot”: better than individual efforts and more nimble than state/city-wide efforts on a technical, economic and social basis. Our modelling shows that shared energy load diversity at this scale reduces the required storage capacity compared to energy storage for individual homes (Ostfeld et al., 2018). Neighbors that come together to share ownership of solar generation and battery storage can build a safer, more secure, and more resilient community than each individual could afford on his/her own. We discovered that for low-middle income neighborhoods, more participants (especially small commercial businesses) help aggregate cost savings to contribute towards insurance, operation and maintenance of the shared microgrid assets. Socially, a block-scale of neighbors evokes the size of earliest communities that survived because they shared resources and knowledge. Altruism was vital to survival (Wilson, 2019); highly cohesive nested social networks was a key part of human evolution (Watkins, 2012).

## Best Practices

While this process is still underway there are several lessons learned from this phase of implementation to consider for future Ecoblocks.

**Prioritize community structure.** The technology piece while it has challenges and limitations based on several existing factors is relatively solvable. While the community organizing is a more challenging aspect requiring a change in relationship of neighbors for governance and shared resources. This is the foundation for the Ecoblock and should be first priority of action with a community. This will support participation and decision-making from the community. Although an association may not be created in the initial stages of the project, the roles and responsibilities of the association positions within the association and decisions-making authority need to be introduced and defined as early on in the process as possible. This can support greater community engagement in decision-making to guide the research and activities particularly surrounding legal and business case as aspects of the project as well as prioritization of interventions.

**Support community activities.** With a multidisciplinary goal to affect energy, carbon, and water savings leading to resiliency, the scope of work can become large and complicated. Identify activities that allows the community to come together in action such as tree planting or laundry to landscape installations at homes. This not only builds community capacity but produces tangible products.

**Define Priorities and Rule Set.** Develop project goals support by priorities and a rule set. This may include performance goals for the microgrid (i.e support minimum operation in all homes for 1 day during power outage or offset 60% of peak evening load on daily basis), define a minimum set of measures for each home to achieve specific goals (i.e. all electric, home performance plus all electric, electrification plus energy efficiency of all appliances, etc.), determine targeted budget for additional home improvements, budget for aspects such as green infrastructure, mobility or other interventions for community to prioritize. This will provide the framework for the analysis and decision-making that will need to occur with implementation as budgets become more real.

**Identify key legal and regulatory challenges.** The current regulatory framework in California does not readily support microgrids and behind the meter PV and storage systems. As mentioned drivers can take many forms and will dictate and restrict design opportunities.

**Bring in Practitioners and Contractors early on in process.** There is a significant amount of policy and research required to determined legal and regulatory challenges for implementation. Yet, bringing on energy consultants, engineers and solar, general, and electrical contractors who have experience with storage and electrification retrofits is critical to ensure research and engineering can be implemented.

**Balance individual working groups with collective processes.** The intersectionality of all sectors cannot be understated in this project. IT requires incredible in-depth expertise in each field that can be best leveraged in smaller siloed working groups. That said, decisions, designs, thresholds in one sector impact others. Creating a process to support decision-making at the right level and understanding the intersectionality and tenons that are pulling on different aspects is paramount to an effective process and project. This directly ties to defining an order of operations and framework for decision making.

**Define milestones.** Identify all required paperwork and stages of activities upfront, defining deadlines and milestones. Creating this expectation early in the process will reduce delays attributed to outstanding requests or wavering commitment. Identify all paperwork and information requests upfront to reduce asks and time required to obtain documentation.

**Present options to enable community decision-making.** Identify options to support community decision-making and prioritization. This can result in priorities for current scope, identification of  second tier priorities to be executed in subsequent years.

## Conclusions

EcoBlock is a model of advanced energy communities that aims to equitably and radically reduce carbon emissions while building community and improving resilience. The project focusses on existing urban residential neighborhoods including single family and multi-family houses. Factors to rapidly reduce carbon emissions include 1) conducting energy efficiency retrofits of existing homes and small businesses, 2) leveraging the economies of scale of block-level retrofits, 3) switching fossil-fueled appliances, equipment and vehicles to electric, and 4) coupling energy efficiency upgrades with a renewable energy (solar+storage) microgrid. An EcoBlock can provide resilience through affordable energy retrofits, water efficiency upgrades, access to e-mobility improvements, and an islandable microgrid.

This paper focused on the social, legal, and financial elements of the project currently under development. We describe how we recruited a block encouraging groups of people to self-organize, our approach to orchestrate discussions and share information, developing trust, technical details of the building energy and water retrofits and microgrid with e-mobility, and some of the legal and business approaches. The business model for this first EcoBlock includes the community of homeowners forming a governance vehicle to own and maintain the microgrid generation and storage assets, paying from association fees collected based on energy used. The utility will own and maintain the microgrid distribution lines. The next EcoBlock might use a variety of structures to finance the in-home improvements individually and collectively finance the first cost and operation costs of the shared microgrid assets. The Oakland EcoBlock provides an example of a community microgrid 1) with the community as a stakeholder in owning resources, 2) as a microgrid that serves the local community, and 3) that has a community with a shared vision: a stronger community, with improved resilience, and reduced carbon emissions that are affordable.

**Acknowledgement**

We acknowledge the many researchers, professionals, staff, and students who have worked or are working on the Oakland EcoBlock project (list names): Sascha von Meier, Dan Kammen, Harrison Fraker, Tony Nahas, David Warner, Andrea Traber, Corey Lyons, Larry Strain, Susi Marzuola, Christine Thomson, Kate Ringness, Kiran Jain, Eunice Chung, Eric Lee, Carl Blumstein, Tim Lipman, Craig Boman, Maika Nicholson, Bill Kissinger, Monica Schwebs, Cameron Madigan, Nate Perez, Ted Lamm, Ethan Elkind, Michael Ginsberg, We thank the California Energy Commission for funding this work under grant number EPC-xx-xxx.

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