Title

Accelerating the Deployment of Advanced Energy Communities: The Oakland EcoBlock A Zero Net Energy, Low Water Use Retrofit Neighborhood Demonstration Project

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Publication Date

2019-04-01

Energy Research and Development Division

FINAL PROJECT REPORT

Accelerating the Deployment of Advanced Energy Communities: The Oakland EcoBlock

A Zero Net Energy, Low Water Use Retrofit Neighborhood Demonstration Project

California Energy Commission

Gavin Newsom, Governor

April 2019 | CEC-500-2019-043

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ACKNOWLEDGEMENTS

The Co-Principal Investigators UC Berkeley Professor Dan Kammen and Professor Harrison Fraker, and the Project Manager, Tony Nahas, acknowledge these individuals for their remarkable *pro-bono* contribution to the Oakland EcoBlock Project:

- Karen Nardi, Partner, Arnold & Porter LLC (and support staff),
- Barbara Schussman, Partner, Perkins Coie LLC
- William Kissinger, Partner, Morgan Lewis LLC

We acknowledge the generous investment of time made by the *pro bono* members of our Technical Advisory Committee (TAC):

- Dena Belzer, CEO
- Timothy Schaefer, Assistant State Treasurer, State Treasurer's Office, Sacramento, CA.
- Alicia Chakrabarti, East Bay Municipal Utility District (EBMUD)
- Taylor Keep, CEO
- Erica Mackie, CEO, Grid Alternatives

Finally, we acknowledge the time, patience, interest, and support from the residents on the EcoBlock who, collectively, gave us hundreds of hours of their time, listening to our team, as well as sharing their thoughts, concerns and ideas with us. Without their collaboration and cooperation, the EcoBlock project team could never have accomplished the work that is encapsulated in this report.

Please see Appendix A for contact information.

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 solutions, 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 that promote greater reliability, lower costs, and increase safety for the California electric ratepayer and include:

- 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 clean, conventional electricity supply.
- Supporting low-emission vehicles and transportation.
- Providing economic development.
- Using ratepayer funds efficiently.

Accelerating the Deployment of Advanced Energy Communities: The Oakland Eco-Block is the final report for Contract Number EPC-15-058 conducted by Energy and Resources Group, University of California, 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

This report describes the design development process and recommendations of a Community-Scale Zero Net Energy Master Plan for a residential block in Oakland, the Oakland EcoBlock. The recommended master plan includes an integrated system of energy efficiency retrofits, a direct current solar/storage/electric vehicle microgrid, alternating/direct current houses, and water efficiency retrofits with rainwater capture. The recommended master plan is projected to be close to zero-net energy (95 percent) for homes, reduce carbon emissions by 65 percent at the block scale (including transportation), and reduce water use 60–70 percent.

The integrated system of energy efficiency and a direct current solar/storage/electric vehicle (EV) charging microgrid is the first of its kind at the residential block scale. This breakthrough because the deep energy efficiency retrofit savings free up enough capacity in the solar supply and storage to enable residents to switch from natural gas to electricity for heating and domestic hot water and to provide EV charging for 33 percent of vehicle miles traveled. The savings in household transportation costs are a game changer because when combined with savings in the electric and water utility bills, the total cash flow savings are projected to fund the capital improvements of the proposed systems.

This project's benefits include lower and more predictable utility bills; greater resiliency because the system can operate during outages, and vastly improved indoor air quality by reducing natural gas consumption. The local energy storage reduces peak demand for the utility. California benefits from a model that exceeds the targets for reductions in energy consumption and carbon emissions and the reductions in water use address California's severe water challenges.

The Oakland EcoBlock is a transformative model for accelerating the rapid deployment of advanced energy communities.

Keywords: air-sealing, building energy simulation, CFD, city block, community acceptance, community energy, community facilities district, community-scale, decarbonization codes, demand response, direct current, duct sealing, EcoBlock, EcoDistrict, efficiency, distributed energy resources, energy efficiency, energy savings , energy storage, equity innovation, existing residential, flywheel, governance, green bonds, heat pump water heater, HPWH, innovative codes, innovative governance, joint powers authority, JPA, Mello-Roos, microgrid, microgrid permitting, outreach, PACE, photovoltaic, property assessed clean energy, planning, public financing, PV, rainwater, real estate data energy audit, residential, retrofit, smart ventilation, stakeholder engagement, stormwater, utility API, ventilation, wastewater

Please use the following citation for this report:

Barr, Zach, Norm Bourassa, John Bowie, Rich Brown, Nora DeCuir, H. Jordan Diamond, Amy Dryden, Ethan Elkind, Harrison Fraker, Wenjie Fu, Ethan Guy, Daniel Hamilton, Ted Lamm, Maika Nicholson, Leo Rainer, Sandy Robertson, Christine Scott Thomson, Emma Tome, Andréa Traber, 2019. ***Accelerating the Deployment of Advanced Energy Communities: The Oakland EcoBlock.*** California Energy Commission. Publication Number: CEC-500-2019-043.

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EXECUTIVE SUMMARY

Introduction

The large-scale deployment of deep energy efficient retrofit strategies (near zero net energy, ZNE) in existing residential construction will be essential to achieve the carbon dioxide (CO_2) emissions reductions mandated by California Senate Bill 350 (SB 350, De León, Chapter 547, Statutes of 2015). When energy efficiency strategies are considered on their own merits, one house at a time, it is difficult to justify implementing a full suite of measures that achieves ZNE because of diminishing returns as potential strategies are evaluated from the most cost effective (high efficiency lighting) to the less cost effective (high performance windows). This is especially true for energy retrofit strategies applied to existing residential construction.

However, if the boundary of cost analysis and systems integration is expanded to include not only energy efficiency but also renewable energy supply, energy storage, and electric vehicle (EV) charging at the *block* scale, the integrated whole-system benefits can justify a full suite of efficiency strategies. Such a system frees enough available renewable energy capacity to charge EVs, and the savings in the household budget (including savings in transportation costs) can be used to cover the cost of the more expensive energy efficiency retrofits.

Thus, an integrated whole-system approach to electricity demand reduction and renewable energy supply at a scale larger than the house can be the most cost-effective pathway to ZNE and low-carbon emissions for California.

Purpose

This report describes Phase 1 of a two-phase project. Phase 1 funded the design development (technical design, planning, permitting feasibility, and financing models) of a whole-systems approach to retrofitting a low- to middle-income neighborhood block in the City of Oakland. This design would go from high energy and water dependency to the lowest energy and water footprint possible. Phase 2 funding, if approved, would fund the construction documents, bidding, construction, commissioning, and post occupancy evaluation of the Phase 1 master plan at the Oakland EcoBlock, or at another selected similar location. This project could transform an obsolete, resource-wasteful energy model into an integrated design that guarantees long-term energy sustainability while providing a replicable, scalable model consistent with the goals of AB 32 (Nuñez, Chapter 488, Statutes of 2006), SB 350, SB 375 (Steinberg, Chapter 728, Statutes of 2008), SB 1275 (De León, Chapter 530, Statutes of 2014), Executive Order B-30-15, and Executive Order B-29-15.

The goals of this project were to:

- Test the hypothesis that retrofitting on the block scale can be more efficient and cost-effective than the individual house scale in achieving maximum energy efficiency, renewable energy supply and storage, EV charging, energy management and control, water conservation, and local wastewater treatment and reuse—because that approach combines the flows, efficiencies, and cost benefits across multiple residential units, systems, and budgets.

- Advance preliminary research and development of the EcoBlock integrated system concept to move from a promising schematic level to a detailed design and master plan for demonstration integrated with actual field testing.
- Blueprint a pilot system that demonstrates a highly-efficient, affordable neighborhood block-scale energy, EV charging, water, and wastewater treatment and reuse platform and retrofitting process that stimulates consumer demand for its application anywhere in California.
- Use the block-scale test case as a measure of appropriate scale and scalability. As the smallest step increase in scale from the single house, it will provide a proof of technical feasibility that might show that it can be aggregated at a larger neighborhood scale to be even more cost effective.

If approved, the purpose of Phase 2 will be to implement the master plan developed in Phase 1.

Objectives

This project's objectives are to:

- Document the integrated design process developed by the EcoBlock team.
- Design deep energy efficiency retrofit assessments and an implementation plan for the contiguous EcoBlock of residential buildings to achieve 70 percent energy savings.
- Model the production of carbon-free electricity from solar PV at a block scale, and identify key designs and control strategies.
- Design a water and wastewater system for the EcoBlock to achieve up to 80 percent water savings, and assess the potential for decentralized water systems as components of sustainable urban infrastructure.
- Develop a block-scale zero net energy master plan for residential building energy efficiency, integrated electrical supply, and integrated water systems for the EcoBlock.
- Develop recommendations for how planning and building departments can facilitate the rapid deployment of projects similar to the EcoBlock.
- Determine novel financing and policy tools necessary to accelerate the retrofit of millions of energy inefficient and water wasteful California homes to advanced ZNE community standards.
- Develop education and outreach materials to inform local governments, developers, and community groups of project costs and benefits; the approaches and methods used; and benefits to ratepayers, grid reliability, and safety.
- Estimate projected benefits, including green jobs, apprenticeship programs, projected market penetration, energy use and cost, operating conditions, and emission reductions.
- Transfer the knowledge gained, experimental results, and lessons learned available to the public and key decision makers.

Project Results

The project team developed a recommended Community-Scale Zero Net Energy Retrofit Master Plan (ZNE-MP) which includes the following integrated systems:

- Direct current (DC) solar/storage/electric vehicle microgrid
- Energy efficiency retrofits
- Alternating current (AC)/DC houses
- Water efficiency and rainwater capture and use at the house scale

Distributed Energy Resource Systems

The distributed energy resource systems (such as energy efficiency, distributed PV solar, energy storage, DC microgrid) would be distributed according to California's loading order and generate the following CO_2 emissions reductions 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).

- Step 1: Home energy retrofits and electrification reduce home energy use by 60–70 percent.
- Step 2: Converting to shared EVs for local trips electrify about 33 percent of vehicle miles.
- Step 3: Adding rooftop PV, a DC microgrid, and central flywheel storage enables on-site solar generation to meet about 75 percent of the remaining electricity use.
- **Total: These measures are expected to reduce blockwide CO_2 emissions by about 65 percent, with close to a zero net energy (95 percent) reduction at the house scale.**

The Regulatory Process

This project identified the following approaches to address regulatory compliance:

- Planning and Zoning Codes and Processes
    1. Home-scale improvements can be permitted with existing options.
    2. Block-scale improvements mostly fit in Major Use Permits.
    3. Demonstration Ordinance or Overlay zones may offer easier permitting procedures.
- Building Codes and Processes
    1. The majority of energy improvements can be achieved using existing codes.
    2. Some water improvements require additional code adoption.
    3. Building staff may need additional training to understand some technologies.
- Engineering Codes and Processes
    1. Existing permit processes allow for creativity in right-of-way and private property improvements (for example sewer mining, easements).

2. Maintenance and operations standards and agreements are key to success.

Alternative Financing, Governance, and Business Models

The project team also identified and analyzed alternative financing, governance, and business models and "layered" them together to provide an innovative framework that shows how the project can be implemented.

- **Financing**
  1. **Community Facilities District** (CFD) mechanism allows residents to collectively finance communal energy and water installations—both upfront capital and ongoing operation and maintenance costs—via assessments on property tax bills.
  2. **Property Assessed Clean Energy** (PACE) mechanism allows residents to individually finance home-specific energy and water retrofits and appliances, via assessments on property tax bills.
- **Governance and Ownership**
  1. **Joint powers authority (JPA)** allows local governments to collectively insure, indemnify, or insulate against liabilities related to public ownership of EcoBlock assets via the CFD.
  2. A **nonprofit trust** allows residents to collectively ensure and organize EcoBlock participation, coordinate multiple financing mechanisms, and manage ongoing maintenance of assets.
- **Scaling Beyond the Pilot**
  1. CFD, PACE, and JPA facilitate scaling to additional blocks (such as statutory annexation).
  2. As EcoBlocks proliferate, third parties may assume a governance role and administer the financing, creating a streamlined process for residents.
  3. CFD and PACE are flexible to finance larger or smaller portions of assets.

Market and Information Transfer

The project team engaged a wide variety of stakeholders to ensure that the project results were shared with as wide of an audience as possible.

- Homeowners and neighborhood associations have been informed of the overall concept and hypotheses for the project through meetings and interviews.
- The City of Oakland has participated in the "design charrettes," and the evaluation of the multiple scenarios analyzed, and are informed about the recommended systems, the permitting issues, and the innovative finance, governance and business model.
- Additional industry sponsors (the Rexel Foundation, the Veolia Foundation, and the Ramboll Foundation) have been briefed on the progress of the work undertaken in the report.

Outreach materials developed for this project are included in Appendix N and includes information packets, brochures, and fact sheets describing the EcoBlock concept. Project information was shared at venues such as town hall meetings, local government workshops, and workshops for developer and engineering firms.

Project updates and results were shared with a Technical Advisory Committee comprised of representatives from academia, non-profit community based organizations, municipal utilities, local governments, and the state treasurer's office.

Benefits

The concept of an EcoBlock, as exemplified by the Community-Scale Zero Net Energy Retrofit Master Plan has the potential to provide the following ratepayer benefits.

General:

- The cash flow savings from utility bills and gasoline can fund the energy and water system upgrades for homeowners who could otherwise not afford them.
- The savings also fund the conversion to a locally distributed renewable energy supply with built-in storage that balances the load profile of the utility.
- The energy savings from the energy efficiency retrofits creates enough capacity in the rooftop renewable PV supply and storage to charge EVs for the equivalent of 25 percent of vehicle miles traveled (VMT).
- The renewable supply has enough capacity to allow fuel switching from gas domestic hot water and home heating to an electric heat pump system.
- Energy storage changes load profile of the block, dramatically reducing peak demand for the utility.
- Improvements in the housing envelope result in increased occupant comfort and well-being through the reduction of indoor natural gas consumption and through smart ventilation.
- Upgrades result in increased real estate value.

Block scale:

- Energy reduction (close to ZNE at each house)
- Water savings (a 60–70 percent reduction in water use)
- Steep CO_2 reduction (65 percent at the block scale, including VMT)
- Electrification of heating, hot water, and local car trips
- Improved indoor air quality for all participants

Social/Local Economy:

- Green jobs

    - Electricians, plumbers, and contractors
- Workforce development
    - Apprenticeship and training programs for advanced energy and water infrastructure

CHAPTER 1:
Introduction and Background

For California to reach the requisite carbon dioxide (CO_2) reductions in emissions mandated in Assembly Bill 32 (Nunez, Chapter 488, Statutes of 2006), deep energy efficiency retrofit strategies, renewable energy supply and storage, and the decarbonization of transportation must be found for existing housing stock. In addition, California needs to develop solutions to current and future serious water shortages and severe heat waves due to climate change.

The Oakland EcoBlock project was conducted in response to Electric Program Investment Charge (EPIC) solicitation GFO-15-312. The solicitation's purpose was to "…fund a competition that will challenge project teams comprised of building developers, local governments, technology developers, researchers, utilities, and other project partners to develop innovative and replicable approaches for accelerating the deployment of Advanced Energy Communities in Pacific Gas & Electric (PG&E), Southern California Edison (SCE) and San Diego Gas and Electric (SDG&E) service territories."

This study's purpose was to conduct the design development (technical design, planning, permitting feasibility, and financing models) of a whole-systems approach to retrofitting a low- to middle-income neighborhood block in the City of Oakland from high energy and water dependency to the lowest energy and water footprint possible.

The Oakland EcoBlock represents typical housing development in first-ring neighborhoods around almost every city in California, equaling approximately 40 to 45 percent of its housing stock. The pressing questions are: (1) can these neighborhoods be retrofitted to achieve zero net energy (ZNE), zero-carbon emissions, and low water usage while promoting the adoption of electric vehicles (EVs) and create climate-positive mitigation/adaption to global warming; and (2) can such retrofits be rapidly deployed at the community scale?

The project was proposed to be conducted in two separate phases: (1) design development, and (2) implementation of the master plan developed in the first phase. This report discusses the Phase 1 research and results.

Phase 1: Design Development

The block in Oakland, California, that is the focus of this work is located in Oakland's Golden Gate neighborhood, in the northwest corner of the city, east of Emeryville and south of Berkeley. Over the past two centuries it has evolved from pastureland to the small town of Klinknerville to an urban, residential neighborhood. From the mid-1890s through the 1920s, an efficient, ubiquitous fleet of electric trolleys connected the neighborhood to the larger East Bay. See Appendix B, Map Analysis, for a more detailed discussion of the area's history.

This project had four goals:

1. To test the hypothesis that retrofitting on the block-scale can be more efficient and cost-effective than the individual house-scale in achieving maximum energy efficiency, renewable energy supply and storage, EV charging, energy management and control, water conservation, and local wastewater treatment and reuse. It would achieve these efficiencies by combining the flows, efficiencies, and cost benefits across multiple residential units, systems, and budgets.
2. To advance preliminary research and development of the EcoBlock integrated system concept to move from promising schematic level to a detailed design and master plan for demonstration integrated with actual field testing.
3. To blueprint a pilot system that demonstrates a highly efficient, affordable, neighborhood block-scale energy, EV charging, water, and wastewater treatment-and-reuse platform and retrofitting-process that stimulates consumer demand for its application anywhere in California.
4. To use the block-scale test case as a measure of appropriate scale and scalability. As the smallest step increase in scale from the single house, it will provide a proof of technical feasibility that might show that it can be aggregated at a larger neighborhood scale to be even more cost-effective.

If implemented, this project would transform a resource-wasteful city block into an integrated EcoBlock design that guarantees long-term sustainability while providing a replicable, scalable model consistent with the goals of AB 32, SB 350 (De León, Chapter 547, Statutes of 2015), SB 375 (Steinberg, Chapter 728, Statutes of 2008), SB 1275 (De León, Chapter 530, Statutes of 2014), Executive Order B-30-15, and Executive Order B-29-15.

Phase 2: Detailed Design and Engineering

Phase 1 of the EcoBlock project completed the schematic design of various scenarios of energy efficiency retrofits and an integrated electrical system for the block. If additional funding and support is received, the project will move into Phase 2 through a typical project design process of development, construction documents, cost estimating, bidding, and permitting and construction management for the selected scenario.

Report Structure

- Chapters 2, 3, and 4 present the technical research conducted on deep energy efficiency analysis, integrated electrical system design and evaluation, and integrated water system design and evaluation. This work provided the baseline technical analyses upon which the other work was developed.
- Chapters 5 and 6 present the research focusing on regulations, permitting, governance, and financing needed to implement the EcoBlock project.
- Chapter 7 presents the master plan that was developed as guidelines for the potential Phase 2 implementation of the project.
- Chapters 8 and 9 present benefits and technology and knowledge transfer, respectively.
- Chapters 10 and 11 present a case study and outreach strategy.

- The appendices present information both about the Oakland EcoBlock project and for stakeholders interested in pursuing their own EcoBlock project.

CHAPTER 2:
Deep Energy Efficiency Analysis

Abstract

The EcoBlock energy efficiency retrofit method is an approach that can help the state meet the goals of SB 350 and the AB 32 Global Warming Solutions Act by providing a template response to address climate change emissions from existing residential building communities in California. The Deep Energy Efficiency Analysis team analyzed the existing energy performance and potential efficiency upgrades for 27 buildings in a case study Northwest Oakland, California, demonstration site. The block currently has 12 single-family detached homes, 13 multi-unit house rental properties, and 2 midsized multifamily buildings (an 11-unit condominium and an 8-unit apartment building). In total, the block contains 65 individual PG&E utility accounts.

During this Phase 1 work, the team produced preliminary energy efficiency upgrade designs and energy consumption and electrical demand estimates to support a microgrid design (see Chapter 3). For this Phase 1 work, the team developed building energy simulation methods using the Lawrence Berkeley National Laboratory (LBNL) Home Energy Saver Professional tool, drawing only from publicly available real estate building description information, drive-by audits, and online map imaging. The team then generated block-scale post-retrofit energy and power demand estimates and designed a preliminary solar energy and storage system microgrid, as well as three grade levels of energy efficiency and electrical retrofit implementations (scenarios 1e, 2e, and 3e) for the EcoBlock Master Plan (Chapter 7). In future Phase 2 work, the team will conduct on-site investment-grade building audits, targeted diagnostic testing, and calibrated investment-grade energy models to validate or refine the Phase 1 assumptions and recommendations, and also produce construction work scopes and bid specifications.

A core concept of the EcoBlock analysis process is to access extended financial payback opportunities through the on-site solar-powered microgrid, thereby enabling deeper energy-efficiency retrofits for each building than would normally be cost-effective when calculated for each individual building one-by-one from their own energy cost budgets.

Overview of the EcoBlock Energy Efficiency Retrofit

Policy Context and State Goals

Significantly improving the energy efficiency of new buildings would cut energy bills dramatically, improve indoor air quality, and ensure comfortable home and workplace temperatures. Energy efficiency is also one of the most cost-effective ways to reduce carbon pollution and take action on climate change while stoking a new clean energy market that creates jobs and improves overall livability for residents. California has one of the cleanest energy economies and some of the most aggressive climate policies worldwide.

California has established reach goals for reducing greenhouse gas (GHG) emissions and doubling its energy efficiency by 2050. Senate Bill 350 (De León, Chapter 547, Statutes of 2015)[1] requires the State of California to increase the procurement of renewable-sourced energy from the previous goal of 33 percent to 50 percent, and to double the energy savings in electricity and natural gas end uses for retail customers through both efficiency and conservation actions by 2030. Senate Bill 350 also mandates a widescale electrification of the state's transportation system. Senator De León's Draft SB 100 (De León 2017) advances this initiative by five years to achieve (1) a target of 100 percent clean energy by 2045, (2) a target of 50 percent renewable energy by 2026, instead of 2030, and (3) policy development of energy companies to capture methane emissions. In addition, in 2016 California passed SB 32—the Global Warming Solutions Act of 2006 (Pavley, Chapter 249, Statutes of 2016),[2] which set interim greenhouse gas reduction goals of 40 percent by 2030.

The California Energy Commission (Energy Commission) has proposed subtargets for non-utility programs, funded through investor-owned and publicly owned utility programs, as well as government, private, and utility ratepayer resources to achieve state doubling targets. Subtargets for utilities are based on utility programs, while subtargets for non-utility programs are based on codes and standards, financing programs, and behavioral and market transformation programs (Jones 2017). Transitioning to all-electric construction practices is essential to meeting the above-mentioned state climate change response goals. California's electricity supply will continue to become cleaner as the state advances toward its 2030 goal of 50 percent renewable energy. Installing new gas-fired equipment today will lock in GHG emission sources for another 15–20 years.

The EcoBlock approach can help California meet SB 350 and AB 32 goals by providing a template response to addressing emissions from existing residential communities in California. The following sections discuss a simplified energy modeling methodology (Preliminary Phase 1 Energy Analysis) that uses a publicly supported modeling method in conjunction with fully public building description data. It is plausible that this method could be applied at a macro scale for each California climatic zone region, using a representative sample of the residential building stock along with residential survey weighting factors (i.e., RASS[3] and RECS[4]). The resulting analysis could provide valuable policy scenario information on potential statewide EcoBlock-style retrofit deployments toward the support of SB 350 goals.

EcoBlock Site Description

The selected EcoBlock location is in a Northwest Oakland, California, neighborhood, and is highly representative of typical older residential buildings in Oakland.

The block consists of 27 separate buildings on 26 individual lots, of which 25 are single-family detached houses and 2 are multifamily buildings (one lot has a documented detached rental unit). There are also two lots with informal detached in-law buildings, however, in the interest of modeling simplicity these small buildings were not modeled separately. The two multifamily buildings are an 11-unit condominium building and an 8-unit apartment building (Figure 2-1).

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[1] The Clean Energy and Pollution Reduction Act of 2015

[2] The Global Warming Solutions Act of 2006

[3] Residential Appliance Saturation Study, http://www.energy.ca.gov/appliances/rass

[4] Residential Energy Consumption Survey, https://www.eia.gov/consumption/residential

Figure 2-1: Block Arial and Diagram Views

Source: Google Maps (left); UC Berkeley (right)

The large condominium building was built in 1964 as a high-bay warehouse with heavy uninsulated concrete wall construction. At some unknown point it was converted into an 11-unit apartment building, and then in early 2015 it was converted into individually owned condominium units. The remaining buildings are all wood frame structures. Twelve of the single-family detached homes are currently occupied as single-family properties, while the remaining have been converted to multi-unit rental buildings. In whole, the block contains a total of 65 individual dwelling units with separate PG&E utility accounts.

Energy Efficiency Analysis Overview: Phase 1 and Phase 2

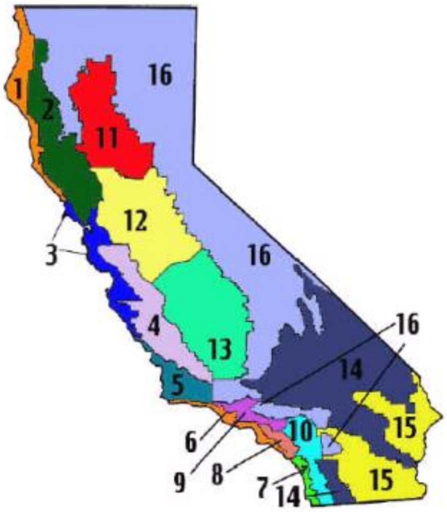
The EcoBlock energy-efficiency retrofit analysis project is designed to occur over two project phases. Phase 1 consists of a research and development effort to identify and evaluate block characteristics and housing type characteristics, at a conceptual level, to support the preliminary designs of deep energy retrofits at a block scale, as well as an annual energy consumption and peak electrical demand estimate to support the preliminary design activities described in Chapter 3. Phase 1 tested the ability of the project team to estimate household energy consumption using a limited data set of building description information, drawing from real estate Multiple Listing Service (MLS) data, drive-by audits, and online mapping image resources. Through this initial energy modeling process, the team identified target energy-efficiency upgrades, established reduction targets, and developed preliminary block-scale renewable sizing and storage systems. The team then was able to develop a series of EcoBlock retrofit packages into the models at a higher level of capital investment than would typically be cost-effective at a individual household scale.

In Phase 2, the project team will conduct on-site investment-grade building audits and targeted diagnostic testing, and develop site-specific and calibrated investment-grade energy models to validate or refine the assumptions and recommendations developed during Phase 1. During Phase 2, the team also will provide final construction documents and work scopes for the installation of each identified house and block-level upgrade. In addition, the team will further evaluate the scalability of the EcoBlock concept as a cost-effective model to achieve deep energy-efficiency savings and carbon emission reductions within existing residential buildings in California.

Three Tiered Retrofit Scenarios

The City of Oakland is located in California Climatic Data Zone 3 (CZ3) (Figure 2-2), which covers the moderate climatic regions of the San Francisco Bay Area.

Figure 2-2: California Climatic Data Zones



Source: https://engineering.purdue.edu/DLAT/help/cacz.htm

Along with most of the coastal climate zones in California, CZ3 experiences difficult energy-saving payback calculations for many capital-intensive residential energy efficiency retrofits due to moderate space-conditioning loads and by extension relatively low monthly utility bills. As a result, the team's analysis methodology did not use the conventional method of removing long payback (i.e., greater than 10 years) upgrades. Instead, all commercially available upgrades for the building envelope, space conditioning equipment, electrical lighting, and major appliances were included in three separate EcoBlock retrofit scenarios, and the cost-effectiveness of each scenario was analyzed at the block microgrid scale.

Fuel switching from natural gas to all electric is a core component of the EcoBlock building retrofit process. Once converted, the building can access the on-site solar-powered microgrid serving the block and therefore access a better payback calculation for energy-efficiency retrofit investments. This is in contrast to a typical non-upgraded house with its own separate utility budget for the ZIP code EcoBlock location. This typical house would be a 1968-built, 1800 square foot, single-story house with a natural gas central furnace and domestic water heater. Assuming that this hypothetical house had not been upgraded in the past 20 years, it would likely have only six cost-effective energy-efficiency upgrades with less than a 10-year simple payback (Figure 2-3).[5]

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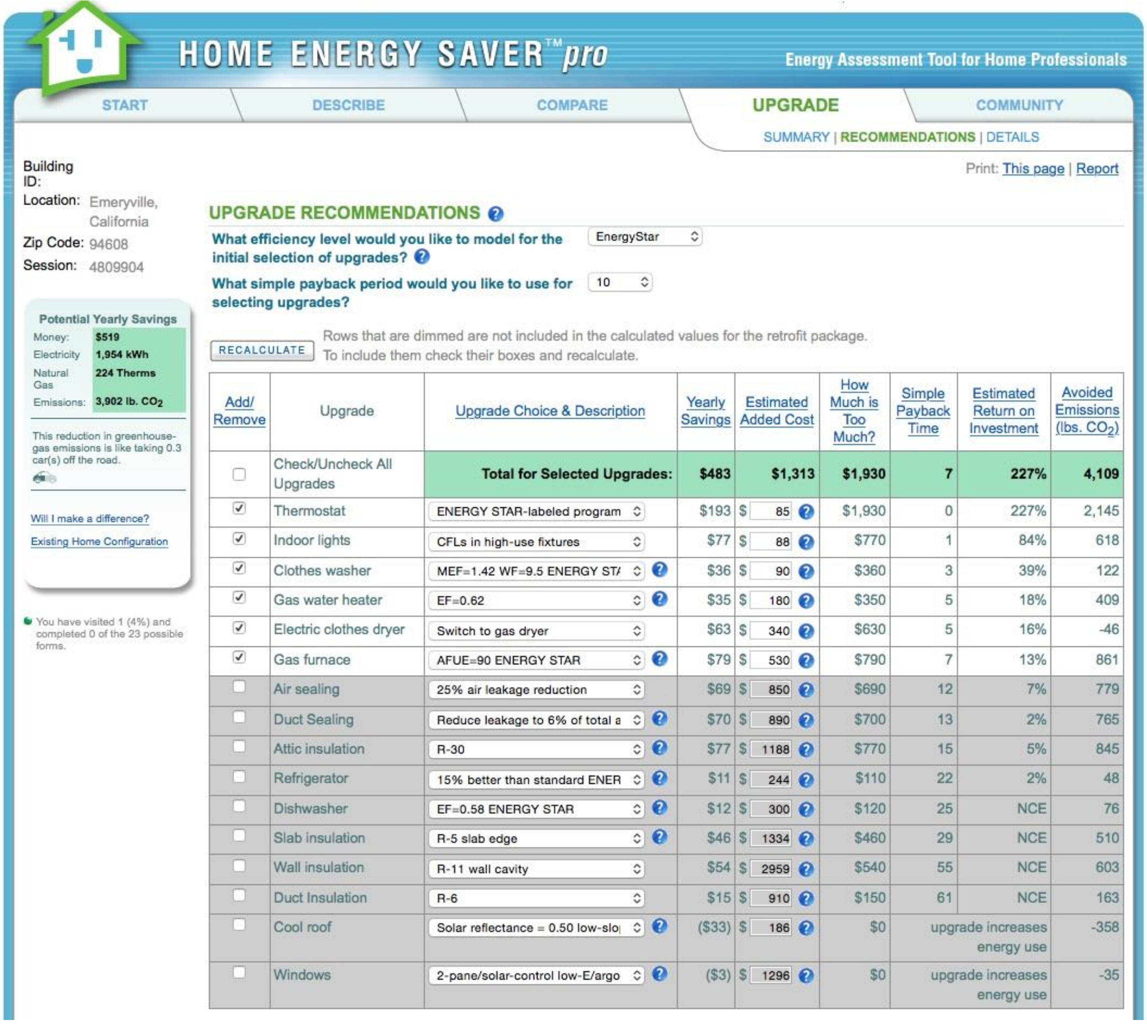
[5] This was determined using a full default Home Energy Saver Professional (http://hespro.lbl.gov) session, entering only the 95608 ZIP code and executing Calculate.

Figure 2-3: Typical Cost-Effective Retrofits for a 94608 ZIP Code, Single-Family Detached Home



Building ID:
Location: Emeryville, California
Zip Code: 94608
Session: 4809904

Potential Yearly Savings

Money:	$519
Electricity	1,954 kWh
Natural Gas	224 Therms
Emissions:	3,902 lb. CO_2

This reduction in greenhouse-gas emissions is like taking 0.3 car(s) off the road.

You have visited 1 (4%) and completed 0 of the 23 possible forms.

UPGRADE RECOMMENDATIONS

What efficiency level would you like to model for the initial selection of upgrades? EnergyStar

What simple payback period would you like to use for selecting upgrades? 10

Rows that are dimmed are not included in the calculated values for the retrofit package. To include them check their boxes and recalculate.

Add/ Remove	Upgrade	Upgrade Choice & Description	Yearly Savings	Estimated Added Cost	How Much is Too Much?	Simple Payback Time	Estimated Return on Investment	Avoided Emissions (lbs. CO_2)
☐	Check/Uncheck All Upgrades	Total for Selected Upgrades:	$483	$1,313	$1,930	7	227%	4,109
☑	Thermostat	ENERGY STAR-labeled program	$193	$ 85	$1,930	0	227%	2,145
☑	Indoor lights	CFLs in high-use fixtures	$77	$ 88	$770	1	84%	618
☑	Clothes washer	MEF=1.42 WF=9.5 ENERGY ST/	$36	$ 90	$360	3	39%	122
☑	Gas water heater	EF=0.62	$35	$ 180	$350	5	18%	409
☑	Electric clothes dryer	Switch to gas dryer	$63	$ 340	$630	5	16%	-46
☑	Gas furnace	AFUE=90 ENERGY STAR	$79	$ 530	$790	7	13%	861
☐	Air sealing	25% air leakage reduction	$69	$ 850	$690	12	7%	779
☐	Duct Sealing	Reduce leakage to 6% of total a	$70	$ 890	$700	13	2%	765
☐	Attic insulation	R-30	$77	$ 1188	$770	15	5%	845
☐	Refrigerator	15% better than standard ENER	$11	$ 244	$110	22	2%	48
☐	Dishwasher	EF=0.58 ENERGY STAR	$12	$ 300	$120	25	NCE	76
☐	Slab insulation	R-5 slab edge	$46	$ 1334	$460	29	NCE	510
☐	Wall insulation	R-11 wall cavity	$54	$ 2959	$540	55	NCE	603
☐	Duct Insulation	R-6	$15	$ 910	$150	61	NCE	163
☐	Cool roof	Solar reflectance = 0.50 low-slo	($33)	$ 186	$0	upgrade increases energy use		-358
☐	Windows	2-pane/solar-control low-E/argo	($3)	$ 1296	$0	upgrade increases energy use		-35

Source: UC Berkeley

It is important to note that all the capital-intensive retrofits in fall below the cost-effective line, an unfortunate outcome of this moderate climatic region, which often pushes the payback of commercially viable retrofit measures beyond 10 years.[6]

A core concept of the EcoBlock analysis is to access extended financial payback opportunities through the on-site solar-powered microgrid, thereby enabling deeper energy-efficiency retrofits. With that in mind, our energy modeling analysis for the 27 EcoBlock buildings occurred through the following stages, leading to three scenarios of energy-efficiency retrofit packages:

1. Assemble 27 existing as-built models (electricity and natural gas fuels)
2. Convert as-built models into all-electric baseline models

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[6] Note that all Home Energy Saver equipment upgrades are calculated using incremental costs that assume that the upgrade is done at the time of equipment replacement.

3. Implement the three scenarios of EcoBlock Energy Efficiency (EE) Retrofit packages on the all-electric baseline models
    - Scenario 1e – AC Solar/Storage Microgrid with EE Retrofits:
        - Air sealing on building envelope (reduce infiltration by >25 percent)
        - Upgrade wall cavity insulation to maximum possible (R11 to R21)
        - Upgrade existing attic or roof insulation by R30 or R15, respectively
        - Convert to a high-efficiency heat pump water heater (Sanden n.d.), delivering domestic hot water (DHW) and heating hot water (HHW)
        - Replace the existing furnace with a new air handler and HHW coil
        - Seal the existing heating air distribution ducts
        - Install high-efficiency LED lighting fixtures and lamps. Where applicable, use fixtures with integrated ceiling fans
        - Install new ENERGY STAR®-rated major appliances
        - Install web connect smart thermostats and a home energy monitoring system
        - Install a smart ventilation system that meets the current California Building Energy Efficiency Standards (CEC 2016, 55–89) for indoor air quality
    - Scenario 2e – DC Solar/Storage/EV Microgrid with EE Retrofits – Includes all Scenario 1e EE upgrades plus:
        - Upgrade windows to high-efficiency, double-glazed, argon filled, low-e with wood or vinyl frames
    - Scenario 3e – DC Solar/Storage/EV Microgrid with EE Retrofits – Includes all Scenarios 1e EE and 2e EE upgrades, plus:
        - Install direct current (DC)-powered major appliances

Each model generated results for annual energy consumption, peak electrical demand, and an annual 8,760 hour kilowatt load profile. The 27 individual model results were then summed into an EcoBlock aggregate load profile.

Preliminary Phase 1 Energy Analysis

The Phase 1 analysis consisted of an initial preliminary analysis using default data sources and a Level 1 energy analysis. This analysis relied upon publicly available data sources specific to the individual EcoBlock buildings, along with the professional experience of the LBNL Home Energy Saver energy modeling team.

"Drive-By" Audit Methods

Phase 1 site audit methods were limited to outside, street access visual observations through online and in-person means. While other teams within the project were conducting parallel community outreach and occupant interview activities, none of those activities included data that could support the energy model development. As a result it was decided to limit this phase of modeling to an asset-level analysis, which defaulted the occupant operational factors into a standardized set for all the buildings. The ACEEE 2012 paper *Validation of the Home Energy Saver Calculation Methodology* discussed the various forms of audit methods in more detail (Parker 2012).

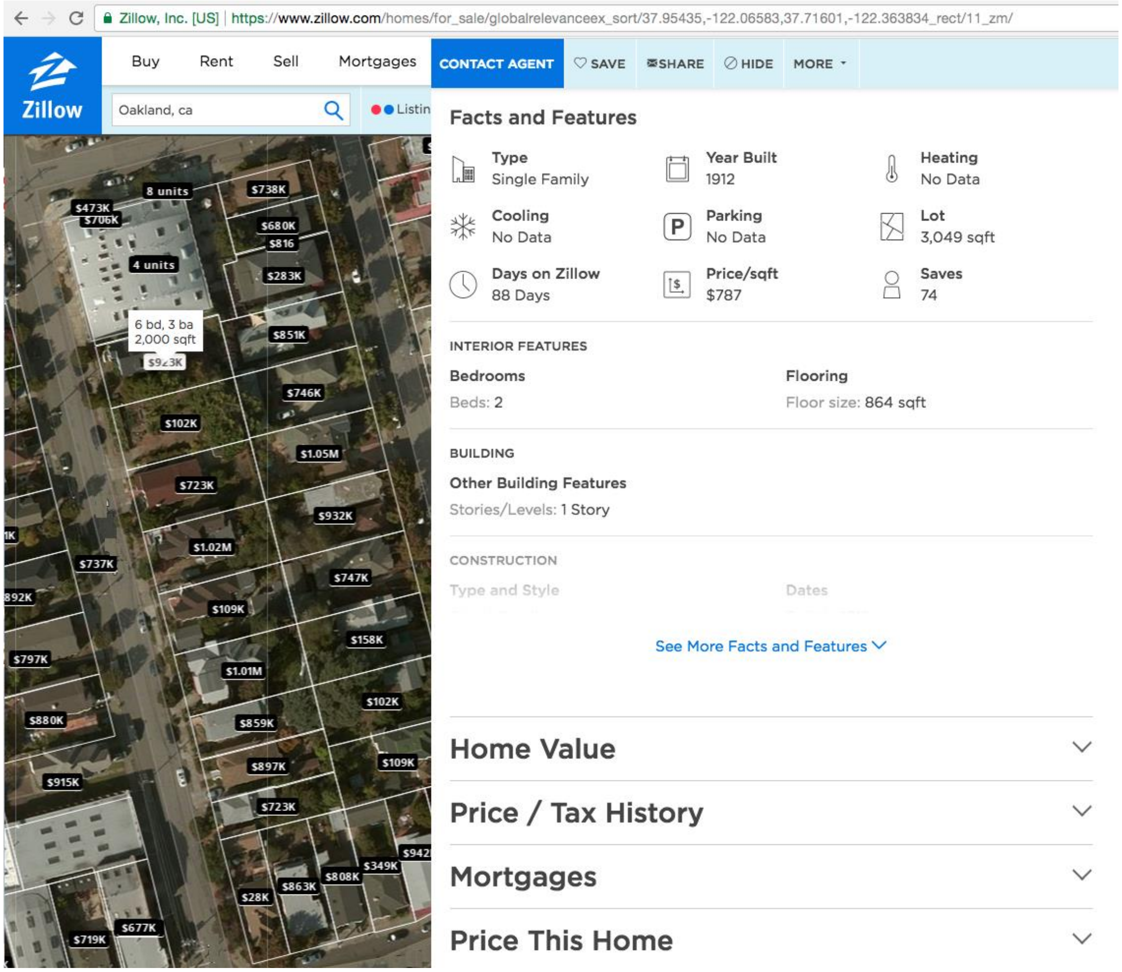
Virtual Drive-by

Two virtual "drive-by" methods were used in gathering as much as-built information about each building as could be easily obtained through public and non-intrusive methods.

Zillow Website

MLS real estate home description and existing tax assessment information were gathered using the Zillow online mapping tool (Figure 2-4) (Zillow website, n.d.).

Figure 2-4: Zillow Map View – Example MLS Details



Facts and Features

Type
Single Family

Year Built
1912

Heating
No Data

Cooling
No Data

Parking
No Data

Lot
3,049 sqft

Days on Zillow
88 Days

Price/sqft
$787

Saves
74

INTERIOR FEATURES

Bedrooms
Beds: 2

Flooring
Floor size: 864 sqft

BUILDING

Other Building Features
Stories/Levels: 1 Story

CONSTRUCTION

Type and Style

Dates

Source: Zillow.com

Google Maps Street View

The team used the Google Street View feature[7] to observe the front of each EcoBlock building, which provided an estimate of the general exterior wall factors, including window-to-wall ratios, siding type, roof type, and window type.

While the use of these public data sources provided adequate information for the initial energy analysis models, the project team understood that these data sets can be out of date due to delays in image updates on these online websites. Since the Phase 1 plans called only for accessing publicly available building description data, it was deemed that in-person curbside observations of each building was needed to better capture their current condition.

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[7] Google Street View. https://www.google.com/streetview/

Physical Drive-by

As a rapid and inexpensive validation of the Google Maps Street View gathered data, the team also recorded a video drive-by of the entire block, which provided a more recent view of the home exteriors and slightly better views of the building facades. During the Phase 2 energy analysis, detailed site audits will be conducted on each building.

Energy Modeling Tools

Home Energy Saver

The Deep Energy Efficiency Analysis team is also the developer of the Home Energy Saver Professional[8] website (HESaver), an online interactive home energy assessment tool that is combined with extensive decision-support content. HESaver is a fully documented and free-to-use energy simulation tool, based on peer review building science input from both the public and private energy modeling community, with funding sponsorship from the U.S. Department of Energy (DOE) and others. It has been well validated as providing accurate results (Parker et al. 2012) and has a wide user base. HESaver supports the federal energy mission by helping to build national recognition of the ENERGY STAR brand and other federal programs. The website also is used periodically by students and researchers as a tool for analyzing residential energy performance issues, and for learning from actual homeowners about their experiences with implementing energy-saving upgrades.

HESaver Application Programming Interface (API) Batch Processing

The various Home Energy Saver websites are built upon a server-side backend of Application Programming Interface (API)[9] web services, which control the core Home Energy Saver calculation engines.[10] The HESaver APIs are available to researchers and public markets alike, allowing direct programming script-level control of HESaver so users can automate simulation of multiple residential buildings with a minimum of user interface and scripting commands. The LBNL researcher team used this feature with an in-house batch-processing tool to run all the building models with automated and easily repeatable methods. Traditional engineering tools such as spreadsheets, formatted data files, and programming script languages (i.e., PHP, AWK, and Python) were used to edit the individual building inputs, execute energy result simulations, and analyze results.

In the final energy efficiency retrofit package (the analysis of advanced heat pump-based systems for combined domestic water heating and space conditioning) the analysis branched away from the public HESaver API system into an offline development version of the HESaver DOE2.1e model. The offline DOE2.1e model is the same calculation engine that is currently being used in the Home Energy Scoring Tool, the official calculation tool for the DOE's Home Energy Score Program (DOE, n.d.).

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[8] The professional version, for the energy efficiency informed public, is located at http://hespro.lbl.gov. Home Energy Saver Consumer, which targets general consumers and homeowners, is located at http://hes.lbl.gov.

[9] Home Energy Saver Multifamily API portal. http://developers.buildingsapi.lbl.gov.

[10] Public engineering documentation is located at https://sites.google.com/a/lbl.gov/hes-public/

Multifamily Tool for Energy Analysis (MulTEA)

MulTEA is part of the Weatherization Assistant,[11] a family of easy-to-use but advanced computer audit software programs that select energy-efficiency retrofit measures for homes to be weatherized.

MulTEA is a multifamily buildings energy audit tool designed to provide weatherization auditors with an improved analysis tool to identify cost-effective energy-efficiency retrofit measures. It is a DOE-approved tool specifically designed to help states and local governments implement DOE's Weatherization Assistance Program[12] in their jurisdictions. It is also available to be used by other organizations such as utilities or small business home energy professionals.

LBNL created a new multifamily version of the Home Energy Saver API, which uses the DOE-2.1e hourly building energy simulation program together with supplementary engineering calculations to estimate the annual energy use and potential energy savings of weatherization retrofits. MulTEA uses this API to estimate the heating, cooling, lighting, and appliance energy consumptions of a building. The assessment takes into account local weather, building heat losses and gains, internal gains, and building air tightness (e.g., from a blower door test), and allows users to enter whole-building electricity and fossil fuel energy bills to manually calibrate the building model.

Energy Retrofit Analysis and Building Components

Energy Analysis

As discussed earlier, the Phase 1 energy analysis was conducted as an *asset* analysis, in which the operational factors were set to the HESaver defaulted values for the 94608 ZIP code. The extensive input assumptions are provided in tabular form in Appendix C.

As mentioned, these retrofit upgrades involve fuel switching from natural gas to all-electric equipment. Fuel switching creates a small complication in calculating energy savings ratios, due to differing source energy factors between electricity and natural gas, as well as differing energy fuel units. For the energy efficiency analysis phase, the team conducted all the building energy simulations on a site energy basis. Source energy emission factors were calculated at the aggregate EcoBlock scale as part of the benefits analysis in Chapter 8.

Table 2-1, Figure 2-5, and Figure 2-6 present the building simulation results, using MBtu energy content units, thereby providing the basis to compare as-built baseline home electricity and natural gas energy consumption against the three energy-efficiency retrofit scenarios which only consume electricity.

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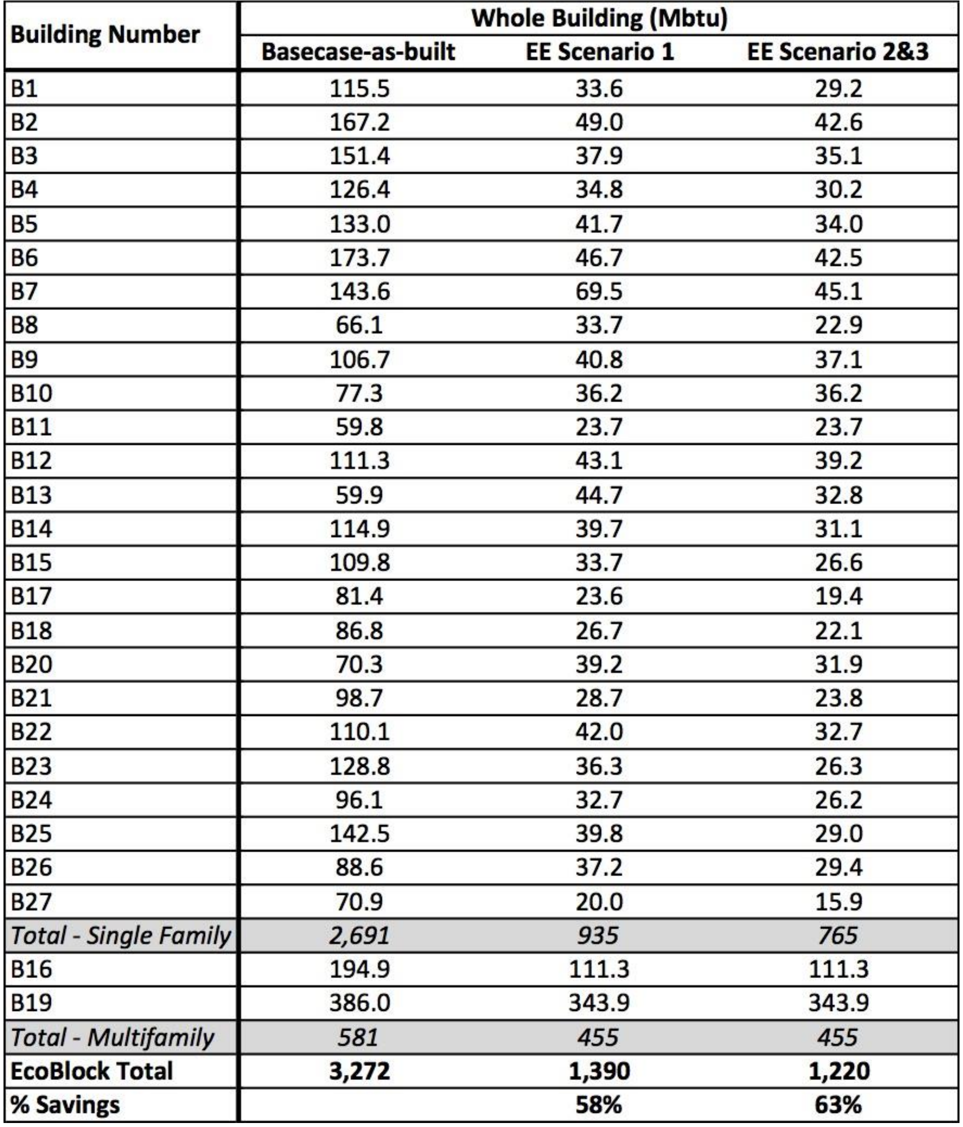
[11] Weatherization Assistant. http://weatherization.ornl.gov/assistant.shtml

[12] Weatherization Assistance Program. https://energy.gov/eere/wipo/weatherization-assistance-program

Table 2-1: Phase 1 Energy Simulation Results

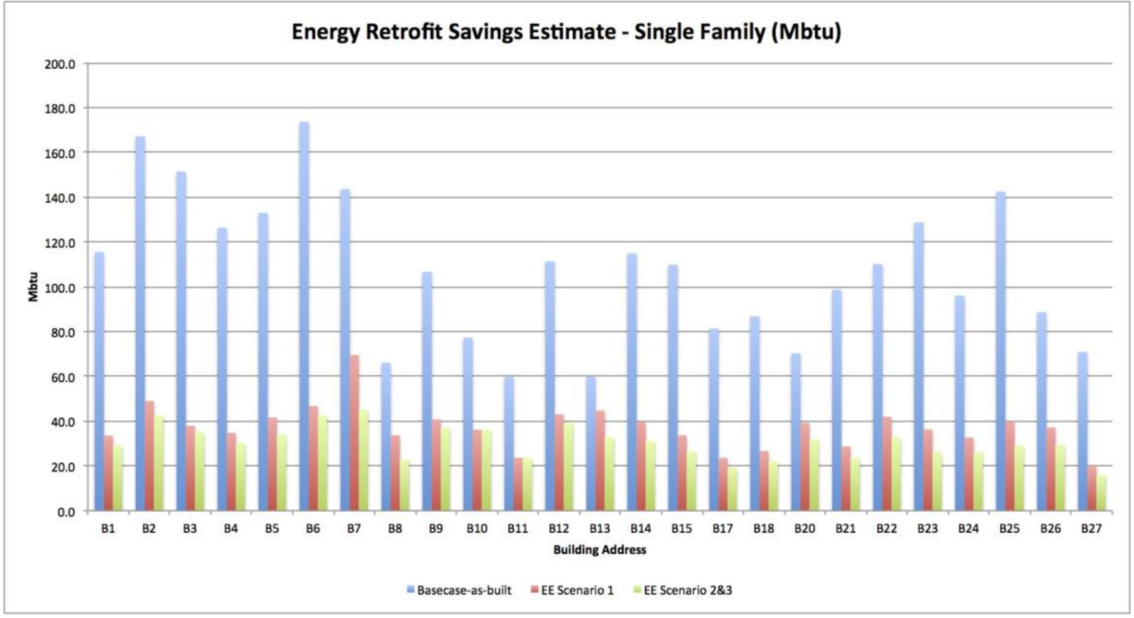


Building Number	Whole Building (Mbtu)		
	Basecase-as-built	EE Scenario 1	EE Scenario 2&3
B1	115.5	33.6	29.2
B2	167.2	49.0	42.6
B3	151.4	37.9	35.1
B4	126.4	34.8	30.2
B5	133.0	41.7	34.0
B6	173.7	46.7	42.5
B7	143.6	69.5	45.1
B8	66.1	33.7	22.9
B9	106.7	40.8	37.1
B10	77.3	36.2	36.2
B11	59.8	23.7	23.7
B12	111.3	43.1	39.2
B13	59.9	44.7	32.8
B14	114.9	39.7	31.1
B15	109.8	33.7	26.6
B17	81.4	23.6	19.4
B18	86.8	26.7	22.1
B20	70.3	39.2	31.9
B21	98.7	28.7	23.8
B22	110.1	42.0	32.7
B23	128.8	36.3	26.3
B24	96.1	32.7	26.2
B25	142.5	39.8	29.0
B26	88.6	37.2	29.4
B27	70.9	20.0	15.9
Total - Single Family	*2,691*	*935*	*765*
B16	194.9	111.3	111.3
B19	386.0	343.9	343.9
Total - Multifamily	*581*	*455*	*455*
EcoBlock Total	**3,272**	**1,390**	**1,220**
% Savings		**58%**	**63%**

Source: UC Berkeley

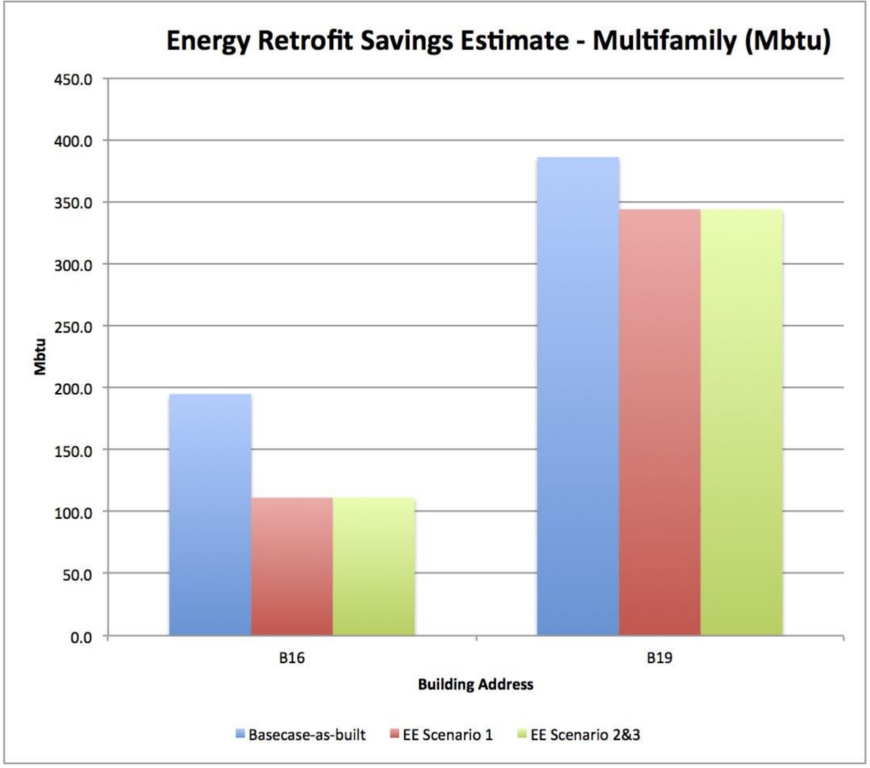
The Phase 1 energy simulations show that the Scenario 1e list of energy-efficiency upgrades is estimated to provide a block-scale aggregate site energy savings of 58 percent. By adding the expensive measures of retrofitting all the windows and installing DC-powered major appliances, scenarios 2e and 3e are estimated to provide 63 percent site energy savings.

Figure 2-5: Single-Family Retrofit Savings



Source: UC Berkeley

Figure 2-6: Multifamily Retrofit Savings



Source: UC Berkeley

While the figures above are valuable to more easily represent the energy savings numbers, MBtu energy values are not useful for designing solar energy and microgrid systems (see Chapter 3). Table 2-2 provides a concise summary of the annual energy consumption results in kilowatt-hours and peak electrical demand in kilowatts, which were delivered to the project team designing those systems.

Table 2-2: Simulation Results - Annual Energy Consumption (kWh) and Peak Electrical Demand (kW)

Building Number	Whole Building						
	Basecase-as-built		**Basecase-all-elec**	**EE-retrofit-Scenario 1**		**EE-retrofit-Scenario 2&3**	
	Elec (kWh)	**NG (Therms)**	**Elec (kWh)**	**Elec (kWh)**	**Peak kW**	**Elec (kWh)**	**Peak kW**
B1	6,516	933	16,906	9,833	3.7	8,561	2.6
B2	9,624	1,344	23,135	14,357	4.6	12,486	3.4
B3	8,254	1,233	21,062	11,112	3.3	10,278	2.9
B4	6,604	1,039	16,935	10,201	3.2	8,847	2.5
B5	6,662	1,103	16,488	12,216	3.9	9,962	2.8
B6	9,624	1,409	25,489	13,692	4.6	12,441	3.7
B7	8,313	1,153	19,548	20,374	9.9	13,206	5.7
B8	4,724	500	10,374	9,878	3.8	6,718	2.4
B9	6,516	845	14,788	11,945	5.7	10,872	3.9
B10	6,223	561	15,345	10,596	4.1	10,596	4.1
B11	4,636	440	11,430	6,935	2.3	6,935	2.3
B12	7,932	843	21,232	12,617	5.2	11,496	3.9
B13	6,868	365	16,144	13,109	4.4	9,619	2.8
B14	8,020	876	19,727	11,647	4.1	9,120	2.9
B15	5,017	927	12,456	9,876	3.3	7,802	2.3
B17	4,782	651	12,568	6,931	2.3	5,686	1.7
B18	4,812	704	12,715	7,828	2.8	6,478	2.1
B20	8,216	423	19,143	11,492	4.3	9,341	3.2
B21	6,457	767	14,143	8,411	2.4	6,965	1.8
B22	7,932	831	20,212	12,298	4.0	9,578	2.7
B23	6,633	1,062	16,195	10,633	3.2	7,695	2.2
B24	4,900	794	12,075	9,573	2.7	7,664	1.9
B25	8,254	1,144	18,698	11,676	3.6	8,511	2.2
B26	7,785	621	18,935	10,897	3.5	8,622	1.2
B27	4,724	548	11,664	5,851	1.9	4,665	1.2
Totals - Single Family	*170,028*	*21,116*	*417,407*	*273,978*		*224,144*	
B16	10,108	278	57,123	32,613	5.8	32,613	5.8
B19	56,592	593	113,121	100,786	35.3	100,786	35.3
Totals - Multifamily	*66,700*	*871*	*170,244*	*133,400*		*133,400*	
EcoBlock Total	**236,728**	**21,987**	**587,651**	**407,378**		**357,544**	

Source: UC Berkeley

While Table 2-2 results constitute the standardized results output from both the HESaver and MulTEA energy analysis tools, the team also included additional custom 8760-hour annual load profile output files (referred to as “Hourly Reports” in DOE2.1e documentation) for each of the modeled buildings and generated the following energy end-uses plus the whole-building electrical load.

- TOTAL ELEC-PWR KW (Whole-building load)
- HEATING ELEC KW (Space heating)
- DHW HEAT ELEC KW (Domestic hot water)
- VENTILAT ELEC KW (Space conditioning and exhaust fans)
- EQUIP ELEC KW (Miscellaneous loads; small and major appliances)
- AREA LITE ELEC KW (Interior and exterior lighting)
- COOLING ELEC KW (Space cooling)

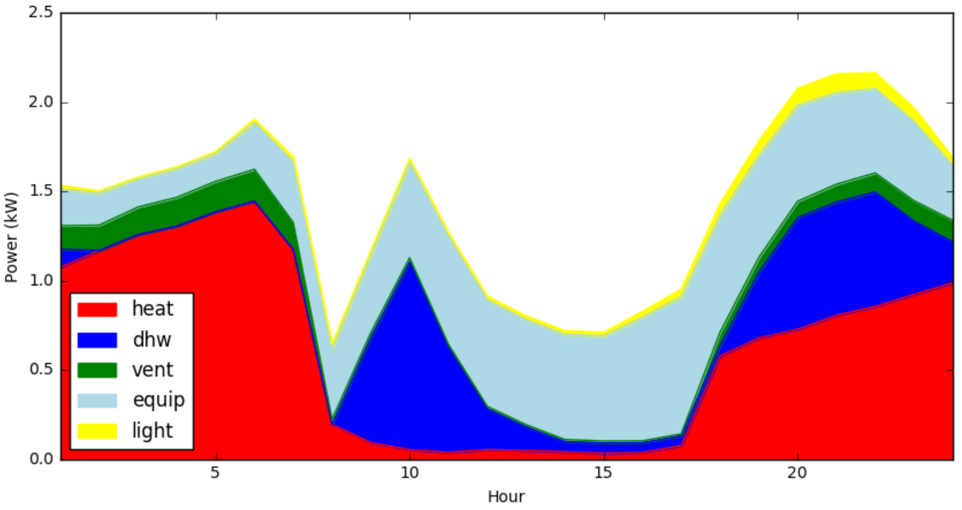
A sample DOE2.1E output report, which includes an Hourly Report statistics summary, has been included in Appendix C. The next section discusses how the 27 individual DOE2.1e hourly reports were summed into a block-scale load profile, containing an acceptable energy end-use load diversity, which could be used for the integrated electricity system design analysis.

Load Profile Development

A single aggregate hourly load was required for the Distributed Energy Resources Customer Adoption Model (DER-CAM) simulations, as well as for the microgrid and solar energy designs. This load was developed based on hourly end-use profiles from the individual DOE2 runs. An example is shown in Figure 2-7. When the 27 individual files were aggregated, however, the resulting profile showed unrealistically high peaks of power consumption due to the coincident end-use schedules (every run used the same lighting, equipment, and thermostat schedule since no survey data were available). These peaks were smoothed out by shifting each of the end uses a random number of hours (between -4 and +4) before they were aggregated. After completing this step, there were still a few days with significantly higher loads that were due to emergency (strip) heat being included in the simulation. Because the specified Sanden heat pump maintains capacity at low outdoor temperatures, and so does not require strip heat, it was removed from the simulation model. The resulting profile is shown in Figure 2-8. Median peak load for the block was 75 kW, with some peak days getting as high as 115 kW.

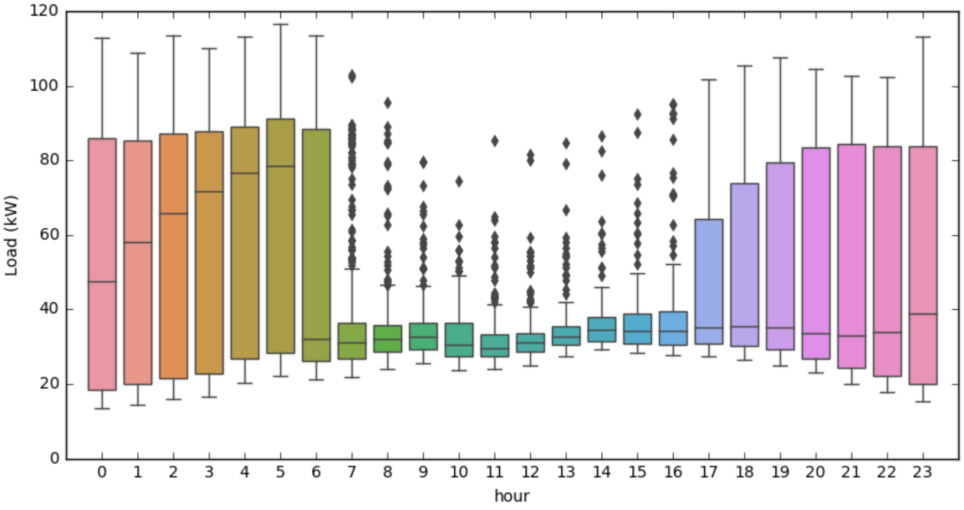
Figure 2-9 compares the resulting aggregated electricity profiles for the As-Built, and Energy Efficiency scenarios. The As-Built profile is lower, as it contains only lighting and equipment loads due to the DHW and heating being provided by natural gas. It peaks in the evening at the time of greatest occupancy. The Energy Efficiency profile exhibits two peaks, one in the morning and one in the evening, due to DHW and heating loads. These could be shifted somewhat using controls and hot water set points to be better aligned with PV generation, but this was not included in the Phase 1 simulation.

Figure 2-7: Hourly Loads From a Typical DOE2 Run (Building 10)



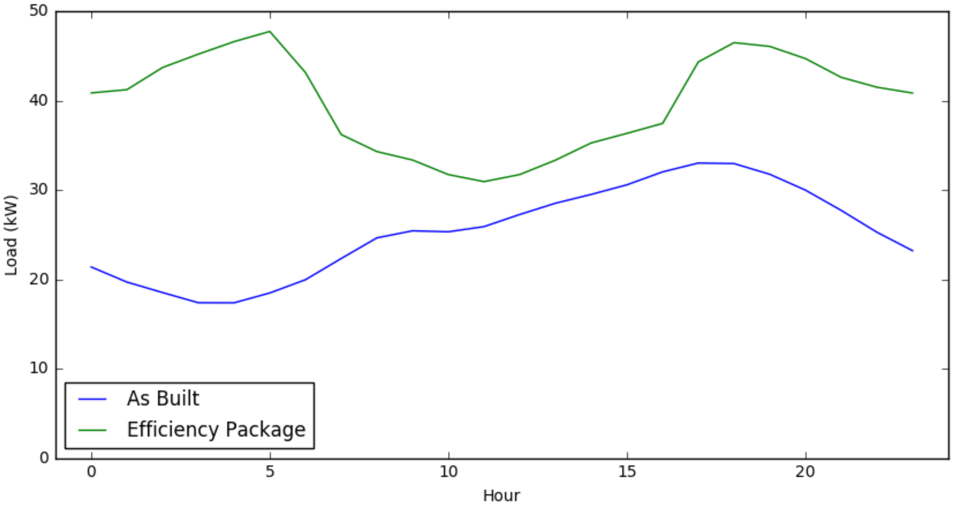
Source: UC Berkeley

Figure 2-8: Aggregated Load for the Full Block After Smoothing and Removal of Strip Heat



Source: UC Berkeley

Figure 2-9: Aggregate Load Profile Comparison of As-built and Energy Efficiency Packages



Source: UC Berkeley

Energy Efficiency Retrofits

The energy retrofits are intended to provide a deep energy retrofit and reduce energy consumption by 40 to 60 percent based on the preliminary modeling. Below is a description of the existing conditions and the proposed upgrades based on the Phase 1 assessment. The scope of the retrofit package of measures will be refined in Phase 2 through on-site audits and diagnostic performance testing. The scope has been categorized under Envelope (insulation, air sealing, roofing, and windows), Heating Ventilation and Air Conditioning (HVAC), Domestic Hot Water, Lighting and Miscellaneous Electrical Loads (MELs), and Large and Small Appliances.

Energy Efficiency and Climate Change

The modeling tools, Home Energy Saver and MulTEA, use Typical Meteorological Year (TMY)[13] weather files, the current standard for building energy simulation tools, which are created using the most average months from multiple years of historical weather data. As mentioned earlier in the chapter, the Oakland EcoBlock's CZ3 location is a mild climate posing moderate space conditioning loads, but in a changing climate how long will the mild climatic conditions persist? With an increased understanding of the impacts of climate change, the question becomes how to model or account for the potential impacts of climate change. The online set of Cal-Adapt Tools were developed to easily visualize global climate change modeling projections to inform virtually any policy or adaptation planning effort (CEC, Cal Adapt, n.d.). The Cal-Adapt tool is not an energy consumption model tool, but can be used to better understand the variation potential in baseline assumptions from energy consumption models and future climate predictions.

Cal-Adapt tools are designed to capture climate change projections of the long-term behavior of multiple atmospheric statistics in their average trends. Examples of the data sets are: annual average temperature, average rainfall, and heating and cooling degree days. These data provide information such as how much warmer temperatures in different months may become over time or how frequent extreme events such as heat storm days will occur. Not every year will be an average year, so these events could occur more or less year-to-year in the future. These projections are the result of global climate model experiments at hundreds of square kilometers in which climate scientists have accounted for future concentrations of greenhouse gas emissions and other conditions to see how the model responds to the varying conditions. Cal-Adapt has implemented methods to downscale the projections to a more useful regional scale (a 6-kilometer grid). Within this resolution, Cal-Adapt provides different geographic scales such as county or census tract for user selection to enable usability.

Human-caused climate change is the main driver of increased release of carbon dioxide and greenhouse gas emission into the atmosphere. The atmospheric warming as a result of the increase in greenhouse gases trapping heat results in a variety of changes to our environment, including rise in air and water temperatures, decrease in precipitation, and increase in extreme events. The Cal-Adapt tool has two ranges of predictions: (1) a low emission scenario where emissions level off around 2040 and are lower than 1990 levels by end of the twenty-first century, and (2) a high emissions scenario where emission continue to rise through 2050.

Climate projections are our best approximations of future climate, but as with any prediction, there is uncertainty. While the specific impact of increase in greenhouse gas emissions cannot be predicted, and simulation models may have varying levels of accuracy or results, identification of contributors increasing greenhouse gas emissions can be targeted for reductions. In addition, within Cal-Adapt, the visualization of data can be based on several models, with a recommendation of four models selected by California state agencies as priority models to be included in the data set, to account for model variation.

The tools in Cal-Adapt provide a scientific basis for exploring climate-related risks and resilience options for energy sector planning and adaptation. Cal-Adapt offers a variety of tools for exploring high-resolution projections of climate, including temperatures, precipitation,

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[13] NREL. National Solar Radiation Database. TMY. https://nsrdb.nrel.gov/tmy

snowpack, sea level rise, and wildfire through interactive maps and charts. The tools can inform energy planning and allow for integrated planning with resilience.

As discussed, the EcoBlock is located in climate zone 3 (CZ3), which is typically a mild climate zone. Cal-Adapt tools were used to visualize maximum temperature, minimum temperature, average precipitation, extreme heat days, and heating and cooling degree days to paint a picture of impacts from climate change and relationship to energy upgrade recommendations.

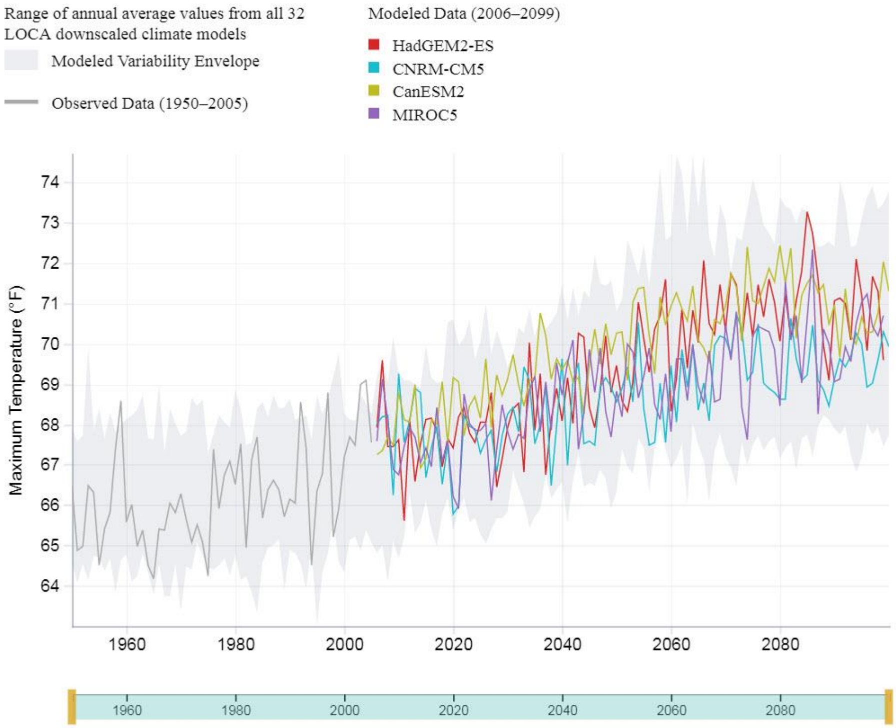
Below are the charts from Cal-Adapt that represent climate information at the census tract where the EcoBlock is located. The following descriptions apply to those charts:

- The gray line (1950–2005) represents observed data. The colored lines (2006–2100) are projections from 10 localized constructed analogs (LOCA) downscaled climate models selected for California. The light gray band in the background shows the least and highest annual average values from all 32 LOCA downscaled climate models.
- These models have been selected by California state agencies as priority models for research contributing to California's Fourth Climate Change Assessment.

Average Maximum Temperature

Figure 2-10 shows the annual averages of observed and projected maximum temperature under the low emission scenario. The modeled mean of 70°F in the low emission scenario and 73°F at the high-emissions scenario are both above the historic baseline of 65°F. This information indicates that cooling loads will increase in this mild climate region, although this rise will not result in significantly higher cooling loads, so a change in the EcoBlock space conditioning plans is not needed.

Figure 2-10: Maximum Temperature in the Census Tract Using Low Emission Assumptions

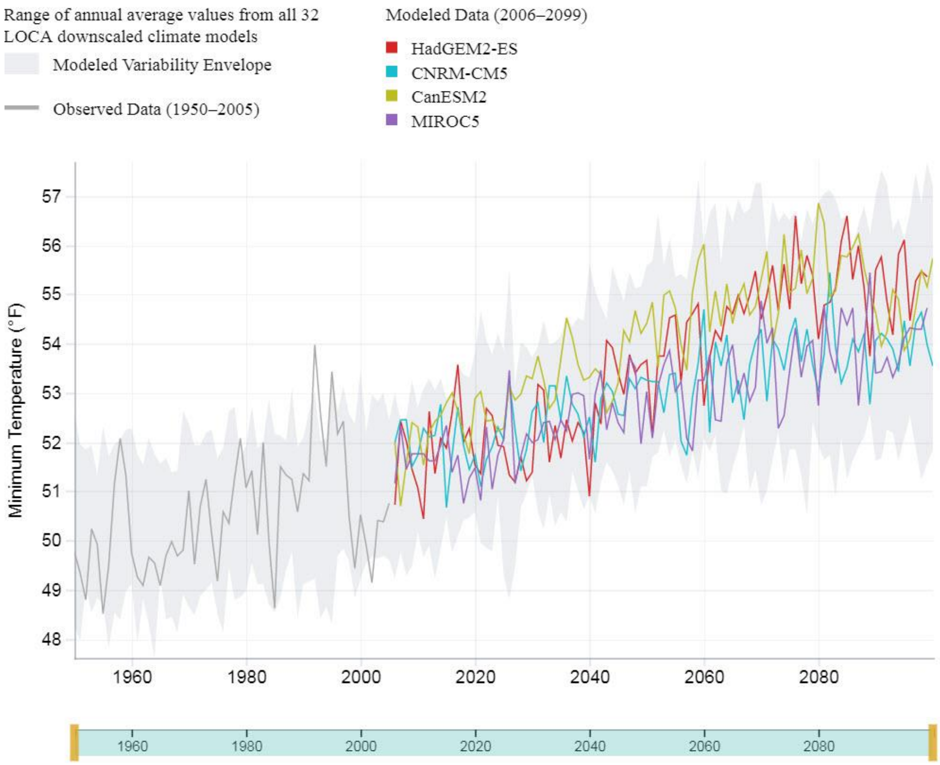


Source: UC Berkeley

Minimum Temperature

Figure 2-11 shows the annual averages of observed and projected minimum temperature under the low emission scenario. The modeled mean of 54.6°F in the low emission scenario and 57.5°F at the high emissions scenario are both above historical mean of 50.4°F. This information indicates that heating loads will decrease with the rise in minimum temperatures in a mild yet heating dominant climate.

Figure 2-11: Minimum Temperature in the Census Tract Using Low Emission Assumptions

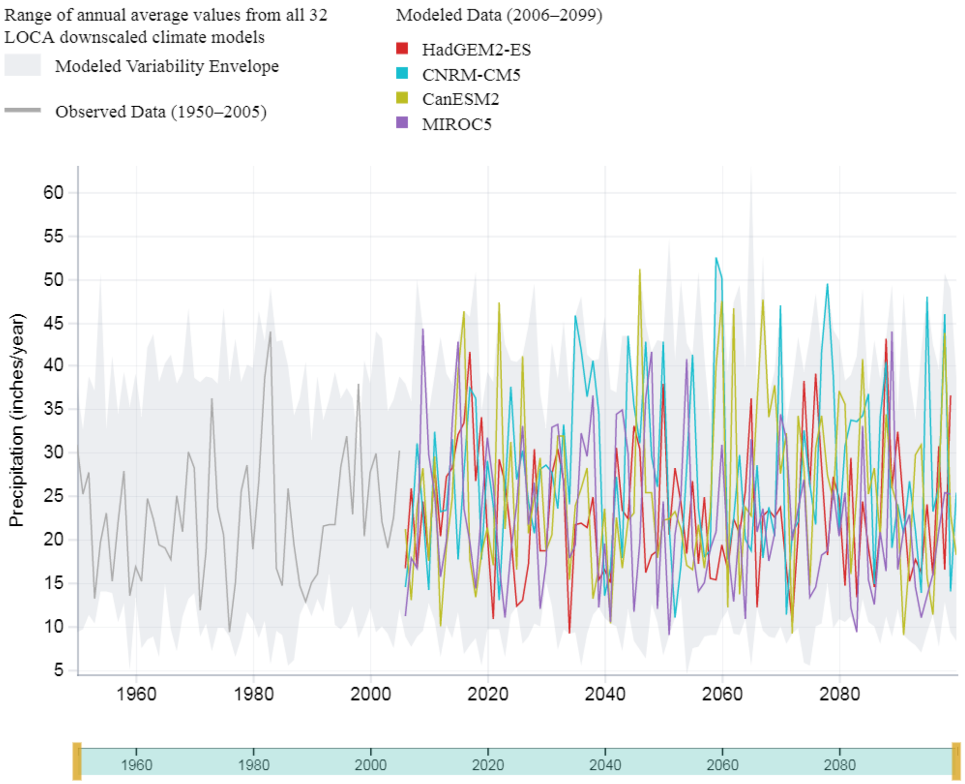


Source: UC Berkeley

Precipitation

Figure 2-12 shows the annual averages of observed and projected precipitation under the low emission scenario. The modeled mean of 24.9 inches per year in the low emission scenario and 27.8 inches per year in the high emissions scenario are both above historical mean of 21.9 inches per year. This informs the potential impact on flooding, as well as potential for rainwater catchment.

Figure 2-12: Average Annual Precipitation in the Census Tract Using Low Emission Assumptions

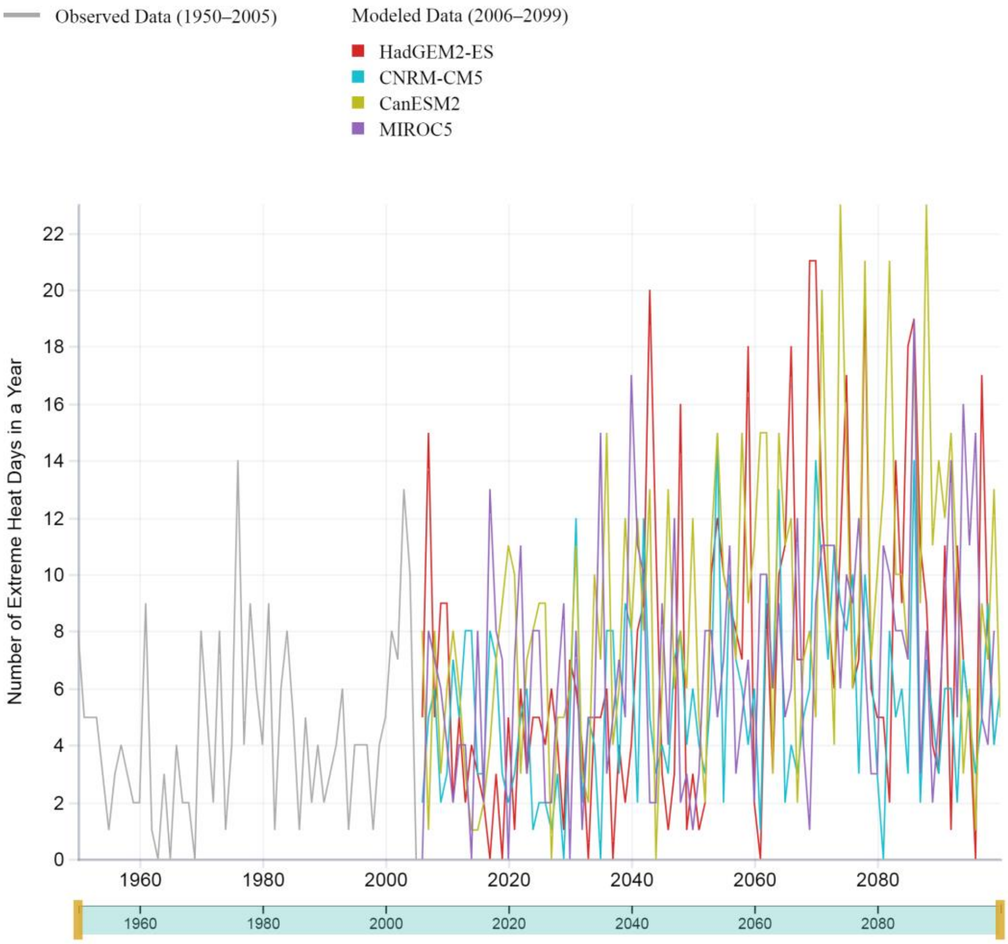


Source: UC Berkeley

Extreme Heat Days

Figure 2-13 shows the number of extreme heat days in a year for the specific location under the low emission scenario. An *extreme heat day* is defined as a day in April through October when the maximum temperature exceeds the specific location’s extreme threshold, 98th percentile of observed temperature between April 1–October 31 between 1961–1990. The extreme heat threshold for this tract is 88.3°F. Historically there have been just over four days that exceed the threshold, and future prediction estimates 9 to 16 days for the low and high emission scenarios, respectively. Extreme heat days inform the need for building cooling on critical event days to counter occupant health impacts, especially for sensitive groups such as the elderly and home care patients.

Figure 2-13: Number of Heat Days in the Census Tract Using Low Emission Assumptions

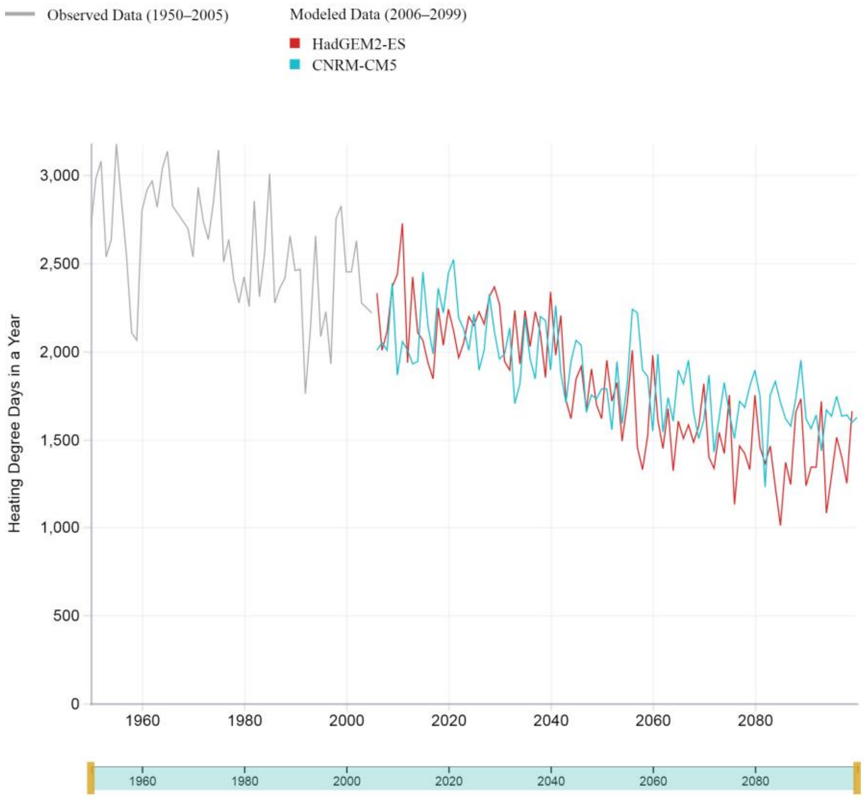


Source: UC Berkeley

Heating and Cooling Degree Days

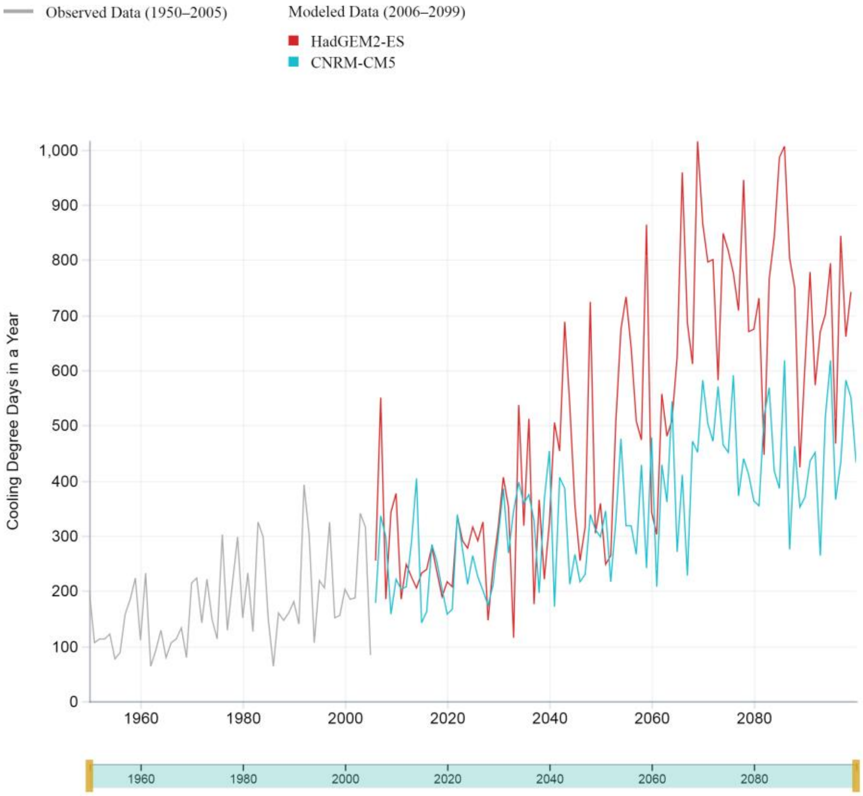
Heating degree and cooling degree days are metrics that inform our current energy simulation modeling tools. In the projections for low emission, heating degree days decrease by over 50 percent, and cooling degree days increase over 300 percent. Figure 2-14 shows the decrease in heating degree days, and Figure 2-15 shows the increase in cooling degree days. In the high emission scenario, the heating degree days decrease by 40 percent, and the cooling degree days increase 600 percent over a baseline of 167 days in a 29-year period.

Figure 2-14: Number of Heating Degree Days in the Census Tract Using Low Emission Assumptions



Source: UC Berkeley

Figure 2-15: Number of Cooling Degree Days in the Census Tract Using Low Emission Assumptions



Source: UC Berkeley

The average maximum temperature, extreme heat days, and cooling degree days show an overall increase in cooling loads for this mild climate. The rise in the minimum temperature and reduction in heating degree days show a decrease in overall heating loads. This analysis shows a good confidence level that a tighter envelope and heat recovery ventilator will be able to address the cooling loads of these homes without the addition of mechanical cooling systems. With smaller heating loads the combination heating and domestic hot water system will meet demands while reducing carbon loads and energy consumption.

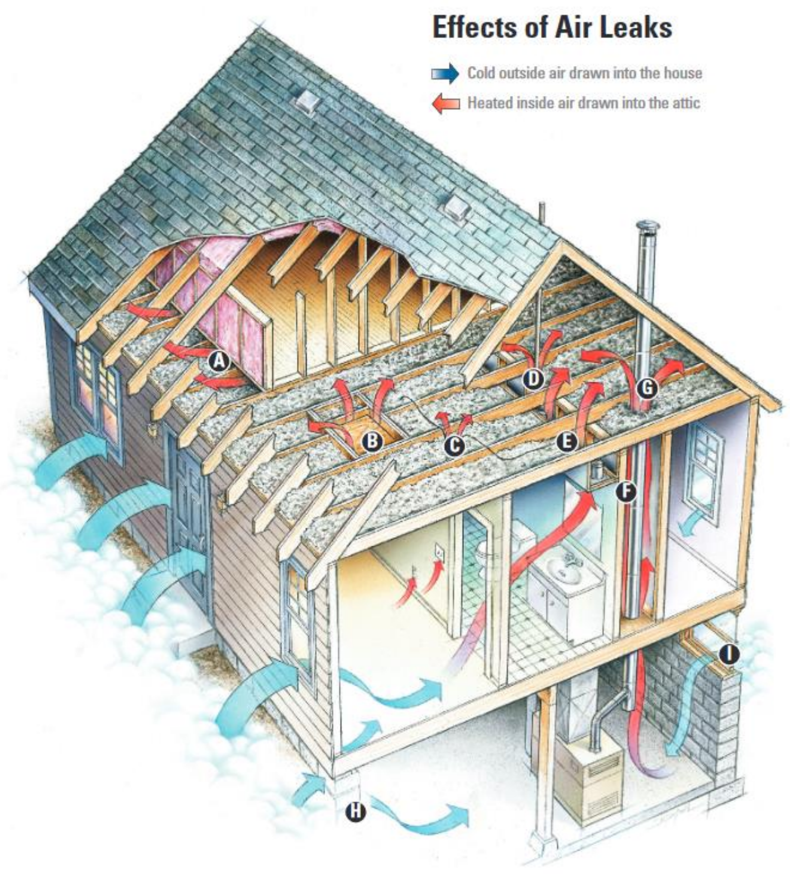
The energy efficiency measures selected for the EcoBlock can reduce greenhouse gas emissions contributing to climate change and allow for adaptation to climate change and resiliency in extreme events. In addition, materials for the energy efficiency upgrades have been specified not only to meet energy efficiency improvements and greenhouse gas emission reductions, but also health impacts. General material specifications are included in each section below, and a high-level chemical evaluation of materials can be found in *The Oakland EcoBlock Project: A General Survey and Assessment of Proposed Building Materials and Their Constituent Chemicals proposed by the Water and Energy Sub-groups* in Appendix D. The specifications and chemical analysis will be developed in further detail upon project implementation.

Energy Efficiency Elements

Envelope

Envelope improvements include insulation of attic, crawlspace, and walls, as well as air sealing and efficient windows (Figure 2-16). Leaky envelopes result in drafty homes, and uncontrolled air infiltration results in discomfort and higher utility bills. Envelope improvements will improve the comfort of the home while reducing heating loads.

Figure 2-16: Impacts of Air Leakage and Infiltration



A: behind kneewalls, B: attic hatch, C: wiring holes, D: plumbing vents, E: open soffit, F: recessed lights, G: furnace flue or duct chaseways, H: basement rim joists, I: windows and doors

Source: U.S. EPA ENERGY STAR. A Do-it-Yourself Guide to Sealing and Insulating with ENERGY STAR.

Insulation and Air Sealing

Wood-framed homes constructed prior to 1978 are assumed to have no insulation in the wall and no sheathing, no crawl space insulation, and minimal attic insulation, resulting in a very drafty envelope. Air leaks in a home often contribute as much to high utility bills and discomfort as poor insulation or single-pane windows. Air leaks can also allow in unwanted moisture, pollen, mold, dust and other contaminants. Weatherization involves sealing leaks by applying caulk, weather stripping, and patching to all cracks and seams where unwanted air might be able to leak in. After properly air sealing a home, it can be insulated. Studies show that poorly installed insulation severely decreases the material's insulating value. Insulation levels are a measure of thermal resistance or ability of heat to transfer from hot to cold through the insulation material and the entire wall or floor assembly. The higher the R-value, the more a material prevents heat transfer. R-value depends on a materials' resistance to heat conduction, as well as its thickness and any heat losses due to convection and radiative heat transfer. Effectively installed insulation creates a more comfortable home and reduces the owner's utility costs. Lower energy demand reduces pollution and improves public health.

Air sealing and insulation will be completed in all EcoBlock homes that opt into energy upgrades.

Air sealing is the systematic finding and sealing of air leakage points throughout a home or building, from the attic to the walls to the crawlspace. Air sealing the top of the wall (in the attic) and the bottom (in the crawlspace) will reduce airflow through the wall system, which reduces the value of any insulation installed in the cavity and increases heat loss to the exterior through convection (otherwise known as the *stack effect*). Smaller measures to reduced infiltration include weather stripping on exterior doors and outlet gaskets on all receptacles and switches.

At a minimum, the attic and crawlspace will be air sealed and insulated with a minimum of R-38 insulation in the attic and R-19 in the crawlspace. Effectively air sealing the walls would require either removing siding sealing, insulating the cavity, and then sheathing and replacing siding, or drilling access holes through the existing siding and blowing in insulation. As it is a typically high-cost measure, it is not recommended to complete wall air sealing and insulation unless it is coupled with other remodel work that the customer is undertaking. . If the wall cavities are insulated, it is recommended to use dense-pack cellulose (3.5 lbs. per cubic foot) or loose-filled fiberglass blown to a high density (at least 2 lbs. per cubic foot), both of which will result in a reduction of air leakage through the wall (North 2012).

The retrofit scope of work is estimated to result in a 25 percent reduction of infiltration due to air sealing of the envelope. This estimate is based on sealing the top and bottom of the walls and insulating a portion of the walls.

Materials used for air sealing should be impermeable to air and create a continuous layer over areas being sealed. Caulk and foam can be used to seal cracks, small holes, and electrical and plumbing penetrations. Sheet materials such as drywall, duct board, or plywood should be used on larger holes, with edges sealed using caulk or foam.

Materials for insulation and air sealing fall under the following categories: insulation; air sealing; caulking; and building wrap. It is recommended that the materials installed meet the following specifications.

Insulation
The insulation will be specified to reduce impacts to indoor air quality. Insulation may be fiberglass batt, loose cellulose fill, and rigid insulation board (polystyrene) that meet the following criteria:

- Conforms to California Department of Public Health, Environmental Health Laboratory Branch, Standard Method for the Testing & Evaluation of VOC Emissions, V1.1, 2010 (CA

Specification 01350) using the single-family residence scenario found in Appendix B of that standard. Exterior rigid insulation may be exempt from this specification.

- Cavity Insulation shall not include halogenated flame retardants. No plastic foam insulation shall be installed.
- Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - Glass-Fiber Insulation:
    - CertainTeed Corporation
    - Johns Manville Corporation
    - Owens Corning
    - Knauf
  - Cellulose Insulation
    - Green Fiber
  - Cotton Insulation

Air Sealing

Air sealing products may be used to seal holes between 1/8 inch and ½ inch. Air sealing products will be specified as polyurethane spray foam non-CFC formula and construction-grade indoor- and outdoor-rated caulking with a volatile organic compound (VOC) level of 30 grams per liter (g/l) or less.

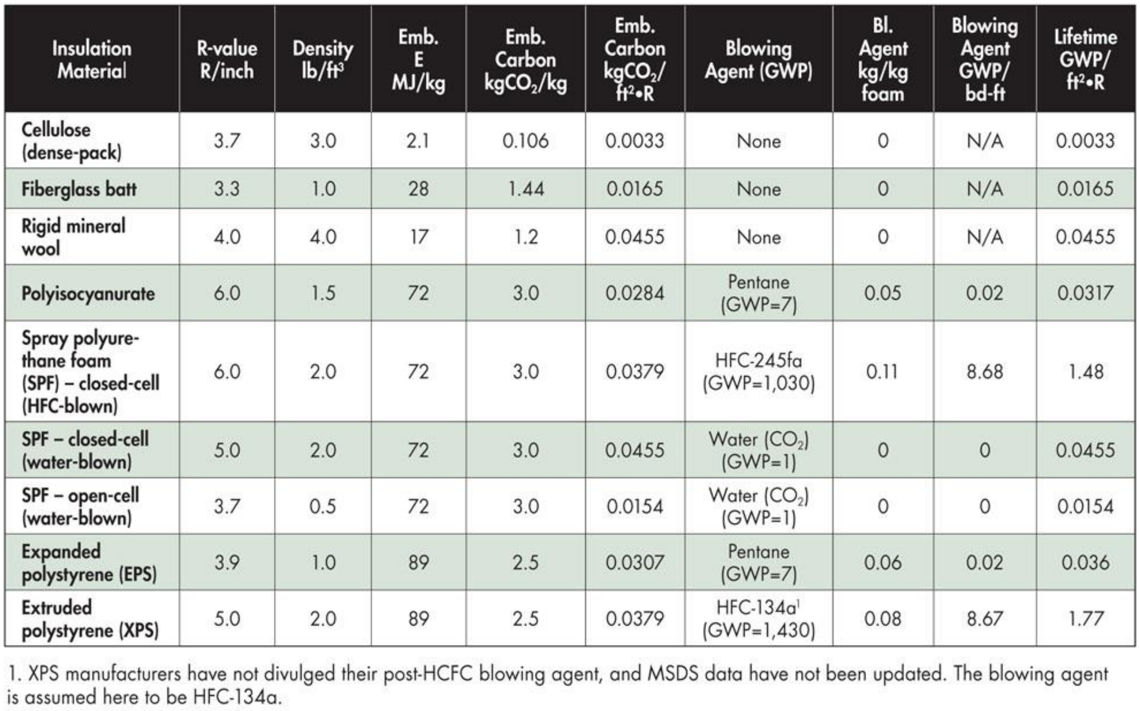
Caulking will be used to seal holes less than 1/8 inch. Caulks and adhesives will be specified to emit 30 g/l VOCs or less. Products covered in this category include subfloor adhesive, general construction adhesive, carpet adhesive, duct mastic, window and trim caulk, general use caulk, bathroom and kitchen caulk, tile mastic, and fire and acoustic caulk.

House wrap and or vapor barriers will be employed under some scope of work situations. House wrap and vapor barrier reduce moisture migration into the home and building cavities. There will be limited house wrap or vapor barriers installed, but the following are specifications that would be applied:

- Window Flashing Paper: Fortifiber “Moistop” Multilayer composite reinforced flashing paper. Widths and lengths as indicated.
- Self Adhering Membrane Flashing: Fortifiber “Moistop EZ-Seal” self-adhering membrane flashing. 35 mils thickness. Widths and lengths as indicated.
- Adhesive house wraps
- Plastic house wraps such as DuPont Tyvek.
- Grooved surface house wraps: These house wraps act as an air barrier and provide a drainage plane. Examples of such products include DuPont StuccoWrap, Pactiv GreenGuard RainDrop, Barricade Drainage Wrap, Barricade WeatherTrek, Valeron Vortec, Fortifiber Hydro Tex, Coldbond, EnkaBarrier, Home Slicker Plus Typar, and Benjamin Obdyke HydroGap.

Insulation materials can also contribute to greenhouse gas emissions and health. The chart below shows the variation in global warming potential of different insulation types (Table 2-3). Cellulose, fiberglass batt, and rigid mineral wool have the lower global warming potential (GWP) and are suitable for cavity insulation. Polystyrene, polyisocyanurate, and polyurethane are very effective insulators, but also include halogenated flame retardant chemicals due to their flammability. Most flame retardants have not been fully tested for their impact on human health; however, according to the testing that has been completed, these chemicals have been found to be persistent, bioaccumulative, and/or toxic compounds (Janssen 2005 and Levitt 2012).

Table 2-3: Global Warming Potential Factors Associated With Typical Insulation Materials



Insulation Material	R-value R/inch	Density lb/ft^3	Emb. E MJ/kg	Emb. Carbon $kgCO_2/kg$	Emb. Carbon $kgCO_2/ft^2 \bullet R$	Blowing Agent (GWP)	Bl. Agent kg/kg foam	Blowing Agent GWP/ bd-ft	Lifetime GWP/ $ft^2 \bullet R$
Cellulose (dense-pack)	3.7	3.0	2.1	0.106	0.0033	None	0	N/A	0.0033
Fiberglass batt	3.3	1.0	28	1.44	0.0165	None	0	N/A	0.0165
Rigid mineral wool	4.0	4.0	17	1.2	0.0455	None	0	N/A	0.0455
Polyisocyanurate	6.0	1.5	72	3.0	0.0284	Pentane (GWP=7)	0.05	0.02	0.0317
Spray polyurethane foam (SPF) – closed-cell (HFC-blown)	6.0	2.0	72	3.0	0.0379	HFC-245fa (GWP=1,030)	0.11	8.68	1.48
SPF – closed-cell (water-blown)	5.0	2.0	72	3.0	0.0455	Water (CO_2) (GWP=1)	0	0	0.0455
SPF – open-cell (water-blown)	3.7	0.5	72	3.0	0.0154	Water (CO_2) (GWP=1)	0	0	0.0154
Expanded polystyrene (EPS)	3.9	1.0	89	2.5	0.0307	Pentane (GWP=7)	0.06	0.02	0.036
Extruded polystyrene (XPS)	5.0	2.0	89	2.5	0.0379	HFC-134a[1] (GWP=1,430)	0.08	8.67	1.77

1. XPS manufacturers have not divulged their post-HCFC blowing agent, and MSDS data have not been updated. The blowing agent is assumed here to be HFC-134a.

Source: Bensonwood, Environmental Building News, June 2010

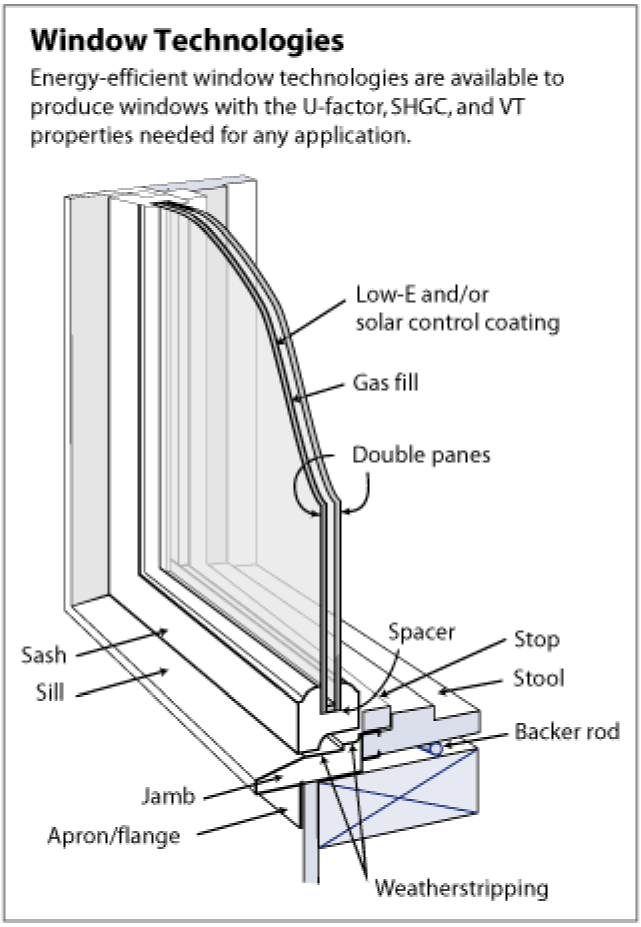
Windows

Windows play a big role in the energy efficiency of homes. In the summer, they can allow unwanted heat into the house, and in the winter, they can account for as much as 25 percent of the home's heat loss. High performance windows reduce heating and cooling costs and keep the home more comfortable and reduce the impact of outdoor noise on occupants.

Based on drive-by audits, the existing windows appear to be primarily single-pane wood frame windows and some aluminum single-pane windows (probably without a thermal break). While the CZ3 climate zone is quite mild, replacing the windows with more efficient windows (Figure 2-17) will reduce the unwanted heat loss and gain and air leakage while also reducing the transfer of outdoor noise. The upgraded windows are specified to be ENERGY STAR low-e argon-filled with a maximum u-factor of 0.3 and minimum solar heat gain coefficient (SHGC) factor of 0.35, which will align with 2019 proposed code standards. The installation of dual-pane argon windows will both lower energy bills and reduce infiltration and convective air flows that create uncomfortable environments. Additional benefits of argon windows included elimination of condensation and increased soundproofing.

Window materials will be specified as ENERGY STAR dual-pane retrofit windows, wood or vinyl or fiberglass frames per owner choice, with a maximum u-factor of 0.3 and minimum SHGC factor of 0.35.

Figure 2-17: Diagram of Retrofit Window Attributes



VT = visible transmittance

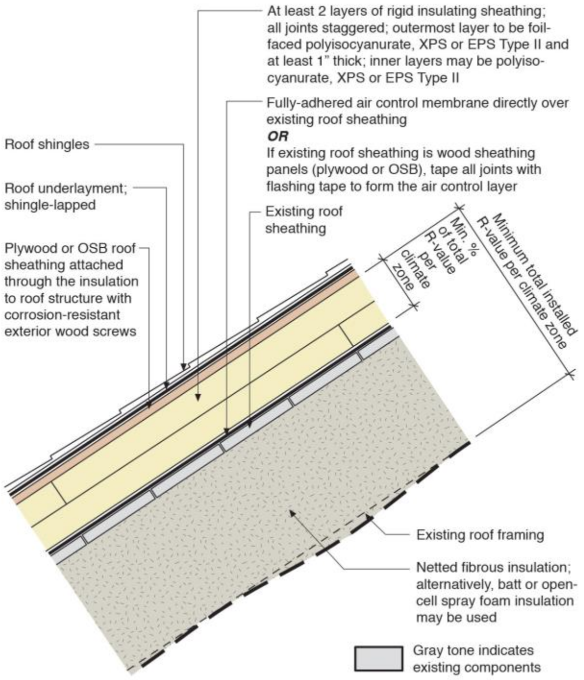
Source: Pacific Northwest National Laboratory

Roofing

Roofing improvements (Figure 2-18) will be completed on an as-needed basis for both envelope improvements and rainwater catchment, but more important, to support installation of on-site photovoltaics (PV). In the event that the roof is in poor condition or there are three layers of asphalt shingles, the roof will be replaced and upgraded. The roof will also be evaluated for structural upgrades to support installation of roof-mounted solar PV. The upgraded roof will allow for rainwater catchment with limited or no filtration.

Roofing materials will be specified as roofing with a minimum 40-year warranty. Preferably, no asphalt shingles would be used, as this would require greater rainwater filtration. Preferred materials are fiber cement, clay, plastic, or metal.

Figure 2-18: Roof Replacement Installation With Insulation



Source: Pacific Northwest National Laboratory

HVAC (including Indoor Environmental Quality and Ventilation)

While for many climates cooling is a critical issue, for Oakland there are little to no cooling loads, even with future temperatures predicted under climate change. The homes of this vintage typically have ducted forced-air units or wall furnaces. To support electrification and greenhouse gas emission reductions, the heating options are electric resistance or heat pump systems. Heat pump systems are over three times more efficient than electric resistance heating. To that end, we pursued high-efficiency heat pump solutions.

The energy analysis indicates the heating loads are also low, and tightening the envelope will additionally lower heating loads, which could be supported by an electric combination heating and domestic hot water system. Each assumed gas-fired forced-air unit will be upgraded to a hydronic air handler unit (AHU) that will be supplied with hot water from the heat pump water heater. The AHU will be sized according to the load of the home, based on on-site audits conducted in Phase 2. The existing ductwork will remain in place and will be sealed to reduce duct leakage to a rate meeting or exceeding Title 24 requirements for existing ducts. If filtration medium is needed the filter will be a minimum of a Minimum Energy Reporting Value (MERV) 8.[14]

The conceptual design assumed existing forced air systems, and the new system is assumed to be a hydronic forced air unit leveraging the existing duct system (Figure 2-19). If there is not a

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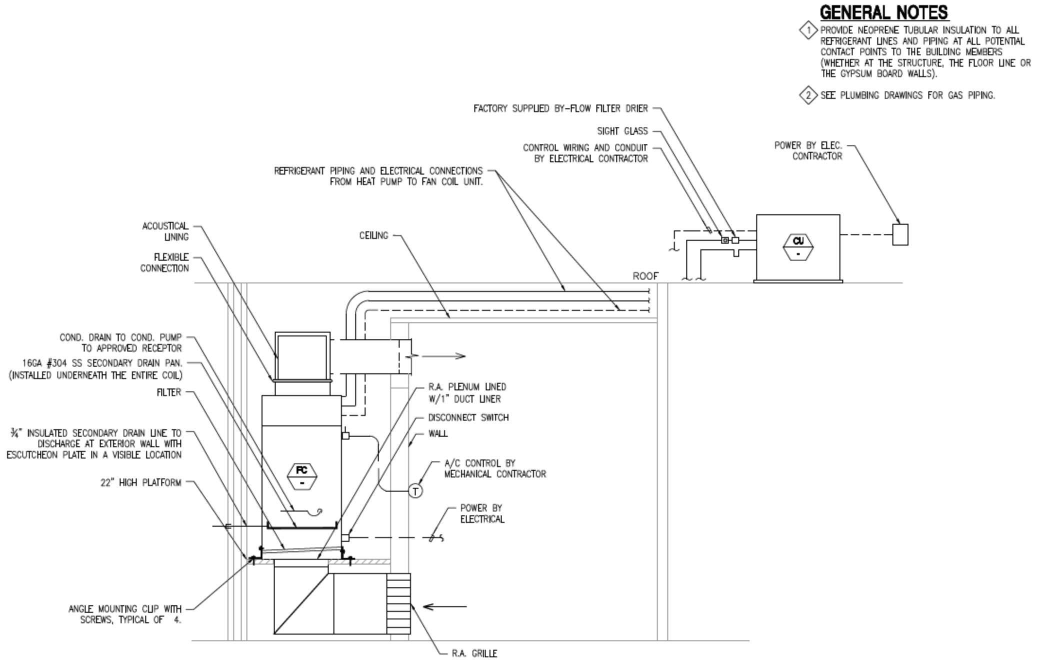
[14] Heating, Ventilation and Air Conditioning filters remove particulates from the air. MERV is a metric used to measure an air filter's efficiency. The MERV scale ranges from 1 to 20. The higher the MERV number, the more efficient the filter is at removing particulates.

ducted system to leverage, this combination system can be used with radiant baseboard heating or radiators. Therefore, there is flexibility in the design and installation of a combination system to maximize the existing infrastructure and meet the demands of both heating and domestic hot water loads of the homes.

Occupant-controlled setback smart thermostats will be installed to align with code regulations, support demand response opportunities, and allow for occupant comfort control (CEC 2016, JA5). The thermostat will be capable of two-way communication using a standard Wi-Fi or Zigbee network. The smart thermostat will also be coupled with a home monitoring system to provide occupants with insight on energy use and their ability to manage that use. The home energy monitor will act as the gateway to a home's energy usage and provide information on how to manage and operate the home more efficiently. Features of household energy monitoring systems that will be considered in selection are: appliance recognition, real-time tracking, mobile apps and notifications, solar ready, and installation requirements. The team will evaluate these features in Phase 2 of the project, when refining equipment selection.

Figure 2-19: Diagram of a Hydronic Fan Coil System From the Plan Set



GENERAL NOTES

1. PROVIDE NEOPRENE TUBULAR INSULATION TO ALL REFRIGERANT LINES AND PIPING AT ALL POTENTIAL CONTACT POINTS TO THE BUILDING MEMBERS (WHETHER AT THE STRUCTURE, THE FLOOR LINE OR THE GYPSUM BOARD WALLS).
2. SEE PLUMBING DRAWINGS FOR GAS PIPING.

Ventilation

As building envelopes are tightened, it is important to have systems in place to support good indoor environmental quality (IEQ). Conversely, adding mechanical ventilation to a high-performing home adds load when the end goal is to reduce the home's overall energy consumption. There are several ventilation systems that can support Title 24 ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) 62.2 mechanical ventilation requirements from exhaust only, supply only, and balanced systems. Typical runtime control mechanisms are timer, 24-hour, and/or humidity.

Smart ventilation allows a home to gain demand response savings through a mechanical ventilation system. As defined by LBNL, a smart ventilation system has two goals:

- Reduce ventilation energy use and cost compared to a continuously operating ventilation system while still maintaining the same or better indoor air quality (IAQ).
- Allow residential ventilation systems to eventually interact through a process called "short-term load shifting," which reduces power draw from ventilation systems during the peak demand period.

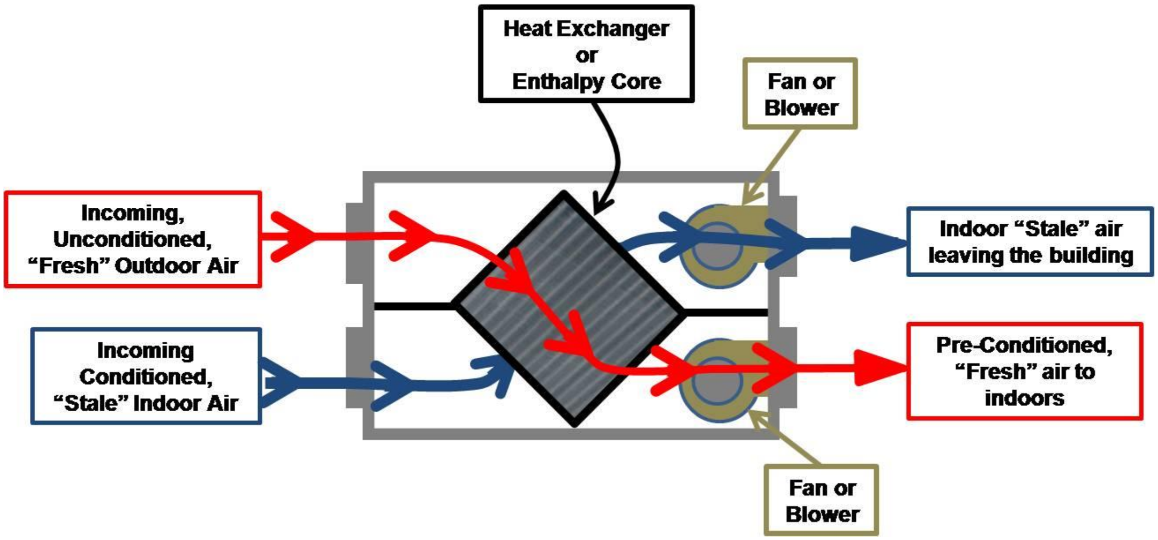
A monitoring system can shift ventilation run times to meet ventilation principles and save energy. A smart ventilation system will maintain IEQ equivalent to ASHRAE 62.2 with the ability to shift to favorable run times and be able to account for operation of other fans such as bath, kitchen or dyer for on/off signals.

Smart ventilation systems meeting current Title 24 indoor air quality standards will be installed to support improved IEQ and occupant comfort. The ventilation system will be triggered by air quality conditions such as humidity and/or minimum air changes per hour.

An Energy Recovery Ventilation (ERV) system (a mechanical ventilation system that tempers incoming fresh air with exhausted indoor air) may be able to address small heating and cooling loads (Figure 2-20). The actual ventilation system to be installed will be determined through the on-site audit.

In addition to whole-house mechanical ventilation, the homes will receive upgrades of spot ventilation in bathrooms and kitchens. The bathroom exhaust ventilation will meet current California Green Building Code and include a humidistat control. The kitchen exhaust specifications to maximize pollutant capture are discussed under the Appliances section below in conjunction with the range.

Figure 2-20: Diagram of ERV Airflow



Source: Calcs Plus via U.S. DOE's Building America Solution Center

Domestic Hot Water

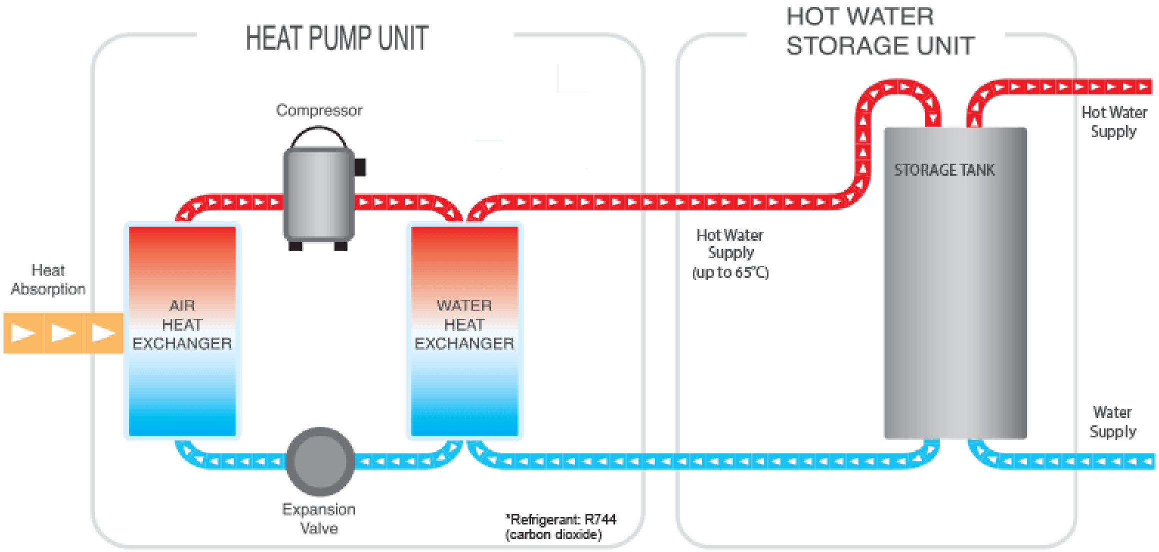
Heat pump water heaters offer greater savings over gas storage and electric resistance water heaters while providing the opportunity for load shifting and demand response performance. In mild-climates domestic water heating makes up a large percentage of a home’s total energy consumption.

We propose using a combination system for domestic hot water and space conditioning for heating only. The combination market is still nascent but there continue to be advancements in product availability and technology. It does appear to be a good fit for efficient homes.

The proposed system uses the Sanden SANCO$_2$ heat pump water heater (Figure 2-21). Just in 2017, Sanden announced advancements such as larger tanks and higher water temperatures that can benefit combination systems as well as multifamily projects. A study completed for Bonneville Power, evaluated Sanden heat pump water heater (HPWH) combination systems prior to Sanden obtaining a Underwriters Laboratory (UL) listing for the split systems installed in the study (Eklund 2015).

Heat pump water heaters offer an efficient electrical option for residential water heating using a refrigerant cycle to move heat from the ambient air to water in the tank. The Sanden unit is designed as a split system to maximize efficiency.

Figure 2-21: Diagram of Sanden HPWH Split System

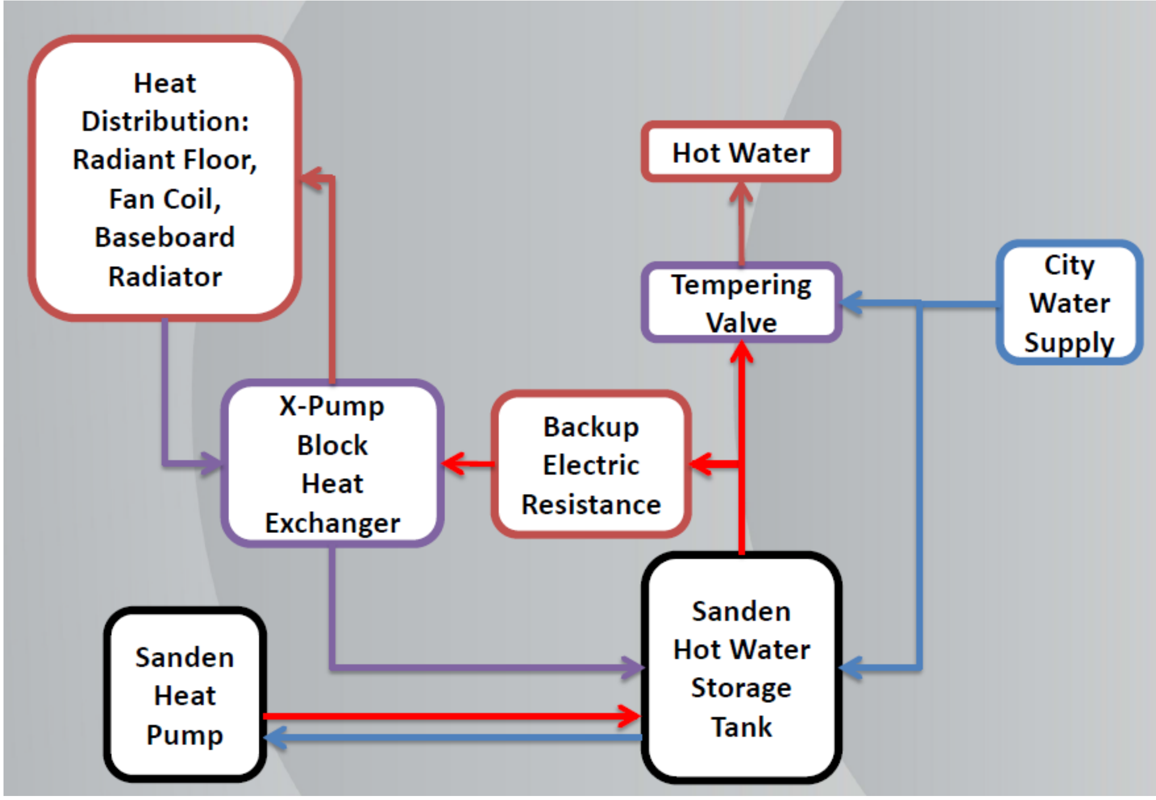


Source: Sanden. Sanden Water Heater

The use of the Sanden heat pump in combined mode for water heating and space conditioning is practical for high-efficiency new homes and for deep energy retrofits with hydronic heating systems. The Sanden SANCO$_2$ Heat Pump Water Heater is a two-part system consisting of a tank (usually placed indoors) and a heat pump unit. It has a capacity of 15 thousand Btu per hour (kBtu/hr) and can be designed to deliver both domestic hot water and space conditioning load hot water. The system accomplishes this by providing domestic hot water at 120 degrees, using a mixing valve to reduce the temperature, and another line to a standard heat exchanger supplying hot water radiators, radiant flooring, or a forced air fan coil for space heating. The design load of the building will be within the capacity of the heat pump design temperature for Oakland which is 37 ˚F degrees outside air temperature.

The proposed combination system, as shown in Figure 2-22 schematic diagram, includes the SANCO$_2$ heat pump water heater, outdoor compressor unit, mixing valve, and air handler unit with electronic commutated motor (Eklund 2016).

Figure 2-22: Schematic Diagram of the Sanden Combinations System



Source: Ken Eklund, Washington State University

The outdoor unit includes the compressor, air-to-CO$_2$, and CO$_2$-to-water heat exchangers, control system, and circulation pump. The heated water is stored in an insulated stainless steel tank in a conditioned space. The outdoor unit is activated when the sensor in the tanks reads a water temperature of 113°F. Unlike other heat pump water heaters that have an electric resistance element, the SANCO$_2$ does not have a backup element, and therefore is always run in heat pump mode for maximum efficiency.

The Sanden functions like a regular air-source heat pump water heater, but with CO$_2$ as a refrigerant. Carbon dioxide has general properties that make it an appealing candidate as a refrigerant. It operates at a higher pressure and narrow temperature range than other refrigerants such as R243a and R7171. Carbon dioxide was introduced as a refrigerant in 1850, fell off in early 1940s, and was revived in 1993. The CO$_2$ refrigerant allows the Sanden to perform in greater temperature ranges and take heat from a lower temperature than other refrigerants. It can extract heat from the air in temperatures as low as -20°F. The unit can raise the water temperature as high as 175°F at 0.3 gallons/minute without a back-up coil, making it a very efficient system. As a transcritical refrigerant, CO$_2$ provides better heat exchange, achieving higher temperature output than other refrigerants such as R-410a or R134a, and with very low pumping power. To achieve this efficiency, CO$_2$ operates well with larger temperature lifts.

In addition, the CO_2 is a low global warming potential refrigerant compared to systems that utilize hydrofluorocarbon (HCF) refrigerants with a GWP as much as 1700 times that of CO_2, as shown in Table 2-4. Current refrigerants include HCFs, which have no ozone depletion potential (ODP) but have significant GWP when released into the atmosphere. Ideal refrigerants are non-toxic and non-flammable, and have zero ODP and GWP, acceptable operating pressures, and volumetric capacity appropriate to the application. The growing international emphasis on global warming mitigation has stimulated interest in a new generation of low-GWP refrigerants. While the market for low-GWP heating and air conditioning refrigerants is still developing, there are strong market candidates for water chillers and heat pump water heaters (Goetzler 2014).

Table 2-4: Summary of Global Warming Potential Factors for Common Heat Pump Refrigerants

REFRIGERANT	GWP	ODP
R-22	1810	0.055
R-134a	1430	0
R-410a	2088	0
CO_2 (R-744)	1	0

Source: UC Berkeley

The tank and outdoor unit of the system are connected by hot and cold water line connections. Cold water from the bottom of the tank is pumped into the heat exchanger at the bottom of the outdoor unit, where heat is transferred from heated CO_2 gas (Eklund 2015). The heated water returns to the top of the tank. The tank temperature can be set from 120°F–165°F. With a higher temperature of 160°F, the domestic hot water uses a mixing valve to bring the temperature to a safe set point of 120°F while the 165°F water can be run through the hydronic air handler unit when heating is called for.

The systems will be sized according to domestic hot water loads and heating loads to ensure demands can be met. Referencing the Eklund et al. (2015) calculations, the sizing parameters and tank size can be determined. There are two tank sizes: 43 gallons, which provides a 71-gallon first hour delivery, and 83 gallons for five or more occupants, which delivers a 101-gallon first-hour delivery (Sanden Water Heating, n.d.).

To have the system function well, the plumbing needs to be optimized. The plumbing of the system will be based on lessons learned from a Multifamily Zero Net Energy EPIC study underway, *Optimizing Water Heating Performance for Multifamily ZNE*, that is evaluating the optimization of domestic hot water for multifamily ZNE. The project team will be able to leverage that Multifamily ZNE EPIC study to plumb individual and central heat pump water heater systems for the EcoBlock. While research is ongoing, very recent information on understanding the energy use in heat pump water heaters will leveraged to inform project-specific design considerations for this project. In addition, the MF ZNE EPIC study will be evaluating the opportunity to use heat pump water heaters for load shifting to minimize the cost burden on occupants as well as the grid. To minimize and potentially eliminate energy use for water heating during peak times, the water heaters will be equipped with an after-market timer to control the tank to leverage solar production at peak solar times, heating water to higher temperature, and eliminate grid energy at peak grid periods. The higher tank temperature of the Sanden is coupled with a mixing valve that can expand a 43-gallon tank to 85 gallons of 120°F water. By extending the volume of available hot water, occupant hot water demand can be met during peak grid periods without utilizing electricity to heat water. The Multifamily ZNE EPIC study will evaluate how to maximize this capacity, and the findings will be used to refine the design of the systems for the EcoBlock.

Lighting and Miscellaneous Electrical Loads (MELS)

Plug loads and lighting make up half the loads in a home's electrical energy consumption Rubin 2016). According to KEMA (2010), lighting (hardwired and plug in, interior and exterior) and plug loads constituted 80 percent of electric consumption in residential. Plug loads are defined as household appliances (refrigerators, laundry, dishwashers, and ranges) and electronics plugged into a receptacle. Therefore, these loads would include the large and small appliances discussed below. Through advances in both code and technology, lighting efficiency has increased, and therefore the energy use attributed to lighting has decreased. Plug loads and other miscellaneous device loads are not very well defined, as some are decreasing, but many are increasing. That said, with existing homes, unlike new construction, there is greater opportunity to replace incandescent and inefficient lighting with light-emitting diode (LED) lighting and to provide plug load reduction technologies.

Under current code as defined in the California Energy Code (Title 24 Part 6), all residential indoor and outdoor lighting must be high efficacy. In addition outdoor lighting must be controlled in one of the following manners (1) photo control and motion sensor, (2) photo control and automatic time switch control, (3) astronomical time clock, or (4) energy management control system. The upgrades for these homes include replacement of lamps with LED lamps with an efficacy at or above 70 lumens (lm)/watt that are also ENERGY STAR and JA8 (Joint Appendix 8 of Title 24) compliant (Goldthrite 2016). Where appropriate, ceiling fans with light kits will also be upgraded to LED and ENERGY STAR. In addition as needed, outdoor lighting will be upgraded with controls to meet current Title 24 Part 6, standards.

Lighting specifications will meet the following a minimum efficacy of 70 lm/watt and be ENERGY STAR and JA8 compliant.

In Scenario 3e, the most comprehensive retrofit scenario, a DC circuit will be added to provide reliable energy to the homes. Lighting circuits can powered by through the DC panel. Chapter 3 describes the AC/DC inverter and infrastructure to support a block-scale DC microgrid in the home.

As other technologies and end uses become more efficient, plug loads have increasingly become a larger percentage of a home's loads and are harder to manage because of the variable nature and phantom loads. Advanced power strips (APS) offer an opportunity to reduce plug loads and phantom loads. Tier 2 power strips actively manage both standby and active power consumption. Studies have found that Tier 2 APS devices result in savings, demand reduction, and user acceptance for audio/video (A/V) systems in California (Northeast Energy Efficiency Partnerships 2015) Tier II APS may not be appropriate for non A/V equipment, and Tier I APS can be recommended (Colbert 2017). Tier 2 APS products specified will be able to turn off at least one peripheral device when they sense the device (such as a DVD player) is not in use In addition, power strips will conform to the latest UL1449 standard. When corded, Tier 2 APS shall also conform to the latest UL1363 standard and allow for infrared control with remote.

Large and Small Appliances

For this project, large appliances are defined as refrigerators, ranges and range hoods, clothes washers, and dryers. These appliances will be upgraded to the current ENERGY STAR ratings at a minimum. It is assumed that all appliances in the homes are at least eight years old and that none meet current ENERGY STAR standards. The upgraded appliances will be specified to ENERGY STAR ratings as shown in Table 2-5 and Table 2-6 (US. EPA, n.d.)

Table 2-5: Dishwasher ENERGY STAR Criteria

Equipment	Capacity	Current Criteria (kWh)	Current Criteria (gallons/ cycle)
Standard	**≥ 8 place settings + 6 serving pieces**	**≤ 270 kWh/year**	**≤ 3.5 gallons/cycle**
Compact	**< 8 pace settings + 6 serving pieces**	**≤ 203 kWh/year**	**≤ 3.10 gallons/cycle**

Source: U.S. Environmental Protection Agency

Table 2-6: Clothes Washer ENERGY STAR Criteria

Product Type	Current Criteria Levels (Integrated Modified Energy Factor)	Current Criteria Levels (Integrated Water Factor)
ENERGY STAR Residential Clothes Washers, Front-loading (> 2.5 cu. ft)	**IMEF ≥ 2.38**	**IWF ≤ 3.7**
ENERGY STAR Residential Clothes Washers, Top-loading (> 2.5 cu. ft)	**IMEF ≥ 2.06**	**IWF ≤ 4.3**
ENERGY STAR Residential Clothes Washers (≤ 2.5 cu. ft)	**IMEF ≥ 2.07**	**IWF ≤ 4.2**

Note: These criteria were last updated March 7, 2015.

Source: U.S. Environmental Protection Agency

It is assumed the ranges currently in the homes operate on natural gas. To support reduction in greenhouse gas emission and facilitate offset of electrical end uses, homeowners will be offered an induction cooktop and range. Induction cooktops generate heat from an electromagnetic field below the glass cooktop surface that quickly and directly heats the pan. There is no ENERGY STAR rating for ranges or induction cooktops, but DOE research indicates an induction cooker is 84 percent efficient at energy transfer, versus 74 percent for a smooth-top electric unit, giving it a heating performance comparable to a gas element. More significant, induction is

90 percent efficient with its power use, using 2.8 kW to deliver 2.52 kW. This is a substantial improvement over electric coils of electric stoves, which use 2.0 kW to deliver 1.1 kW (a 55 percent efficiency), and over gas stoves, which use 3.5 kW to generate 1.75 kW (Best Induction Cooktop Guide, n.d.).

Range hoods will also be upgraded. Currently there is no performance threshold for pollutant capture for range hoods; therefore, a prescriptive approach to support good performance has been developed. The prescriptive aspects of the hood range specification address capture efficiency, optimized air flow, and occupant satisfaction. The range hood specification will include the following attributes: Home Ventilating Institute-certified airflow of 200 cubic feet per minute (cfm) or greater, a 4 sone or less sound rating, smooth rigid ducting, and a one-inch sump with 50 percent coverage of the front burner to maximize pollutant capture.

For Scenario 3e, with the addition of a DC grid to the homes, the major appliances installed will be DC appliances. Chapter 3 describes the AC/DC inverter and infrastructure to support the block-scale DC microgrid. Each home will have an existing AC load center tied to the utility and a DC load center tied to the block microgrid. DC appliances are typically constructed for off-grid homes, tiny homes, or marine vessels. There is a nascent market of efficient appliances that can meet the market demand. The potential appliances include refrigerator, dishwasher, clothes washer, stove, and dryer. The appliance selection will be based on market availability and capacity of appliances relative to household size.

For smaller appliances, which are typically kitchen appliances, there be no energy upgrades under this retrofit plan.

Retrofit Scenario Details and Results

The upgrades described above are briefly discussed below in context of the three scenarios and summarized in Table 2-7.

Scenario 1e: AC Solar/Storage Microgrid with EE Retrofits

Scenario 1e focuses on the individual home scale, with on-site generation to offset electrical use. Fossil fuel end uses are converted to electrical end uses to reduce carbon emissions and allow for electrical consumption to be offset by on-site generation. In addition the homes will leverage two types of storage. First, heat pump water heaters will be installed and set points configured to maximize thermal storage, providing hot water through the peak grid period, thereby minimizing energy consumption from the electric grid. Second, the homes will have on-site battery storage to support electrical end uses when solar production is not available. The upgrades are designed to result in zero net energy on an annual basis and a minimum 85 percent reduction in carbon dioxide equivalent (CO_2e) emissions.

Scenario 2e: DC Solar/Storage/EV Microgrid with EE Retrofits

Energy retrofit Scenario 2e expands the house scale to include block-level elements. The additional energy-efficiency features included in this scenario are new windows. The renewable generation is net metered and has the potential to be redistributed among neighbors. The block level effect is achieved with energy storage at block scale, and battery storage is eliminated from the home scale. In addition, EV charging occurs at the block scale. This scenario, with greater storage, is estimated to achieve a 90 percent CO_2e reduction, as gas stoves are assumed to remain in place.

Scenario 3e: DC Solar/Storage/EV Microgrid with EE Retrofits
In Scenario 3e, the additional energy features are replacement of the gas stove, therefore eliminating fossil fuel end uses from the homes. In addition, a DC panel and circuit are added to each home to provide reliable energy sources. To maximize the contribution and availability of the DC grid, all commercially available major appliances and lighting will be upgraded. It is assumed that this scenario will provide 100 percent zero net energy on an annual basis, plus a significant reduction of peak demand to the grid.

Table 2-7: Upgrade Measure Summary by Scenario

Measure Description	Scenario 1e	Scenario 2e	Scenario 3e
Space Heating / No Air Conditioning	Hydronic Air handler with HHW coil No air conditioning	Hydronic Air handler with HHW coil No air conditioning	Hydronic Air handler with HHW coil No air conditioning
Lighting	High-efficacy LED	High-efficacy LED	DC supply for high-efficacy LED
Envelope Insulation and Air Sealing	Insulation and Air Sealing	Insulation and Air Sealing	Insulation and Air Sealing
Duct Sealing	Duct sealing	Duct sealing	Duct sealing
Ventilation	Smart ventilation system	Smart ventilation system	Smart ventilation system
Domestic Hot Water (DHW)	HPWH & Heating Hot Water (HHW) Loop Timer control	HPWH & Heating Hot Water (HHW) Loop Timer control	HPWH & Heating Hot Water (HHW) Loop Timer control
Appliances	ENERGY STAR appliances (except ranges)	ENERGY STAR appliances (except ranges)	ENERGY STAR appliances (except ranges) DC supply for some appliances
Plug Loads	Tier 2 APS	Tier 2 APS	Tier 2 APS

Source: UC Berkeley

Phase 2 Energy Analysis Planning

Phase 2 Onsite Assessments and Evaluation

A home energy retrofit must be based on site-specific evaluation of the homes by a qualified energy professional to determine the upgrades and identify installation conditions. The on-site evaluation will include documentation of existing conditions, modeling the home, identification of energy-efficiency improvements, and recommendations for upgrades. In the conceptual phase, the upgrades were based on accessible information from drive-by audits, Zillow data, and assumptions based on vintage of homes and industry experience. In Phase 2, the project team will refine the recommendations through on-site audits and performance testing.

There are several standards for audits of existing buildings (CEC 2008; BPI 2008, 2014; HUD 1998; RESNET, n.d.; Enterprise, n.d.; Build It Green, n.d.) An assessment means visual evaluation, diagnostic and Combustion Appliance Safety "Test-In" and/or "Test-Out" events, as well as energy software modeling and document submission. It specifically excludes installation or other work performed by participating contractors and/or subcontractors. Based on the assessment/audit, a project-specific scope of work will be developed that meets the project's technical goals and incorporates the project's specifications.

The audit will be an equivalent to an ASHRAE Level 2 audit, which is a whole-building model, as defined below (Baechler 2011).

> **Level 1: Site Assessment or Preliminary Audits** identify no-cost and low-cost energy saving opportunities and a general view of potential capital improvements. Activities include an assessment of energy bills and a brief site inspection of your building.
>
> **Level 2: Energy Survey and Engineering Analysis Audits** identify no-cost and low-cost opportunities, and also provide energy-efficiency measure recommendations in line with your financial plans and potential capital-intensive energy savings opportunities. Level 2 audits include an in-depth analysis of energy costs, energy usage, and building characteristics, and a more refined survey of how energy is used in your building.
>
> **Level 3: Detailed Analysis of Capital-Intensive Modification Audits** (sometimes referred to as an "investment grade" audit) provide solid recommendations and financial analysis for major capital investments. In addition to Level 1and Level 2 activities, Level 3 audits include monitoring, data collection, and engineering analysis.

The audit will consist of (1) data collection and diagnostic testing, (2) interviews with the tenants and owners, and (3) energy consumption modeling and utility bill analysis.

The Audit process will:

- Conduct a comprehensive analysis that identifies all reasonable opportunities for energy and water conservation savings, including equipment and system retrofits and replacement, and operations and maintenance improvements.
- Gather data from diagnostic field tests and extensive site analysis. This may include visual inspection, building systems testing, spot measurements, and short-term energy monitoring.
- Conduct an evaluation of the building's integrity to identify any deficiencies that could result in health and safety hazards to residents, code violations, and/or degradation of building systems that might jeopardize the long-term viability of the building over a minimum ten-year horizon.
- Conduct an intensive engineering and economic analysis to produce reliable estimates of the project's energy and financial performance with the high confidence needed for major capital projects.

Data Collection and Diagnostic Testing

A whole-building audit is based upon building science principles. Many homes—particularly those built before Title 24 was enacted in 1978, can have leaky building enclosures, causing homeowners to use more heating or air conditioning to maintain a comfortable indoor temperature. The outcome of a whole-building audit can encourage residents to think about their house as a complete system, a “whole house,” rather than focusing on individual elements. The concept is to seal and insulate the house first, and then install heating and cooling systems that are correctly sized for the upgraded condition of the home.

The auditor will inspect, evaluate, and analyze the home and engage with the homeowners to document existing conditions and refine recommended upgrades consistent with the Building Performance Institute Standard Practice for Basic Analysis of Buildings (BPI 2008, 2017). An audit will include the following: (1) measure the home to determine square footage and conditioned floor area, wall area, and glazing area, (2) document existing conditions of envelope and equipment and appliances, (3) complete any test-in diagnostics as necessary (i.e., combustion safety, blower door and/or duct leakage), and (4) interview occupants to get insight into operations and maintenance issues. The auditor will use this information to develop an energy consumption model, evaluate energy efficiency recommendations, and produce a report that can be easily read and understood by the residents.

“Test-in” helps define an energy use baseline and comprehensive work scope, including repair of existing health or safety issues discovered. “Test-out” documents that specified improvements have been properly sized and installed, performance-based measure data are tested and modeled, and safety tests have been successfully completed.

An energy upgrade project can be enhanced by including measures that enhance indoor air quality, water efficiency, and resource conservation, and capitalize on possible environmental advantages based on the home’s location. On average, Americans spend 90 percent of their time indoors, yet the air inside our homes can be 10 times more polluted than the outdoor air, according to the U.S. Environmental Protection Agency (1989). Children are particularly vulnerable when it comes to air pollution. In addition to combustion safety concerns, airtight homes may present potential hazards as a result of existing building materials which emit toxic particles and can affect occupant health. Low toxicity or low-VOC materials and mechanical ventilation will be integrated into the upgrades.

With California residences using more than 5.6 million-acre feet of applied water annually, lower water consumption also translates to reduced energy required to pump water for distribution and reduced energy and other inputs required at water treatment facilities. A reduction from 232 gallons per day per capita in 1995 to 178 gallons in 2010 (Mount 2016) demonstrates the impact of lower-flow water fixtures for urban water use. Upgrading older infrastructure in existing homes can continue to drive down water use. Lower hot water consumption translates to lower energy and water bills.

Further, residential remodeling activities consume large quantities of wood, water, metals, fossil fuels, and other resources. These projects will include construction and debris plans for recycling and reuse as construction and demolition waste comprises 21 to 25 percent of the waste stream in California (Cascadia Consulting Group 2015). All upgrades will meet minimum requirements as defined in the appropriate California Green Building Code (California Building Standards Commission 2016). These requirements will be defined in the full specifications documents.

Owner Survey and Scenario Grade Preference

Surveying and/or interviewing the occupants is a critical piece to understanding how the home is operated and what issues have been identified by the occupants. The purpose of the interviews is to:

- Discuss the audit's objectives and the client's goals for the scope of retrofit
- Discuss building characteristics, existing documentation, and project energy and water performance
- Discuss residents' comfort, health, and safety, and to agree on an approach to accessing residents for interviews and to view dwelling unit spaces for the site visit. If any interviewee wishes their responses to remain confidential, the auditor shall respect those requests.
- Discuss operations and maintenance procedures
- Address any other stakeholder questions or concerns

In addition to discovering information about the home and operational characteristics, an interview and survey provide the opportunity to engage residents in discussions about new technologies, overcome social barriers to adoption, and obtain deeper market penetration. A classic example is replacing a gas stove with an induction cooktop, convection oven, and/or hot pot. The increased safety, efficiency, and precision of new equipment can be discussed in contrast to the poor performance of older electric resistance coil stoves. Through education, residents will become aware of new technologies and the benefits of those technologies.

Energy Consumption Model and Billing History Review

To best understand the energy use in the home, the on–site audit information can be used to building an energy consumption model that will be calibrated using utility bill data. Through calibration the auditor can better understand consumption of end uses to inform recommended upgrades as well as resident behavior.

Phase 2 Energy Analysis Plan and Construction Documents

Refine and finalize Phase 1 preliminary results

As a result of the comprehensive on-site audits documenting the existing energy and water system conditions, as well as indoor air quality, the project team will accomplish the following for each building:

- Refine modeling and advance deep energy savings.
- Refine system specifications, envelope treatment, and lighting and appliances.
- Advance the Deep Energy Efficiency Retrofit Plan and specifications addressing a space conditioning (heating and cooling), lighting, appliances, miscellaneous electrical plug loads, and water heating energy end uses. Identified energy efficiency retrofits will be designed such that the indoor environmental conditions (indoor air, lighting, urban noise, and thermal comfort quality) of each building are maintained or improved in conformance with any applicable California Building Code.
- Provide green building consultation on deep energy retrofits and neighborhood improvements.

The results of the audit for each individual building will also allow the project team to evaluate the applicability of a single home model and general model to support project scaling.

Design and Development Process

The project team will develop a scope of work that is approved by the owner for each building. Once the scope of work has been agreed upon, the team will develop construction documents to support the permit and construction process. The construction documents will include (but not be limited to) plans, specifications, and performance targets that meet the project goals for energy and water reductions and indoor environmental condition standards. Based on the construction documents, the project team will refine the bid estimate for the scope of work, identify any funding sources to support the scope of work.

Construction Process

Throughout the construction process, the design project team will provide consultation to the construction project team, a design-build firm. On-site inspection and diagnostic testing of installation will be completed throughout the construction process to support energy and water reduction and indoor environmental condition goals.

CHAPTER 3:
Integrated Electrical System Design and Evaluation

Rich Brown (Lawrence Berkeley National Laboratory) and Andrea Traber (Integral Group)

Abstract

The electrical system design for the block scale was developed through a research-oriented technical design approach. We developed multiple configurations of the electrical infrastructure needed to support electrical operations for the block, evaluated AC (alternating current) and DC (direct current) microgrid options, evaluated the benefits and feasibility to residents, analyzed the capacity for solar generation and storage, and optimized the integrated system using DER-CAM (Distributed Energy Resources Customer Adoption Model) using various tariff models. The team analyzed four scenarios and identified a preferred alternative. The preferred alternative is a microgrid based on 50 percent participation of households, allowing for increased adoption as the system proves its functionality and benefit.

Introduction: EcoBlock Integrated Electrical System Design

Goals and Analysis Plan

Phase 1 and Phase 2 work scopes

The goal of the EcoBlock energy project is to design, deploy, and test a replicable, modular, cost-effective, and reliable community-scale microgrid platform that can be scaled easily across city districts. The intent is to pioneer a new form of microgrid in which multiple ratepayers are aggregated at the point of interconnection to the utility grid, to achieve economies of scale. The initial Oakland EcoBlock project is intended to demonstrate this concept's operational performance and assess its scalability and replicability. Deploying these clean-energy resources at the block level is intended to verify the hypothesis that substantial benefits accrue from this community-scale approach, namely: (1) improved utilization of assets through shared solar, storage, and electric vehicle (EV) charging systems; (2) enhanced load shape, demand response, and power resilience through optimized and coordinated control of the microgrid's assets; (3) business and financial economies of scale through larger-size development projects. modular, scalable designs, and greater access to capital markets; and (4) lower ratepayer costs.

The purpose of Phase 1 of the EcoBlock project funded the development of a master plan, including technical design, planning, permitting feasibility, and financing models of a whole-systems approach to retrofitting an existing low-to-middle income neighborhood block in the City of Oakland. Phase 1 deliverables include schematic design level documents.

Phase 2 funding, if approved, would fund the design development, construction documents, bidding, construction, commissioning, and post occupancy evaluation of the Phase 1 master plan at the Oakland EcoBlock as defined in Phase1, or at another selected similar location.

To maximize carbon reductions and provide improved energy resiliency to the community, the EcoBlock project team decided that the integrated energy system at the EcoBlock would be a microgrid, with adequate generation and storage resources to serve the energy needs of the homes, and the ability to operate separately ("island") from the utility power grid for extended periods.

The EcoBlock microgrid concept includes five distributed energy resources (DERs) applied in the California loading order: (1) energy efficiency retrofits and electrification of major home equipment (described in Chapter 2); (2) controllable/deferrable loads for demand response; (3) electrification of transportation using electric vehicles (EVs); (4) serving remaining load with a block-scale microgrid system powered by communal rooftop PV; and (5) a central energy storage system.

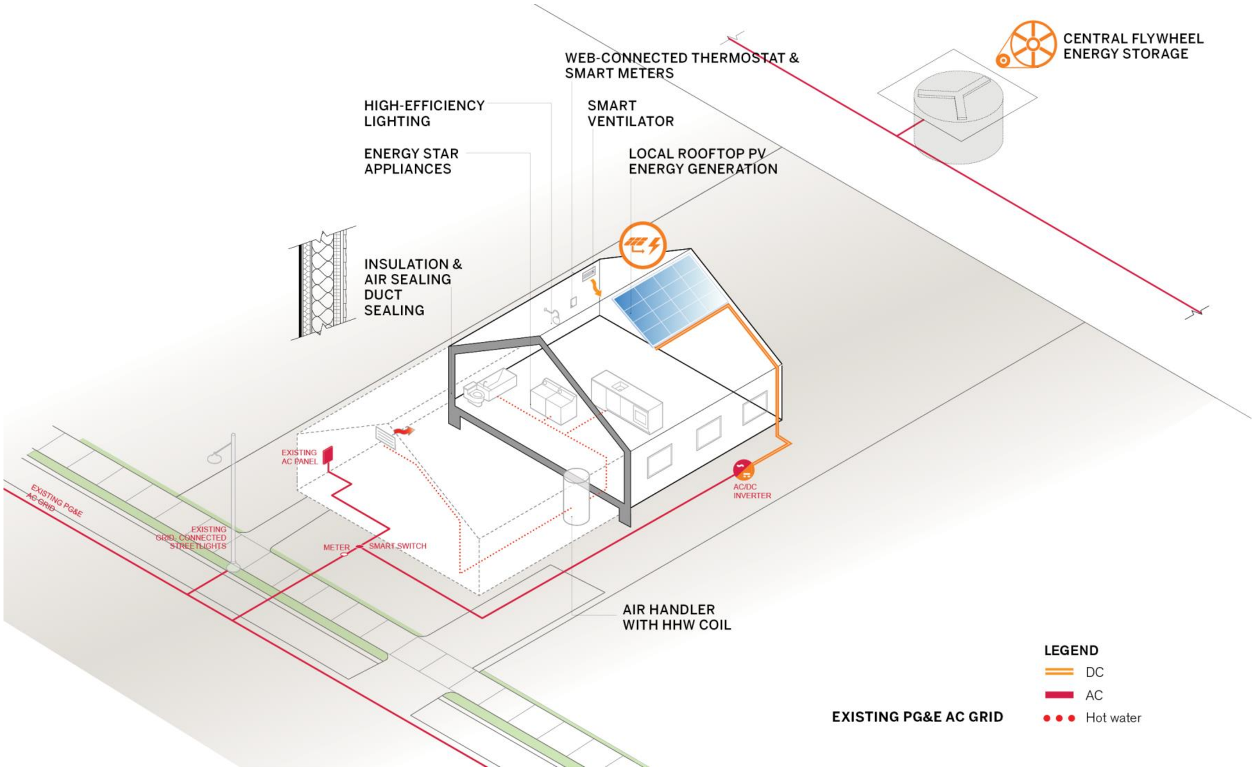
Three Design Scenarios

The design team analyzed three scenarios for the EcoBlock Integrated Energy System, and each scenario includes the five DERs described above, as well as a central utility plant, which is a single location in the microgrid where shared assets, such as the energy storage system and microgrid controller, are located. The scenarios vary primarily in how the power is distributed around the block, where power conversions take place, and where in the system the connection to the utility grid is made. The three scenarios are as follows:

Scenario 1e. AC Solar/Storage Microgrid with Energy Efficiency Retrofits and Existing AC Houses

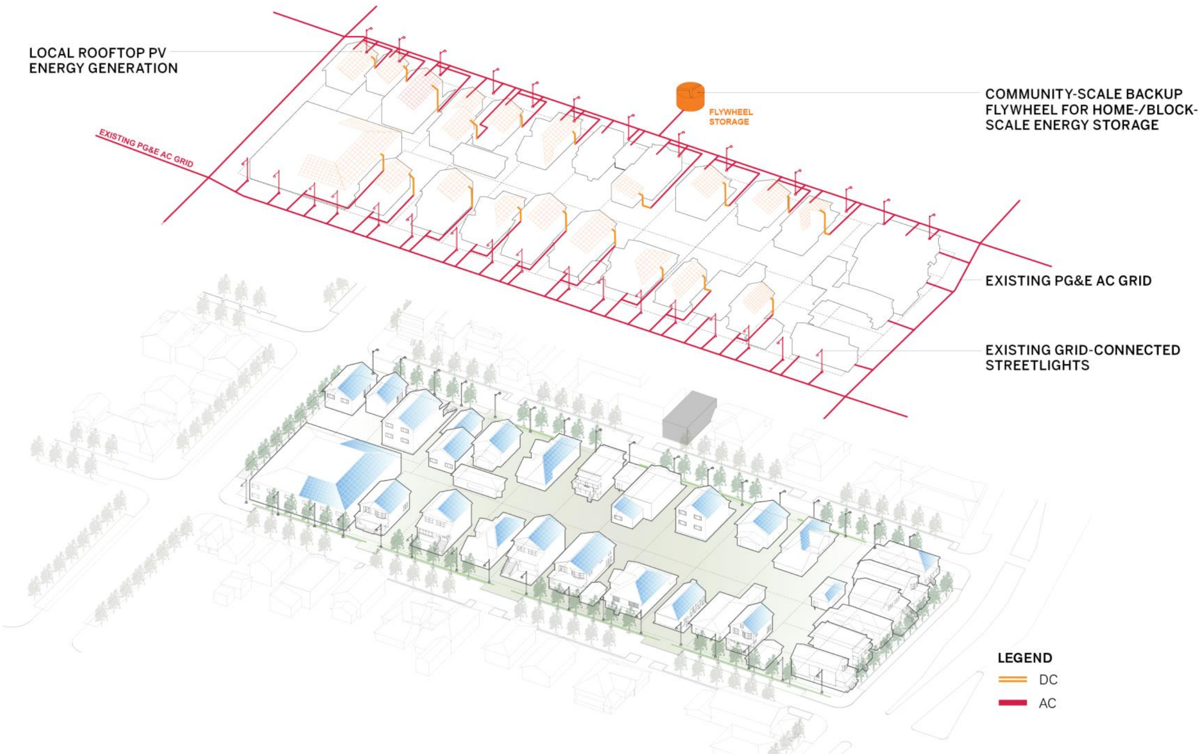
The design strategy in Scenario 1e is to outfit each home with an individual photovoltaic (PV) array and to build an AC distribution circuit around the block, which would connect to each home's PV system through an inverter. The AC microgrid would receive power from the PV arrays, store it in a centralized energy storage system, and distribute it back to the homes. Existing Pacific Gas and Electric (PG&E) high-voltage cables would be reused to connect the block's transformers to the new central utility plant. Existing 240 volt (V) cables from the PG&E transformers, existing AC load centers, and existing power meters would all be maintained. Figures 3-1 and 3-2 show the configuration of this scenario at the individual home and block level. 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.

Figure 3-1: Scenario 1e: AC Solar/Storage Microgrid – House Diagram



AC Solar/Storage, Microgrid with Energy Efficiency Retrofits and Existing AC Houses.
Source: Skidmore, Owings & Merrill, LLP

Figure 3-2: Scenario 1e: AC Solar/Storage Microgrid – Block Diagram

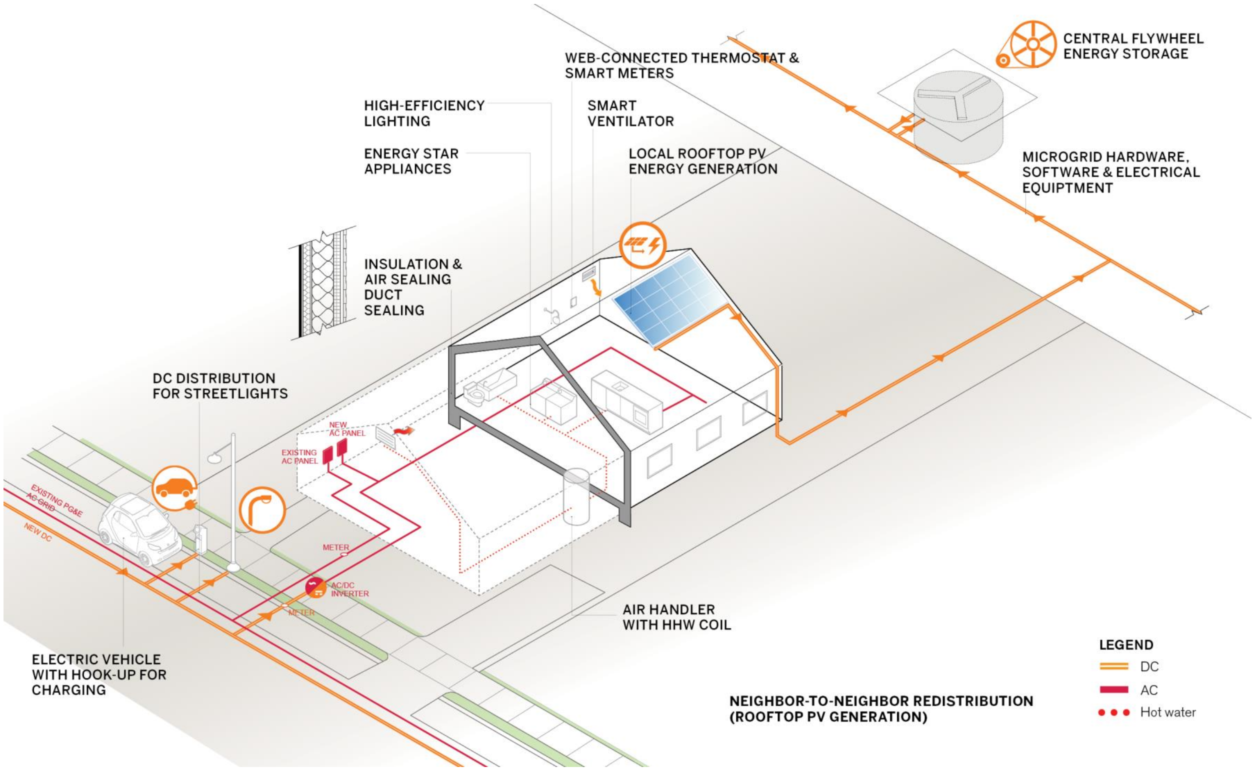


AC Solar/Storage, Microgrid with Energy Efficiency Retrofits and Existing AC Houses.
Source: Skidmore, Owings & Merrill, LLP

Scenario 2e. DC Solar/Storage/EV Microgrid with Energy Efficiency Retrofits and Existing AC Houses, at Block Scale

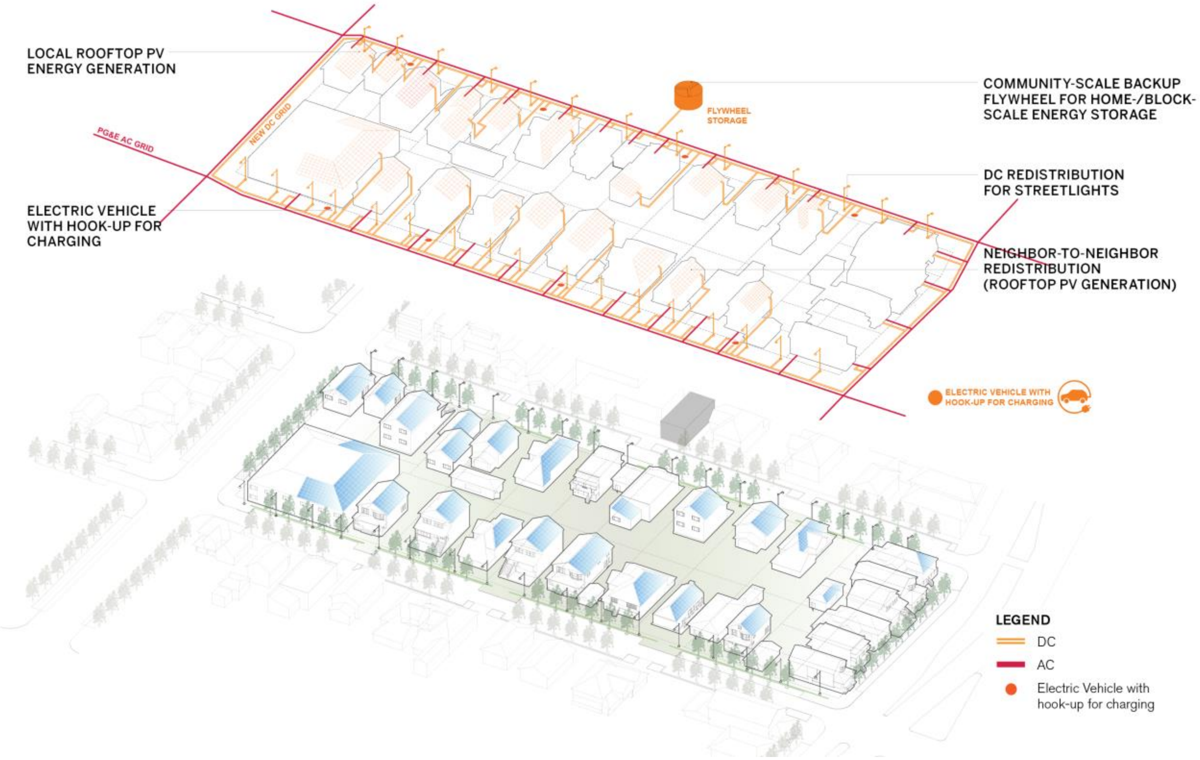
The design strategy in Scenario 2e is to outfit each home with an individual PV array and to build a DC distribution circuit around the block to form the backbone of the microgrid, which would connect to each home. The DC microgrid would receive power from the PV arrays, store it in a centralized flywheel system, and distribute the power back to the homes. Each home would also be outfitted with an inverter, and a new AC load center, in order to feed their loads with reliable power from the DC microgrid. Figures 3-3 and 3-4 show the configuration of this scenario at the individual home and block level. The advantages of this scenario include: reducing the cost of PV by purchasing in bulk, reducing the cost of storage by using a block-scale approach, the ability to underground the DC distribution circuit for improved reliability, and allowing the existing AC circuits in the homes to remain unchanged.

Figure 3-3: Scenario 2e: DC Solar/Storage/EV Microgrid – House Diagram



DC Solar/Storage/Electric Vehicle Microgrid with Energy Efficiency Retrofits and AC/DC Houses.
Source: Skidmore, Owings & Merrill, LLP

Figure 3-4: Scenario 2e: DC Solar/Storage/EV Microgrid – Block Diagram



DC Solar/Storage/Electric Vehicle Microgrid with Energy Efficiency Retrofits and AC/DC Houses.

Source: Skidmore, Owings & Merrill, LLP

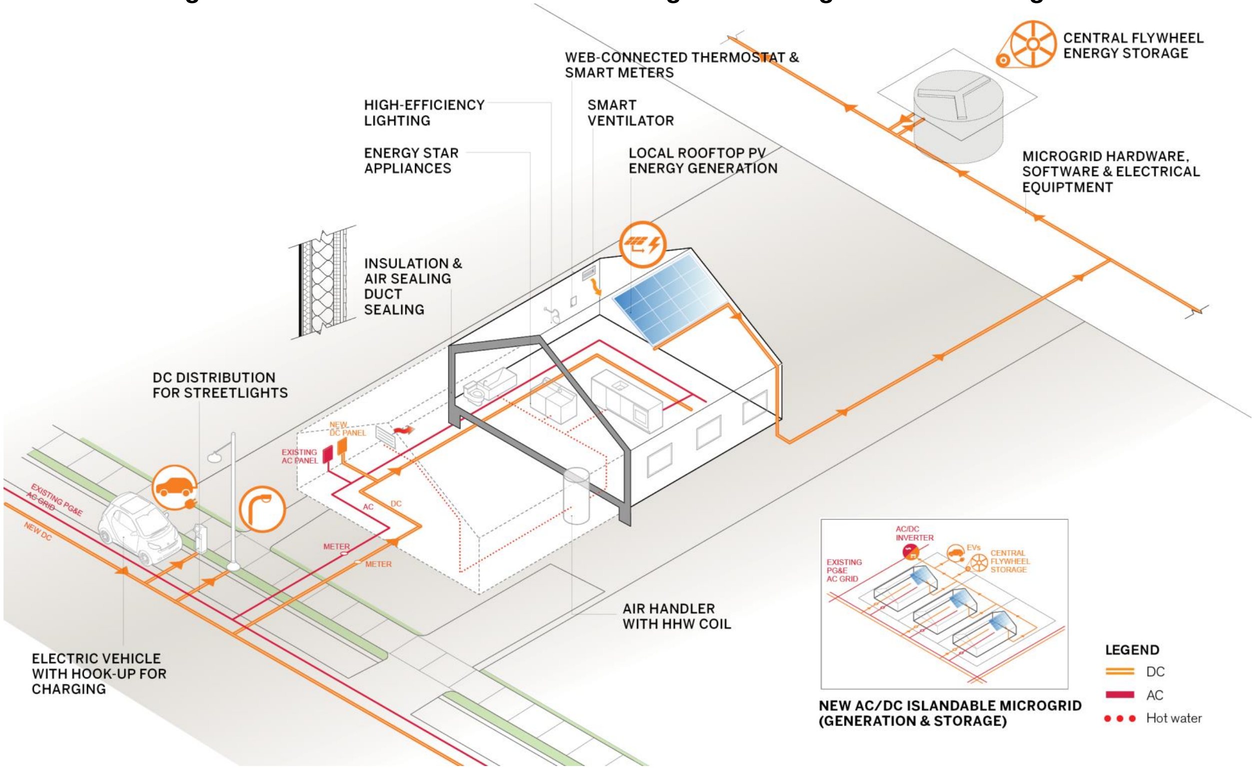
Scenario 3 e. DC Solar/Storage/EV Microgrid with Energy Efficiency Retrofits and AC/DC Houses, at Block Scale (Preferred)

The design strategy in Scenario 3 is to outfit each home with an individual PV array, new energy-efficient DC appliances, and a new DC load center to serve the new appliances. A new DC microgrid would be built around the block and connected to each home. The DC microgrid would receive power from the PV arrays, store it in a centralized flywheel system, and distribute the power back to the homes. A new, central interconnection would tie the DC microgrid to the AC utility, so that the extra power produced during summer hours could be sold to the utility. The existing utility connection and AC load center in each home would be maintained, however most loads would be moved from the AC load center to the new DC load center. Figures 3-5 and 3-6 show the configuration of this scenario at the individual home and block level. The advantages of this scenario include: reducing the cost of PV by purchasing in bulk, reducing the cost of storage by using a block-scale approach, the ability to underground the DC distribution circuit for improved reliability, eliminating the need for inverters in each home, improving efficiency of home loads by powering them with DC while allowing some hard-to-convert existing AC circuits in the homes to remain unchanged, and fully utilizing excess power generated by selling it back to the utility. The team analyzed two different options for Scenario 3 e: a maximum size microgrid and an economically sized microgrid.

1. **Maximum Size Microgrid**
   Option A is to size all of the block-scale equipment (such as the flywheel, DC microgrid conductors, DC/DC converters, and grid interconnection) to accommodate the maximum PV output for every home on the block. This approach would allow homeowners who initially do not opt-in to the EcoBlock to buy in and participate at a later date. The extra capacity could also be used to make the EcoBlock a net energy exporter in ~30 years as the PV arrays are replaced with newer, presumably higher efficiency PV.

2. **Economically Sized Microgrid (Preferred)**
   Option B is to size all of the block-scale equipment to accommodate only the owners who opt-in initially, with incremental expansion of the energy system as additional homes undergo energy retrofits and connect to the microgrid. This expansion would logically happen in one or two "waves" to achieve economies of scale. This incremental approach would reduce the initial cost of the total system using smaller storage and distribution equipment.

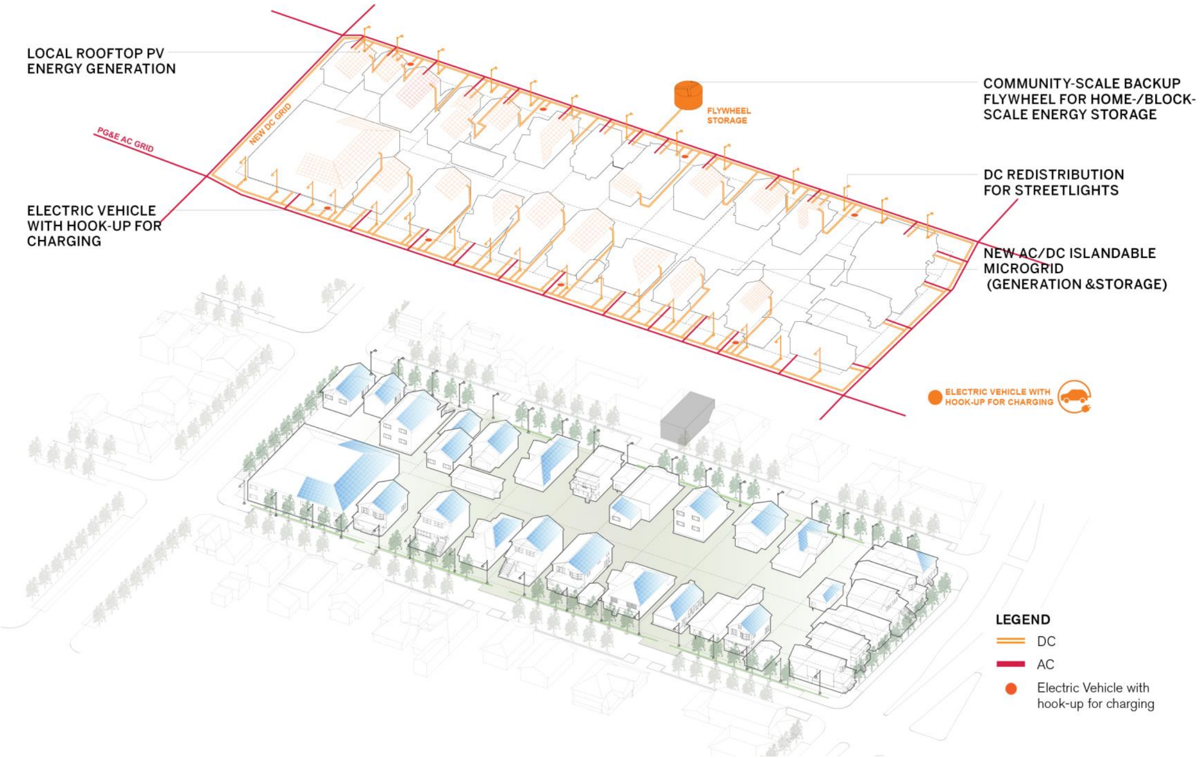
Figure 3-5: Scenario 3 e: DC Solar/Storage/EV Microgrid – House Diagram



DC Solar/Storage/Electric Vehicle Microgrid with Energy Efficiency Retrofits and AC/DC Houses.

Source: Skidmore, Owings & Merrill, LLP

Figure 3-6: Scenario 3 e: DC Solar/Storage/EV Microgrid – Block Diagram



DC Solar/Storage/Electric Vehicle Microgrid w. Energy Efficiency Retrofits and AC/DC Houses.

Source: Skidmore, Owings & Merrill, LLP

Site Description

City Block and Property Lot Details

Electrical power at the site is currently distributed at 12.47 kilovolts (kV) across 17 telephone poles, and then through 7 PG&E pole-mounted transformers into the 28 properties at 240 V/120 V split-phase AC power. Figure 3-7 illustrates the physical layout of the existing PG&E electrical distribution system on the block.

Figure 3-7: Existing Conditions

Source: Google Maps; UC Berkeley

Technologies per Scenario

Photovoltaic retrofits and associated home upgrades

Each home will be outfitted with an array of 78" x 40", 365 W solar panels; the number of solar panels on each home will depend on the size and design of each roof. Based on an approximate estimate of each building’s roof area, the EcoBlock has a combined useable roof area of 37,000 square feet (ft^2). Assuming that 75 percent of the useable area can be utilized, we will be able to fit 1,309 panels on the block, with a peak output of 478 kilowatts (kW) of solar power.

Energy Storage

In each scenario, the microgrid will be supported by three 40 kW flywheels, located in the Central Utility Plant.

AC Microgrid

In Scenario 1e, existing high-voltage cables from PG&E will be used to distribute power from the Central Utility Plant to the existing PG&E pole-top transformers for distribution to the homes. A new AC microgrid (parallel to the PG&E power lines) will be created with a 1000 amp (A), 240 V busway, to collect power from the solar arrays and transmit it to the central utility plant and flywheel.

DC Microgrid

In scenarios 2e and 3e, two DC busways will be installed in new underground conduit using directional drilling (thus avoiding the expense of full trenching). One busway, at 760 VDC, will be used to collect and transmit the solar power from the rooftop arrays to the Central Utility Plant. The other busway, at 380 VDC, will transmit power from the Central Utility Plant to the load panels in each home. These voltages were chosen to minimize line losses while also minimizing conversion losses to the lower voltage loads in the homes.

Electric Vehicle Charging

Scenarios include the installation of curbside electric vehicle chargers (also known as *electric vehicle supply equipment,* or EVSE) to allow EV charging from the solar-powered microgrid. As explained below, the optimal number of chargers is 24, assuming that all houses participate in the microgrid, although that number can be scaled with the amount of PV generation available. The chargers will be fed from the DC microgrid and supply DC power to the EVs using a DC fast charging standard.

Microgrid Design Methodology

Analysis Methodology

Data sources used

Household energy use data and load profiles used for electrical system design were generated by the Deep Energy Efficiency Retrofit team. See Chapter 2 for a full description of the sources and methods used. Electrical component performance data were derived from manufacturer literature and other public sources.

Microgrid Design

Background

The overall microgrid design begins with the fundamental architecture of the system—what devices are present, their core characteristics, and the interconnection configuration and technology. The design alternatives are considered based on how well they meet the project goals. The selection of the optimal design involves trading off several diverse factors, which often involves uncertainty because the EcoBlock approach is new and untested. Since a key goal of the project is innovation and testing new ideas, the project team considered it essential to include new concepts in the alternative designs.

Many factors influenced the evaluation and choice of the configurations (hereafter called *topologies*). Capital and maintenance costs, as well as reducing energy use, are perhaps the most important factors to consider, along with testing design approaches that can be done only at the block scale. Other goals included: use of central storage, providing local electric reliability, decarbonizing fuels provided to the residences, coordinating EV charging, and coordinating with the grid for economic and environmental benefit. Additional concerns or criteria included: annoyance to residents, "coolness," flexibility, technology availability, reliability, net load on the utility grid, and alignment with other project goals.

Initial Topologies

The core elements of traditional household electrical infrastructure include a single utility connection with a meter (and financial relationship), AC power provided in the form of 120 V and 240 V circuits, and end-use devices. The current standard solar PV installation includes PV panels that feed an inverter (or microinverters on each panel) connected to the AC electrical system at the central breaker panel in the house, with a disconnect switch to preclude power backfeeding to the utility grid when the grid is not operating. Essential new elements of the EcoBlock for any scenario include the following:

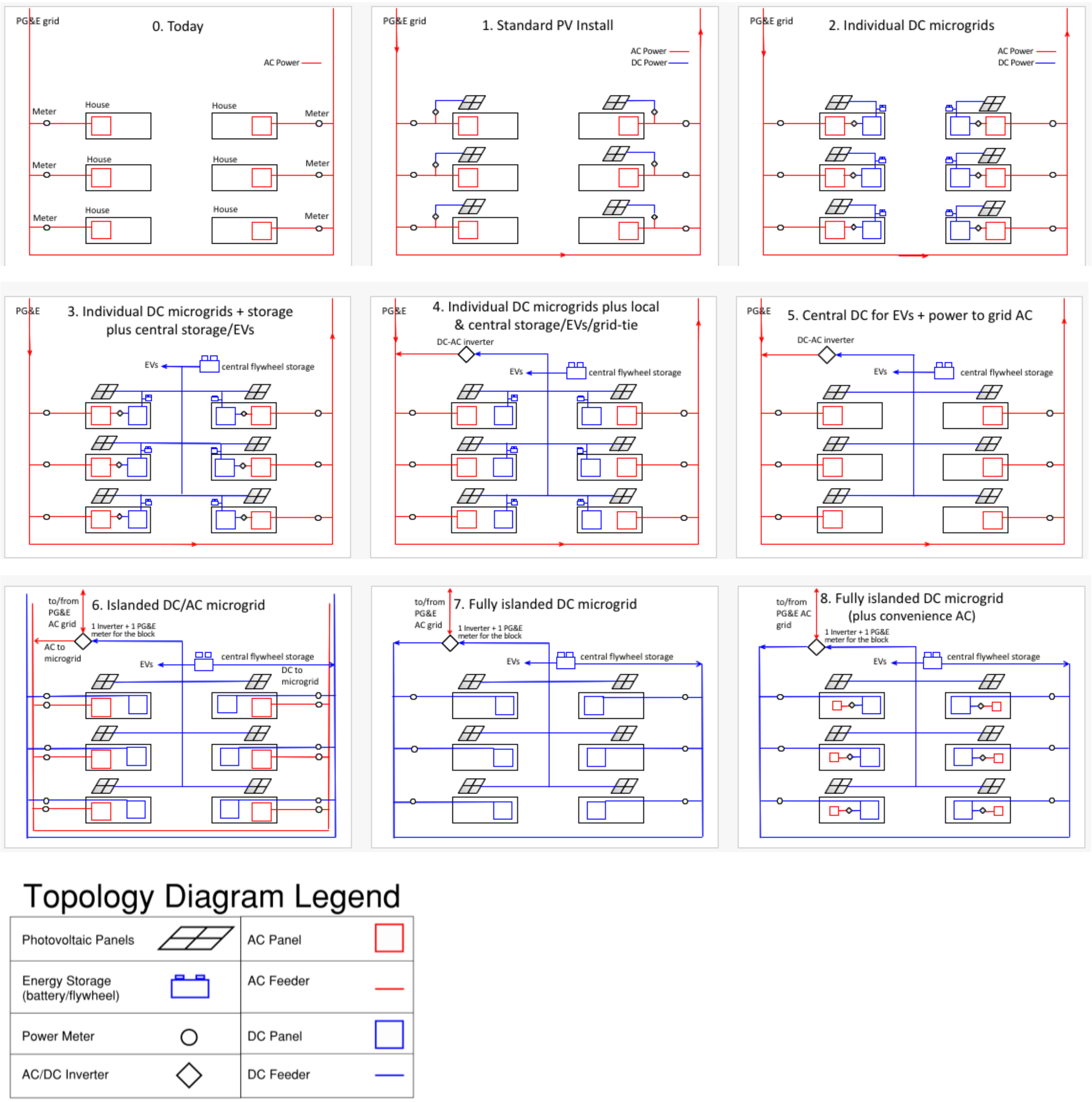
- Utilizing the block-scale context to obtain benefits not obtainable at the single-household scale.
- Considering the benefits of some local storage for local reliability and resiliency.
- Mechanisms for coordinating provision of vehicle charging, management of central storage, and end-use device operation.
- High levels of energy efficiency.

With the block-scale context and desire for innovation, the project team identified several new possibilities, including:

- Collection of DC power from each building to a central point (for potentially more efficient and less costly infrastructure, and integration with central storage).
- New metering relationships possible between and among the utility, the block as a whole, and each household.
- Use of DC power within buildings for end-use devices (for efficiency and reliability benefits).

Figure 3-8 shows a set of high-level topologies considered early in the design process. There are many more possible variations, but these covered most factors of interest.

Figure 3-8: Possible Block Topologies Considered



AC circuits in red, DC in blue

Source: UC Berkeley

Topology 0 is the infrastructure that exists today, with AC distribution, a meter for each household, AC loads, and no local reliability, excepting individual devices with internal batteries. This is not considered an EcoBlock scenario.

Topology 1 is what is typically added to residential buildings when PV is added, with the PV power from the DC being necessarily run through an inverter to connect to the AC power system; since this does not include storage, it is also not an EcoBlock scenario.

Topology 2 provides for DC end-use devices directly powered from local generation and storage. This provides local reliability and efficiency benefits, and is simple in that there is no common infrastructure, which adds cost and complexity. However, it does not allow for central storage for improved reliability, EV powering by EcoBlock, or provision of the DC power to houses that are unsuitable for PV.

Topology 3 adds (to Topology 2) central DC infrastructure to connect all the DC microgrids to storage and to EVs (but not the AC utility grid). Exchange of power with the utility grid is through each house.

Topology 4 removes the connection between the AC and DC circuits in each house in favor of a central interface to the utility with a new meter. This scenario also shows battery storage located in each household. Centralizing the electrical connection to the utility in this manner provides safety, administrative, and financial benefits, in comparison to Topologies 2 and 3.

Topology 5 collects the DC centrally, but provides for no DC distribution to end-use devices, other than possibly EVs. All power is fed to the AC grid. This reduces the direct DC opportunity and provides for no local reliability. The storage in individual households is removed in favor of the central storage, so this scenario is a single, grid-connected DC generation system.

Topology 6 creates both an AC and a DC microgrid, with a single point of connection to the existing AC utility. AC meters in each home are retained, but information is forwarded to the EcoBlock rather than the utility; instead, only the central AC meter communicates with the utility. This topology would have the highest costs.

Topology 7 eliminates all AC distribution, which has simplicity and cost reduction advantages. In this scenario, every appliance in the occupants' homes would need to be replaced with a DC equivalent; this exercise would improve energy efficiency, but would require extensive renovations, and is not currently practical given the lack of availability of direct-DC powered end-use equipment. A number of small, 1.5 kW DC/AC inverters would need to be provided to power legacy AC plug-load circuits.

Topology 8 adds a home-scale inverter and AC load center to the system, rather than utilizing several small inverters, as Topology 7 does. This would require additional cost and reduced energy savings, but it would also allow for a less extensive renovation; residents would be able to keep some of their appliances on AC power.

Scenario Evaluation

Early on in the process a consensus emerged to favor central rather than distributed infrastructure. Centralized equipment will be more cost-effective, more efficient, easier to control, and will better demonstrate the advantages of block-level treatment compared to a distributed approach. This meant central storage, a central inverter, and a central connection to the utility grid. This also was most favorable to EcoBlock management of EV charging. Distributed infrastructure was not favored because it presents a more complex operations and maintenance regime that causes operational and cost inefficiencies, and ultimately a less reliable system.

While most structures will have PV, the team concluded that some will not, due to factors such as unsuitable roofs, windows, and trees. In addition, if the theoretical maximum PV capacity generates more power than can be used on site or sold at a gain to the grid, those structures for which solar is possible but simply less suitable can be dropped. One of the advantages of block-scale deployment is not needing to have PV on all structures to have all households benefit from it financially and otherwise.

The central energy storage system is anticipated to be across the street on a commercial property. This would also likely be the point where a central electrical connection to the utility meter would be placed, along with two pieces of power conversion equipment: (1) a bidirectional converter (that meets CA Rule 21 requirements) to convert the DC power from the microgrid to the AC power used in the grid, and (2) a step-up transformer to boost the AC voltage to the 12.47 kV used in the local PG&E distribution system.

The addition of new DC wiring around the block does add the complexity of needing to put those wires somewhere. One possibility is down the spine of the block, along the fence where properties adjoin. This was done in the past occasionally for both phone and power in various places, but this practice has been mostly phased out and the lines removed due to the complications of accessing the wires for maintenance (such as tree trimming and equipment repair). The other options are underground (particularly if other infrastructure such as utility grid wires and water infrastructure were being placed underground), or on the existing street poles. While the undergrounding option is generally more expensive, the latter option presents a host of problems, such as space on the existing poles (which might need to be made taller), structural overloading of the existing poles, and legal liability with the owner of the poles.

With the goal to decarbonize existing fuel use in space and water heating, all devices for space and water heating in the buildings will be replaced. This opens the door to electric heat pumps that could be powered more efficiently with direct DC if they use variable-speed drives for their compressor motors. See Chapter 2 for a technical description of the energy efficiency retrofits.

Another consideration in the electrical design is that available technology and usage will change over time, which introduces uncertainty but can help make the design more relevant for future conditions if we consider the larger trends. For instance, more and more DC-powered devices are likely to become available, and there will be more use of EVs and possibly more ways to charge them (beyond the Level 1, Level 2, and Fast DC we already have). For EVs, we do not know what EV charging might be routinely available from the utility, the local Community Choice Aggregator (CCA), or a third party. The utility grid will also change, in cost (tariffs), reliability, and services it provides. The residents will also age, and move in and out.

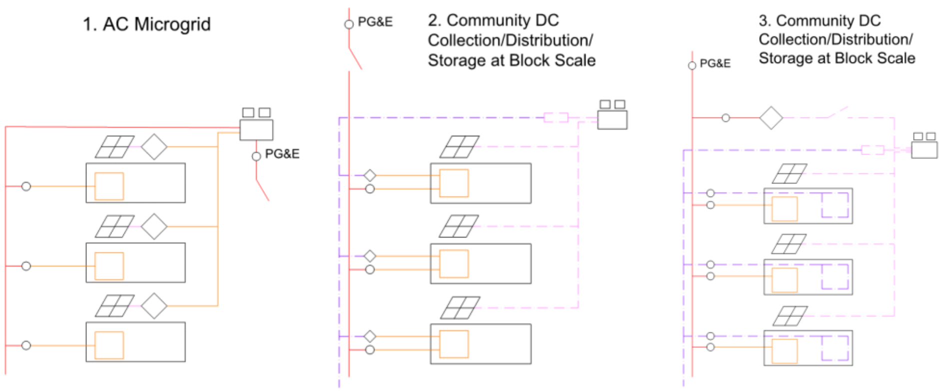
Selection of feasible topologies due to existing conditions

The project team researched and modified all of the topologies discussed above, and ultimately decided to focus the study on three scenarios shown in Figure 3-9:

- Scenario 1e: AC Solar/Storage/EV Microgrid with Energy Efficiency Retrofits and Existing AC Houses

- Scenario 2e: DC Solar/Storage/EV Microgrid with Energy Efficiency Retrofits and Existing AC Houses, at Block Scale
- Scenario 3e: DC Solar/Storage/EV Microgrid with Energy Efficiency Retrofits and AC/DC Houses, at Block Scale (Preferred)
  a. Maximum Size Microgrid (Optional)
  b. Economically Sized Microgrid (Optional, Preferred)

Figure 3-9: Final Microgrid Scenario Topologies



Red/orange indicate AC power, purple/blue indicate DC power

Source: UC Berkeley

Electrical System Design

For the provision of AC power, existing PG&E assets will be retained, including telephone poles for distribution of AC power, as well as the existing distribution switches, transformers, meters, and other equipment required to serve AC power to the buildings within the EcoBlock. In all scenarios, existing service panels at each building will be maintained to keep the existing power distribution system within each structure in place. In scenarios 2 and 3, each building will also be provided with its own DC sub-meter at the existing building service panel; however, this will not be a utility-owned meter. If the residents convert their equipment to operate entirely off the DC microgrid in Scenario 3, at the residents' discretion, the existing PG&E energy meters can be removed, along with the site feeders to each building. Scenarios 2 and 3 also require the addition of central protection equipment (distribution switches) for the DC microgrid. Refer to the options below, as well as the single-line diagrams, for more information on the configuration of the wiring, conduit, and equipment.

The team examined two options for the location of new electrical distribution wires: an interior distribution system or a perimeter distribution system. An interior distribution system (running the major power lines through the center of the block, and distributing power outward to the homes) could save some money and materials by reducing the lengths of cable runs and the number of poles required. However, an interior distribution system would come with the serious complication of requiring utility easements to run through every property on the block.

For the preferred design, we have selected a distribution system located at the perimeter of the block (to avoid the access issues with the center of the block), and undergrounded to avoid the many complications with pole-mounted systems.

Scenario 1e: AC Solar/Storage/EV Microgrid with Energy Efficiency Retrofits and Existing AC Houses

This option will provide homes with PV systems that will be tied to a block-scale AC microgrid containing a shared AC flywheel storage system. Existing connections from the PG&E transformer to each home's AC load center will be retained. Existing PG&E high voltage cables will be rewired from the transformers back to the EcoBlock's Central Utility Plant, and connected to the central flywheel through a switchgear.

During normal operation, the AC microgrid will provide AC power to the houses. The PV system will provide AC power to the AC microgrid through a home-scale DC/AC inverter, and the AC microgrid will charge the central flywheel with excess AC power. Excess power, above what is needed to serve the load or charge the storage, will be fed back to the grid. When the PV system shuts down at night, the flywheel will continue to provide AC power until its charge falls to its minimum allowable state of charge.

If AC utility power is lost, the AC system will island via the switchgear, and the flywheel will continue to provide power to the AC power distribution bus, allowing the residents' AC-powered equipment to remain operational.

Scenario 2e: DC Solar/Storage/EV Microgrid with Energy Efficiency Retrofits and Existing AC Houses, at Block Scale

This option will provide homes with PV systems that will be tied to a block-scale DC microgrid containing a shared flywheel storage system (served directly by the DC microgrid without conversion) and shared EV chargers served by a central DC distribution panel. Each home will house a DC/AC inverter, connected from the DC microgrid to the existing AC load center.

When the utility power goes down, the flywheel will keep the DC microgrid operational, allowing residents to use all equipment in their home while the utility is unavailable. The PV system will also continue to provide power to homes, as well as recharge the flywheel when the PV system is overproducing.

The microgrid in this option will be able to export power to the utility when it is overproducing, allowing for the possibility of net energy metering (NEM). This would allow for not just zero net energy use within the EcoBlock, but also a zero net utility bill. The PV system can overproduce during the summer months, and that energy can then be credited to lower production months during the winter. This means that over the course of the year the utility bill can average out to zero.

Because the loads in the homes are all served from the AC load centers, this option contains all inherent inefficiencies of DC/AC conversion that are typical in PV installations today, but the advantage is that all the AC circuits and equipment in the homes can be used as they are today.

Scenario 3e: DC Solar/Storage/EV Microgrid with Energy Efficiency Retrofits and AC/DC Houses, at Block Scale (Preferred)

This option will provide homes with PV systems and new DC appliances where available; both will be tied to a block-scale DC microgrid containing a shared flywheel storage system (served directly by the DC microgrid without conversion) and shared EV chargers served by a central DC distribution panel. Each home will house an existing AC load center tied to the existing PG&E utility service and a DC load center tied to the DC microgrid.

When the utility power goes down, the flywheel will keep the DC loads operational, enabling users to utilize all DC equipment in their home while the utility is unavailable. DC loads will include lighting, water and space heating, electronic loads, and the refrigerator. Users will also have the option to include two small DC/AC inverters for AC loads that they would like to include on reliable power; these loads will be connected through the small inverters to the DC load center.

The microgrid in this option will be able to export power back to the grid. The DC microgrid will be tied to the PG&E distribution system through a single block-scale bidirectional converter, which can either draw from or export to the grid when needed. As with Scenario 2, the ability to export opens the possibility of net energy metering, or even net-positive energy export through a feed-in-tariff or wholesale supply contract with the local CCA.

Scenario 3e maximizes the block's ability to purchase commercial-scale electrical infrastructure to serve the entire block and minimize costs, and also to benefit from the efficiency of using DC electrical production to power DC end loads. In addition, because the DC microgrid is not synchronized to the AC frequency of the PG&E distribution grid, the process of reconnecting to the grid after islanding is much easier.

Scenario 3e includes two options:

- Option A is to size all of the microgrid equipment that serves the entire block at maximum capacity, to allow all of the homeowners to participate in the microgrid.
- Option B is to size the equipment to a level that assumes only 50 percent of the homeowners will participate in the microgrid. This will provide cost savings by utilizing smaller equipment for the microgrid distribution and storage systems.

New Infrastructure at the Block Level

Table 3-1 summarizes the new infrastructure that would be used for the Oakland EcoBlock, at block level.

Table 3-1: Major New Infrastructure at Block Level

Equipment	1e	2e	3e(a)	3e(b)
DC Photovoltaic Panels 280 W, 17.04% efficient, 31.8 V, 8.81 A, 60-cell modules	✓	✓	✓	✓
DC Power Meter for PV Production	✓	✓	✓	✓
DC Charge Controller	✓	✓	✓	✓
DC/DC Converter Input: 320 VDC–640 VDC, 450 VDC–800 VDC / Output: 23 VDC–800 VDC 400 kW, liquid cooled		✓	✓	✓
DC/AC Inverter 365 KW, 600 VAC, 2625 A, 3-phase, 60 Hz, 875–1300 VDC, 500 A, 99.2% efficient			✓	
DC/AC Inverter 182 KW, 600 VAC, 2625 A, 3-phase, 60 Hz, 875–1300 VDC, 500 A, 99.2% efficient				✓
DC/AC Inverter 24 KW, 600 VAC, 100 A, 3-phase, 60 Hz, 380 VDC, 100 A, 99.2% efficient	✓	✓		
DC Flywheel 40 kW, 800 VDC		✓	✓	✓
AC Flywheel 40 kW, 240 V	✓			
Pad Mounted Transformer 365 kVA, 12.47 kV – 240 V, Green oil filled transformer (biodegradable oil)	✓			
DC Load Center 380 VDC, 100–600A single-phase panel, NEMA 3R with meter and monitoring	✓		✓	✓
Solar DC Substation, 600 A main breaker and bus (4) or (5) 100 A breakers feeding home load centers		✓	✓	✓
AC Switchboard 240 V, 3-phase, 1000 A (7) 100 A breakers feeding home load centers (1) 1000 A breaker from PG&E	✓			
DC Electric Vehicle Distribution Panel	✓	✓	✓	✓
780 VDC Grid, 500 A		✓	✓	✓
780 VDC Grid, 250 A		✓	✓	✓
380 VDC Grid, 1000 A		✓	✓	✓
380 VDC Grid, 500 A		✓	✓	✓

Source: UC Berkeley

Central Plant Design

Equipment requirements for Scenarios 2 and 3

The microgrid will have the ability to provide power to the EcoBlock during power outages. It will accomplish this with a flywheel energy storage system from Amber Kinetics, connected to the DC power distribution system.

The flywheels will be connected in a parallel electrical circuit to increase the output available beyond the capabilities of a single unit. Energy from either the PV system or the utility will be used by the system to charge the flywheels, so that it can later be used when utility power is not available.

Currently, Amber Kinetics offers small 8 kW units that can provide backup for four hours. Future iterations, commercially available in time for the EcoBlock Phase 2 construction, will be larger, including the 40 kW unit that can provide backups for four hours. The 40 kW unit will be the model used in the EcoBlock system, and it will include three units in parallel, for a total of 120 kW of backup for four hours.

The 40 kW flywheels each require their own sub-grade utility vault of approximately 8 feet in diameter, 8 feet deep. The spacing is approximately 4 feet between utility vaults, so if the flywheels are arranged in a single row, they have a ground footprint of approximately 30 by 8 feet. This can be accommodated within the footprint of the central utility plant.

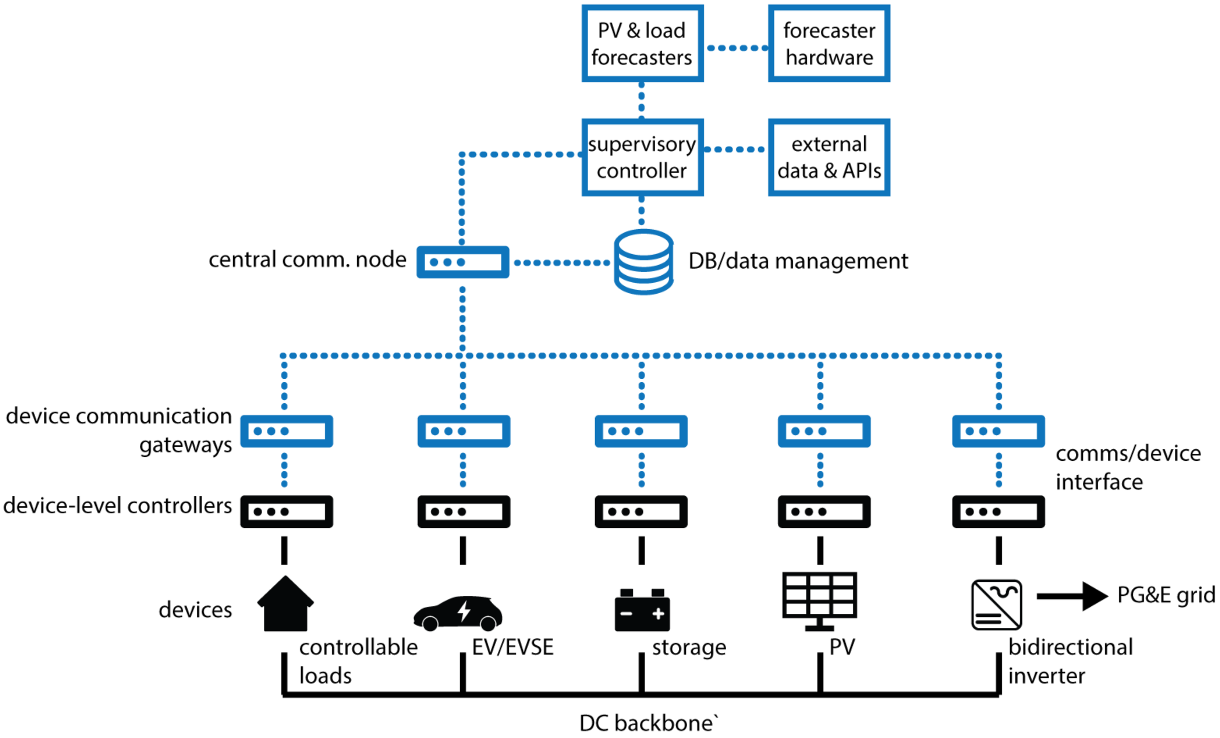
Microgrid Control Scheme

This section describes the microgrid control software architecture. The purpose of the control software is to manage the microgrid assets to achieve two objectives: (1) provide reliable electric power delivery, and (2) minimize operating cost. The control architecture is divided into two hierarchical levels, each with its own time scale. The control system also contains forecasting algorithms, a centralized database, and a web-based management and visualization platform.

Overview

As shown in Figure 3-10, the assets include the energy storage system (ESS), EV chargers, PV inverters, a grid-tied bidirectional converter, and controllable appliances.

Figure 3-10: Schematic of Control Architecture for an EcoBlock Microgrid



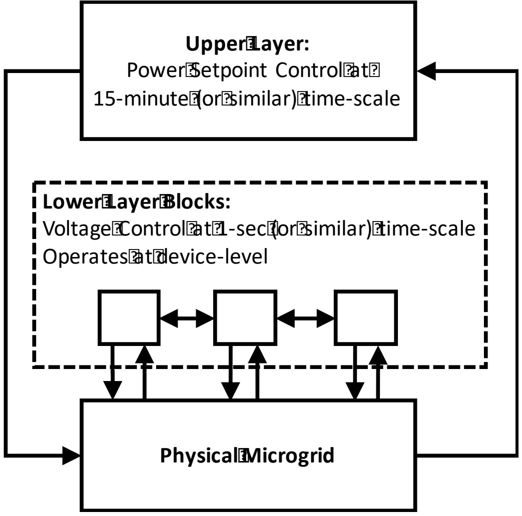
Source: UC Berkeley

Two-Layer Control Scheme

Figure 3-11 shows the hierarchical, two-layer control architecture. The upper layer provides power set-points for economic dispatch at a 15-minute (or similar) time scale. The lower layer provides distributed voltage control at the device level at a 1 second (or similar) time scale.

The role of the upper layer is to provide optimal economic dispatch for the microgrid assets. This achieves the second objective—economic power delivery—which is described above. That is, it provides power set points to each asset to minimize a given objective function, which could be economic cost for electricity imported from PG&E, marginal CO_2 emissions, or any other parameter of interest. This task is performed via a system of model-predictive control (MPC). The MPC algorithm solves a numerical optimization problem that finds the trajectory of asset power set points over a finite future time horizon (e.g., six hours), which minimizes the given objective function. Since the MPC incorporates a model of the microgrid power system over a future horizon, it requires forecasts of the PV power and loads (described next). The optimization is executed at each 15-minute time step over a finite forward horizon, so the MPC periodically re-plans the optimal trajectory of power set points as new measurements and forecasts become available. An example output of this upper layer is depicted in Figure 3-12.

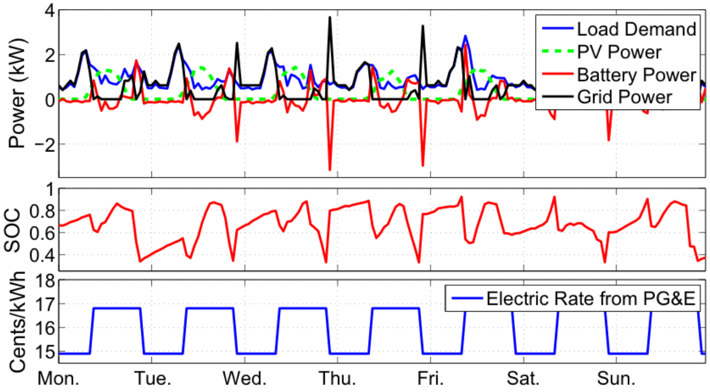
Figure 3-11: Schematic of Two-layer Control Architecture



Includes a centralized model predictive control (upper layer), and distributed voltage control (lower layer)

Source: UC Berkeley

Figure 3-12: Example Output of Power Setpoints From an Upper-layer Model Predictive Control Scheme to Minimize the PG&E Electricity Bill



Source: UC Berkeley

The role of the lower layer is to provide voltage control across the network. This achieves the first objective described above—reliable power delivery. The voltage control algorithms are distributed, and exist on or within each major component in the microgrid (particularly the battery charge controller, but also the other major power conversion equipment and major end-use loads). That is, each asset measures voltage locally and adjusts its power electronics duty ratios and/or loads to regulate voltage. Algorithmically, this is achieved with a simple closed-loop control using proportional integral (PI) controllers, yet the PI controllers have a distributed communication architecture to ensure network stability.

Forecasting Algorithms

The upper-layer MPC controller requires forecasts of three assets: PV generation, EV charging loads, and uncontrollable loads. Separate algorithms (and hardware in the case of PV) will be deployed for each.

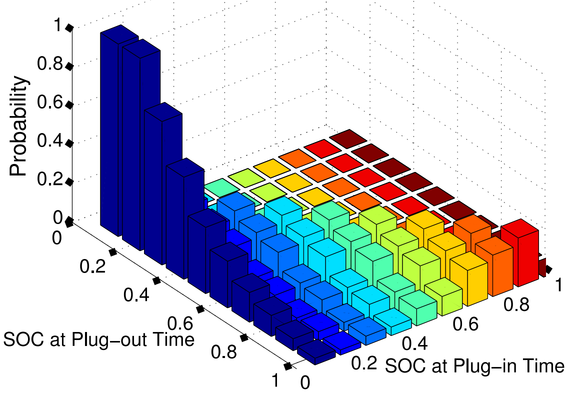
The PV forecaster is comprised of a microforecasting technology capable of predicting irradiance 5 to 300 seconds in advance. The microforecaster contains two components: far-infrared sensors for sky imaging (shown in Figure 3-13) and self-adaptive neural network algorithms for converting the images into power forecasts. Forecasting at short time scales is critical for capturing transient shading from clouds, which can cause rapid fluctuations in power generation and threaten power reliability.

The EV charging load forecasting engine is comprised of a stochastic process model—a Markov chain model—estimated using historical EV charging data. Figure 3-14 visualizes the probability of EV state-of-charge at plug-out, given the EV SOC at plug-in. Using this conditional probability distribution, one can compute the distribution of EV loads. This distribution of EV charging loads is then sent to the MPC forecasting algorithm for optimal economic dispatch.

Figure 3-13: Far-infrared Sensors for the Solar Micro Forecaster

Source: UC Berkeley

Figure 3-14: Probabilistic Model of EV Charging Load

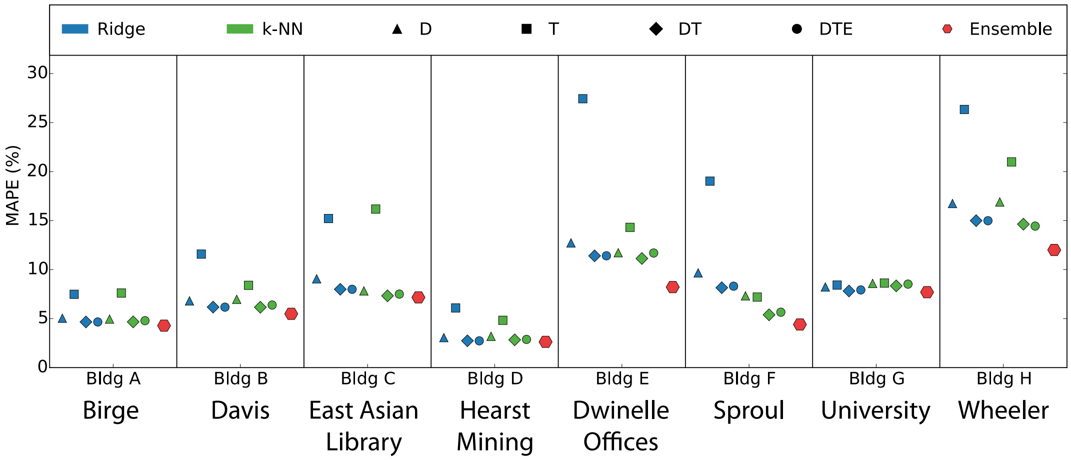


Given as conditional probability of state-of-charge at plug-out given state-of-charge at plug-in.

Source: UC Berkeley

Finally, the uncontrollable-load forecasting algorithm is comprised of a stacked ensemble learning method with moving horizon optimization. This algorithm trains multiple models to predict loads, given features such as time of day, day of week, ambient temperature, and more. Then, it computes a linear combination of these model outputs to generate the final load prediction. Importantly, the weights in the linear combination are reoptimized over a rolling retrospective horizon. This enables the load forecasting model to adapt to varying behavior over time. Sample results from several buildings at the UC Berkeley campus are provided in Figure 3-15, which visualizes the mean absolute percentage error (MAPE) compared to the true load. The red hexagons represent the ensemble approach. The other colored markers represent individual models. This visualizes an important differentiating advantage of the ensemble approach—it performs well across all building types and as well or better than individual forecasting models.

Figure 3-15: Mean Absolute Percent Error (MAPE) for the Ensemble Approach, Compared to Competing Individual Models



Mean absolute percent error for ensemble approach, across various buildings, compared to competing models.

Source: UC Berkeley

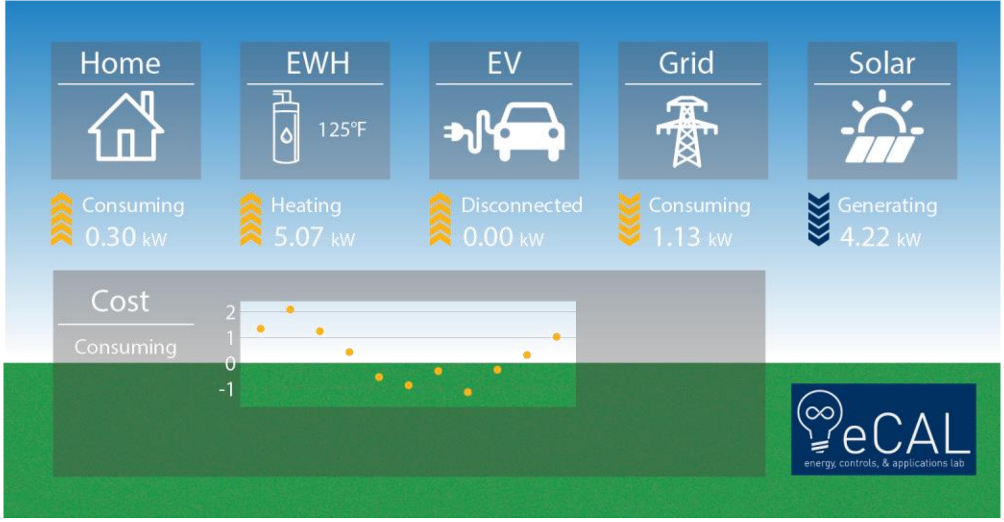
Database and User Interfaces

All measured data and actuated signals will be stored in a centralized database and organized into a tree structure to efficiently capture the hierarchical structure of the EcoBlock microgrid. The database structure was specifically designed for time-series data and control applications.

There will be two user interfaces designed for two different audiences: the Oakland EcoBlock microgrid manager and the Oakland EcoBlock residents. The Oakland EcoBlock microgrid manager will be a centralized interface to monitor and manage the entire microgrid operations. It will provide a global view of the historical, real-time, and forecasted power of each asset. Moreover, it will monitor voltage at measured nodes. This manager will be able to redirect power, adjust set points, tune automated control parameters, and troubleshoot any issues.

The Oakland EcoBlock residents themselves will be the second user interface. Unlike other microgrid demonstration projects, the Oakland EcoBlock will collect multiple building owners and ratepayers behind a single grid interconnection point, which is traditionally where the meter that generates utility bills resides. Because most or all of the residents' power will not be metered and billed by the utility, it is very important to provide feedback to the residents about their power utilization and economic benefits. For this reason, we will develop a smartphone/tablet-based app that provides a visual dashboard of their energy usage. A prototyped example is shown in Figure 3-16, which visualizes the power consumption or generation of each asset. On this dashboard, residents can track their home's real-time energy use, while understanding their cost savings. They can also opt-out of automated control of their controllable appliances.

Figure 3-16: Prototype Power Use Dashboard for EcoBlock Residents



Source: UC Berkeley

Summary

The EcoBlock microgrid control architecture will achieve two primary objectives: (1) reliable power delivery, and (2) economic power delivery. The two-layer architecture provides optimal economic dispatch to each asset to minimize cost, and regulates voltage to ensure reliable operation. Various forecasting technologies predict the PV, EV charging load, and uncontrollable loads for the model predictive control algorithm. Finally, a centralized database and user interfaces provide interfaces for monitoring and control to the microgrid electricity manager and EcoBlock residents.

Cost Estimating

The EcoBlock team worked with TBD Consultants to develop a cost estimate for construction of the Oakland EcoBlock, including the various energy and water scenarios outlined in the master plan. This cost estimate is based on standard industry practice, professional experience, and knowledge of the local construction market costs. The cost estimates should be viewed as rough estimates, because the EcoBlock design is still at the conceptual stage. In addition, there are many uncertainties in the material and labor costs, contractors' methods of establishing prices, and the market and bidding conditions at the time of construction. The bids received in the construction phase are likely to vary from these cost estimates.

This estimate includes block-level microgrid systems for the various scenarios in this master plan. Prices are based on local prevailing wage construction costs at the time the estimate was prepared, and assume a procurement process with competitive bidding for all sub-trades of the construction work, which is to mean a minimum of three bids for all subcontractors and materials/equipment suppliers. If fewer bids are solicited or received, prices can be expected to be higher. Conversely in the current competitive market should a larger number (i.e., six and above) of sub-bids be received, pricing can expected to be lower than the current estimate.

Subcontractor's markups are included in each line item unit price. Markups cover the cost of field overhead, home office overhead, and subcontractor's profit. Subcontractor's markups typically range from 15 percent to 25 percent of the unit price, depending on market conditions.

General Contractor's/Construction Manager's Site Requirement costs were calculated on a percentage basis. General Contractor's/Construction Manager's jobsite management costs were also calculated on a percentage basis.

- Site Requirements 6.0 percent
- Jobsite Management 5.0 percent
- Phasing 10.0 percent

General Contractor's/Construction Manager's overhead and fees are based on a percentage of the total direct costs plus general conditions, and cover the contractor's bond, insurance, site office overheads, and profit.

- Insurance and Bonding 1.5 percent
  - General Contractor Bonding
  - Subcontractor Bonding
  - Office of Self-Insurance Plans (OSIP)
- Fee (General Contractor Profit) 4.0 percent

A Design Contingency was included to cover scope that lacks definition and scope that is anticipated to be added to the design. As the design becomes more complete the Design Contingency will reduce.

- Design Contingency 15.0 percent

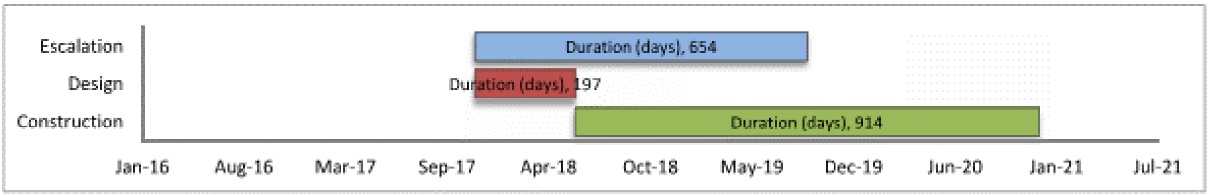
Escalation is required to the midpoint of construction, which for this project is assumed to be 27 months from November 2017.

- Escalation: 25.0 percent simple rate based on cumulative escalation over five years
  - Year 1 5.0 percent
  - Year 2 5.0 percent
  - Year 3 5.0 percent
  - Year 4 5.0 percent
  - Year 5 5.0 percent

Construction Schedule

Estimating the amount of cost escalation over the course of the construction project requires an assumption about the construction schedule. Figure 3-17 presents an expected duration of the project by phase. The blue block shows the assumed escalation period.

Figure 3-17: Construction Schedule



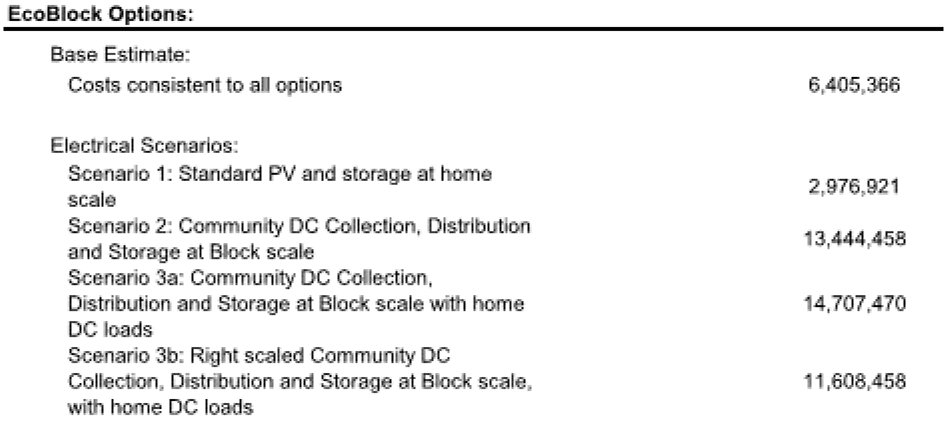
Construction Start Date	Jun-2018	Construction End Date	Dec-2020
Mid-date of Construction	Sep-2019	Construction Duration	30 months
Escalation Period	21 months		

Source: UC Berkeley

Cost Estimates

Using the equipment specifications defined earlier in Table 3-1 and the costing assumptions detailed above, the study team produced the estimated system costs presented in Table 3-2. Since this project is for a pilot demonstration and retrofit construction, these costs can be viewed as extremely conservative for the following reasons: (1) generous levels (40 percent) of contingency and escalation, (2) a generous construction schedule, (3) maximum construction assumptions for energy and water efficiency upgrades on every home, assuming the worst case, and (4) high-end equipment and installation costs for the PV, storage, and microgrid systems. These cost estimates should be seen as an upper boundary and not the actual costs that will be determined in Phase 2; nor should they be used to evaluate the "mature market" cost benefit for the project (see Chapter 8 for mature market estimates for the evaluation of project benefits). The cost details for Table 3-2 are provided in Appendix E.

Table 3-2: Cost Estimates



EcoBlock Options:	
Base Estimate:	
Costs consistent to all options	6,405,366
Electrical Scenarios:	
Scenario 1: Standard PV and storage at home scale	2,976,921
Scenario 2: Community DC Collection, Distribution and Storage at Block scale	13,444,458
Scenario 3a: Community DC Collection, Distribution and Storage at Block scale with home DC loads	14,707,470
Scenario 3b: Right scaled Community DC Collection, Distribution and Storage at Block scale, with home DC loads	11,608,458

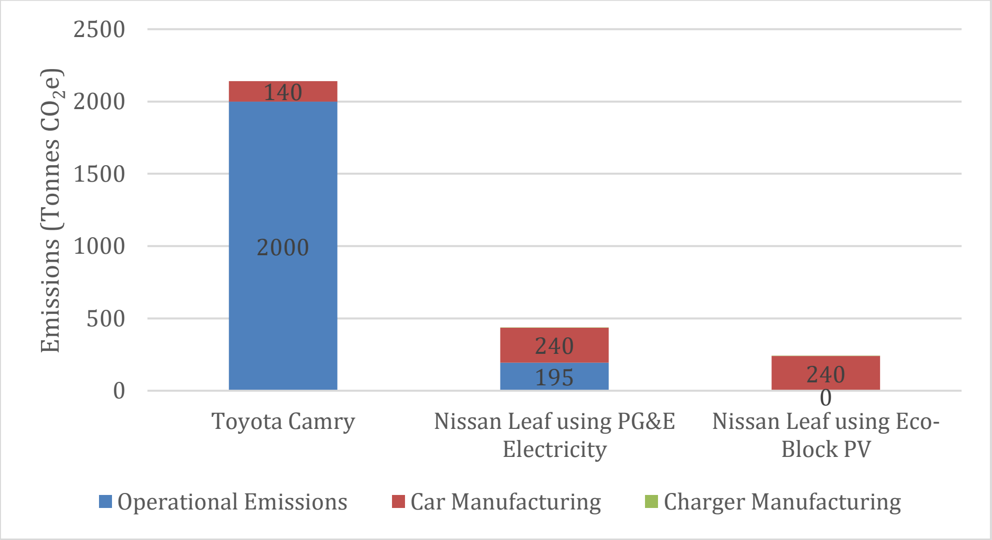
Source: UC Berkeley

Lifecycle Assessment

Lifecycle assessment is an analytical method that quantifies the environmental impacts of products throughout their lifecycle—from production, to use, to decommissioning and disposal. For the EcoBlock, the lifecycle greenhouse gas (GHG) impact will be dictated by both the embodied emissions of the added components needed to construct the microgrid and the corresponding reduction in operational emissions due to higher building efficiency, increased electrification, and on-site electricity generation/storage. In this assessment, we estimated the lifecycle GWP (global warming potential) of the microgrid, building efficiency retrofits, and the EV car-sharing system. The assessment assumes a planning horizon of 15 years. All PG&E electricity emission factors account for a changing, more renewable fuel mix over the 15-year planning horizon, based on PG&E and California Energy Commission projections.

For the EV car-sharing system the study team modeled 24 Nissan LEAFs split between 44 households with an average of about 17 miles driven per household per day. The DER-CAM analysis presented earlier indicates that the EcoBlock will be consuming more electricity on aggregate than it generates, thus we assume that the EVs are charged from PV-generated electricity 50 percent of the time and use PG&E electricity for the other 50 percent. Figure 3-18 shows the GWP benefits of the EV car-sharing system, irrespective of the method of charge.

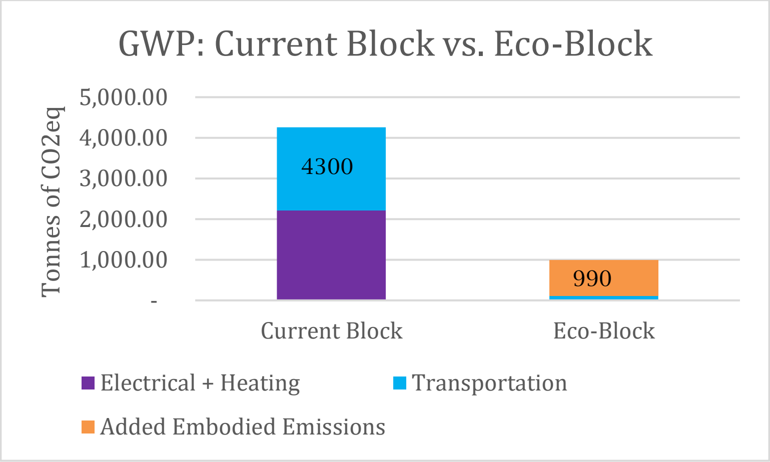
Figure 3-18: Lifecycle Emissions of the Transportation System



Source: UC Berkeley

After taking into account the embodied emissions of the added microgrid components, along with the operational emissions of home electricity use, space heating, and net-metered electricity, the team found that the EcoBlock would be responsible for four times less GHG emissions than the current block. Figure 3-19 shows the GHG contributions of each subsystem.

Figure 3-19: GWP of the EcoBlock Versus the Current Block



Source: UC Berkeley

To compare the current system to the EcoBlock, a few foundational assumptions had to be made. The assessment assumed that in both transportation systems the same number of miles were traveled: one with a 24 EV car-sharing system and one with independently owned gasoline vehicles. The only embodied emissions for the transportation system were those of the EVs and EV chargers—the existing gasoline vehicles were not considered to be an added environmental cost. The assessment also assumed that all EcoBlock homes use electric heating, whereas the current homes are assumed to use natural gas. Additionally, the avoided operational emissions due to power exported under net metering were subtracted from the EcoBlock's electricity consumption.

EcoBlock Micogrid Modeling in DER-CAM

Overview

The objective of this analysis was to support the design process of the EcoBlock system through the use of the microgrid optimization tool, the Distributed Energy Resources Customer Adoption Model (DER-CAM). DER-CAM was used to generate optimized recommendations for sizing and operation strategies of distributed energy resources (DERs) PV, stationary storage, and EV charging; quantify economic and environmental benefits; and assess the impact of uncertain inputs through extensive scenario analysis.

To accurately model the EcoBlock microgrid and the technical and economic environments in which it operates, a number of key inputs must be defined. These include electrical load profiles, electricity tariff, PV export rules and constraints, and EV fleet size and usage patterns. Each of these inputs has the potential to influence the optimal microgrid configuration. In some cases, definitive values for inputs are not yet known. To overcome the uncertainty this poses, the team used a sizing analysis that takes into account all likely scenarios to generate a range of optimal DER portfolios for the EcoBlock by optimizing each combination of inputs individually. Based on the team's expertise and expectations from communication with stakeholders, it reduced the range of recommended DER options to a single configuration that is expected to perform well over the range of possible operational conditions.

The following sections describe DER-CAM's modeling methodology, characterize scenarios for uncertain inputs, explore the outcome of the sizing analysis, describe the final DER-CAM recommended EcoBlock microgrid portfolio, quantify the benefits under typical conditions, and explore the resiliency performance of the final EcoBlock system. In contrast to the earlier discussion about the microgrid design, where the preferred option was selected as 50 percent of the homes, this DER-CAM analysis assumes that *all* the homes on the block receive energy retrofits and connect to the microgrid. The team made this assumption in order to quantify the full benefits from the block-scale system at complete implementation.

Based on the analysis outlined below, and given the uncertainty around external inputs, the DER-CAM recommended that DER capacities for the Oakland EcoBlock are:

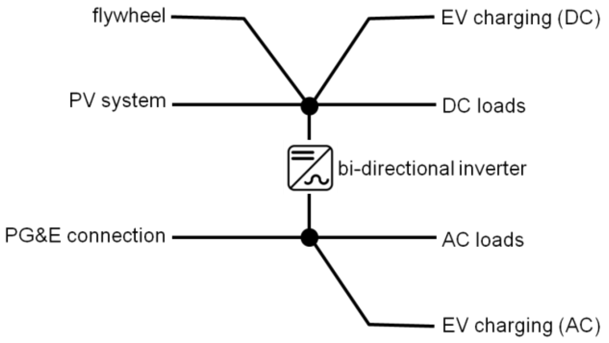
- PV: 215 kW
- Storage: 480 kilowatt-hours (kWh)

DER-CAM Methodology

The project team used the DER-CAM microgrid optimization and decision support tool to conduct the DER planning analysis. DER-CAM is a techno-economic model that optimizes the sizing and operations of microgrids and DERs to satisfy economic or environmental objectives. For this analysis, the team deployed DER-CAM to find economically optimal capacities for PV and storage systems at the Oakland EcoBlock, by taking into account capital costs for investment and annual energy savings from operation. To find the optimal solution, DER-CAM requires data to characterize a typical year of operation. Key input data consist of DER technical and cost inputs, load profiles, solar irradiation, electricity tariff details, EV characteristics and use patterns, and more. DER-CAM is capable of modeling multi-node energy systems and microgrids (Mashayekh et al. 2017).

For this analysis, a simplified approach was used, in which the team defined a two-node model of the Oakland EcoBlock system within DER-CAM. While DER-CAM is capable of modeling homes or metered loads as individual nodes, this level of granularity does not add much value to the analysis, as DERs are all connected and managed centrally in the EcoBlock concept. Instead, the AC and DC portions of the system are each aggregated into their own separate nodes. Figure 3-20 shows a schematic of this model configuration.

Figure 3-20: EcoBlock Microgrid Modeled as a Simplified Two-node System in DER-CAM



Source: UC Berkeley

By characterizing the system this way, model complexity was reduced while still capturing important system characteristics. Furthermore, this modeling approach did not rely on detailed definitions of microgrid network topology, allowing the team to apply it to assessing various topologies throughout Phase 1 of the project.

Under the two-node model configuration, DER components such as PV, storage, and EV chargers are connected to the DC node. The AC node connects to the PG&E grid. Loads are present on both sides, while a bidirectional converter connects the two nodes. Charging of EVs from the AC node is possible in this model, but not used in the following analysis.

For this EcoBlock microgrid analysis, the maximum allowable capacities are 500 kW PV and 480 kWh of storage. Storage can be adopted in 160 kWh increments, reflecting the discrete capacities of individual flywheel units. Storage is limited to four hours charge/discharge rates (i.e., 160 kWh of storage can charge and discharge at a maximum rate of 40 kW).

Scenario Analysis

To develop a comprehensive understanding of the drivers and constraints to DER adoption/operation within the EcoBlock, the team ran a large number of DER-CAM optimizations to assess the impact of a number of uncertain or variable inputs for electricity tariffs, PV export constraints, electric vehicles, AC/DC load split, and residential equipment retrofit level. These input scenarios are outlined below.

Electricity Tariff

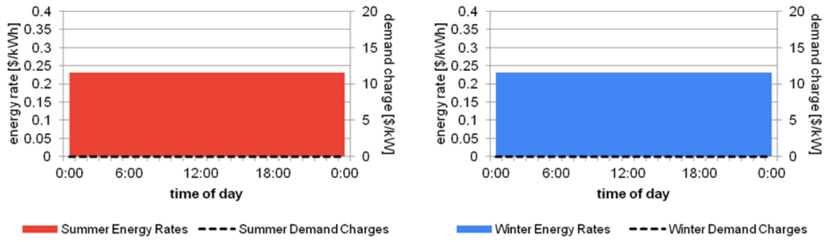
This analysis was first and foremost optimizing for cost, so it was important to determine the tariff under which the EcoBlock system would purchase electricity, as it will have a significant impact on DER deployment. While the EcoBlock is composed of residential loads, the centralized PV collection and storage resources, as well as the single utility connection for the entire microgrid, imply that the block will be transitioning from a group of individual residential customers to a single, commercial-scale customer. Consequently, it is not currently clear what tariff the system would be billed under (i.e., a purely residential tariff structure, a commercial tariff, or some in-between structure). To capture this uncertainty, a range of tariffs of increasing complexity were modeled, based on three real, current PG&E tariffs: E-1, E-6, and A-10.

- E-1: A flat-rate residential tariff with high, static volumetric energy rate
- E-6: A residential time-of-use (TOU) tariff with seasonal and time-of-day variable rates
- A-10: A commercial time-of-use tariff applicable to a commercial entity of comparable size as the Oakland EcoBlock. This tariff has time-variable energy rates, and seasonal monthly demand charges.

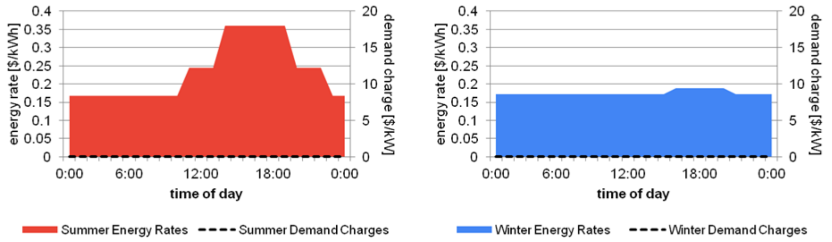
The rate structures Figure 3-21 illustrates these rate structures.

Figure 3-21: Tariff Rate Structures for Weekdays of Varying Complexity Applied to the Oakland EcoBlock DER Sizing Analysis

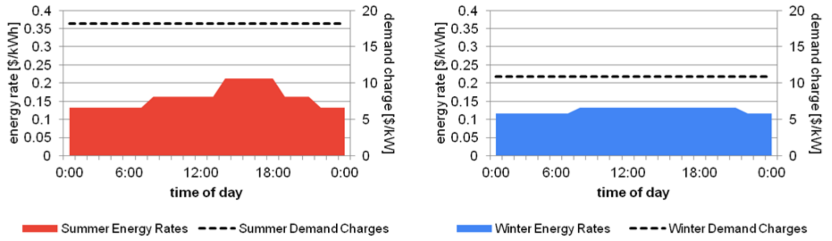
(a) E-1 flat residential tariff



(b) E-6 time-of-use residential tariff



(c) A-10 time-of-use commercial tariff with demand charges



Summer energy rates are shown in red, winter rates are shown in blue. Demand charges (where present) are shown as a dashed line.

Source: UC Berkeley

PV Export Constraints

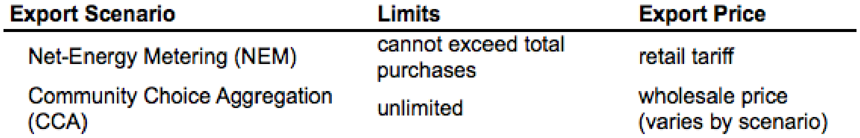
The characteristics of the Oakland EcoBlock's residential load profiles (i.e., lower occupancy and loads during the middle of the day) increases the potential for a mismatch between PV generation and the local load, especially during summer months when generation is high and loads (given no air conditioning) are low. This dynamic means that the constraints on when and how the EcoBlock can export excess PV generation back to the grid will significantly influence how the system is operated, and by extension how it will perform economically. For instance, limits on the amount of PV export, or low prices for exported energy, will mean that the economically optimal PV capacity will be smaller. Conversely, these constraints may increase the optimal capacity of storage, which serves to increase the amount of local load served by the PV-produced energy (i.e., by charging during high PV hours and discharging overnight). If export prices are dynamic, storage may be helpful in increasing export during high-priced hours. Furthermore, given the right incentives, storage can be helpful in mitigating spikes in exports that may have adverse impacts on the local distribution grid.

This analysis assumed that export would be allowed directly from the PV system, or indirectly from storage. Total allowed export amounts vary by scenario; however, in all scenarios total annual exports cannot exceed total annual PV generation. This constraint limits the amount of storage that can be used for price arbitrage (i.e., purchasing energy off-peak to export during high-priced hours).

The simplest export scenario to model is net energy metering (NEM). Under this scenario, electricity exports are compensated at the current retail electricity rate. This rate will depend on the specific tariff, time of day, day-type, and season. Under the NEM scenario, total annual exports cannot exceed total purchases, ensuring that annual net electricity energy costs cannot fall below zero.

In addition to NEM, the emergence of a local community choice aggregator (CCA) as a potential buyer for excess PV generation creates additional scenarios of interest. Under a CCA model EcoBlock electricity exports would be compensated at a rate to be negotiated with the CCA. Unlike NEM, under the CCA model used in this analysis, PV export is not limited to net-zero generation. Existing CCA rates for power purchases vary, and the rates for the CCA encompassing the Oakland EcoBlock's site have not been defined yet. Consequently, the team modeled several CCA rate scenarios, ranging from $50-$100 per megawatt-hour (MWh). These capture the range of rates based on cursory review of other existing CCAs in Marin and Sonoma counties, which offer a premium for power purchased from local solar resources. In addition to these flat-rate CCA scenarios, the team also modeled a dynamic-priced CCA rate using the California Independent System Operator's (CAISO's) Locational Marginal Prices (LMP).[15] CCA rates for PV generation are typically higher than the LMP, which is time variable, but typically below $40/MWh. The LMP CCA scenario therefore represents a lower bound for export revenue for EcoBlock exports. Table 3-3 summarizes each of the export scenarios.

Table 3-3: Scenarios Describing Limits and Prices for Export of PV Generation From the Oakland EcoBlock



Export Scenario	Limits	Export Price
Net-Energy Metering (NEM)	cannot exceed total purchases	retail tariff
Community Choice Aggregation (CCA)	unlimited	wholesale price (varies by scenario)

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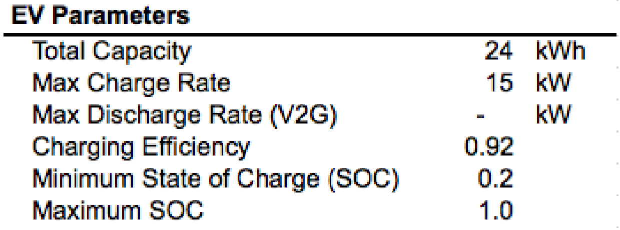
[15] California ISO. OASIS. http://oasis.caiso.com/mrioasis/logon.do

Source: UC Berkeley

Electric Vehicles

Electric vehicles add both additional load and load flexibility to the EcoBlock system. The number of EVs to be deployed, the technical characteristics (such as capacity and charge rates) of those vehicles and the charging stations, and their use patterns are not yet fully defined. For the sake of simplicity, this analysis assumed EVs are roughly equivalent to 2017 model Nissan LEAFs, with properties summarized in Table 3-4. Charging stations were assumed to be able to continuously control charging levels up to a maximum rate of 15 kW. The DER-CAM model allows for vehicle-to-grid (V2G) discharging[16] to support system objectives, though this functionality was not enabled for this EcoBlock analysis.

Table 3-4: Charging Properties of a Single EV as Modeled in DER-CAM



EV Parameters		
Total Capacity	24	kWh
Max Charge Rate	15	kW
Max Discharge Rate (V2G)	-	kW
Charging Efficiency	0.92	
Minimum State of Charge (SOC)	0.2	
Maximum SOC	1.0	

Source: UC Berkeley

The EV usage patterns will significantly impact when the EVs are connected to the system and how they can be charged. Specific data on vehicle usage by Oakland EcoBlock residents was not available for this analysis. Rather, typical trips were defined to represent broad categories of driving patterns. At this point, the ownership model of EVs within the EcoBlock has not been conclusively determined. Whether this model would resemble more private ownership or community car-sharing will impact how the EVs are used. This analysis used a mixture of models, with some trips resembling typical commuter hours, and shorter and more irregular trips resembling usage under a car-sharing model.

AC/DC Load Split

AC/DC load split refers to how much of the total load is served by the AC load panels, versus the DC load panels. Given the assumed efficiency (95 percent) for the bidirectional converter between the AC and DC nodes in the simplified model topology, early analysis of the system found that varying the AC/DC load split did not have a strong impact on the optimal DER sizing or operation. Consequently, a full analysis of this input has not been included here.

Residential Load-Equipment Retrofit Level

This analysis explores two scenarios that differ in the level of energy efficiency retrofit to the buildings and appliances within the EcoBlock. Scenario 1 represents a simple retrofit, composed of high-efficiency lighting, high-efficiency furnace, additional insulation, and other changes.

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[16] V2G charging allows bi-directional power flows between the vehicle and the grid.

Scenario 2 represents a deeper retrofit. In addition to the improvements outlined in Scenario 1, the deep retrofit includes a high efficiency water heater, updated appliances and new windows. Given the additional energy-efficiency improvements, Scenario 2 energy consumption and power demands are approximately 50 percent lower than loads under Scenario 1.

Scenario Summary

To summarize the information above, the major unknown inputs are:

- Electricity tariff
- PV export constraints and price
- EV fleet size
- Residential load-equipment retrofit level

Each of these input parameters potentially will affect the optimal DER capacities. Many cannot be determined at this moment or without input from external parties (such as PG&E, Alameda CCA, and others). The following parameters were selected as a "most-likely" case, which was used as a reference case. The impact of varying the settings of this reference case is explored in the following section.

- **Tariff**: A-10 commercial TOU tariff
- **Export**: CCA with flat purchase price of $70/MWh
- **EV fleet**: 24 LEAF equivalent electric vehicles
- **Residential Retrofit**: "Scenario 1e" retrofit load profiles

Monte Carlo Simulation

Objective of the Monte Carlo Simulation

The DER-CAM analysis presented earlier was used to optimize the design of the EcoBlock microgrid, assuming typical patterns of weather, residential load shapes, and EV charging. It also assumes perfect prior knowledge of these factors to allow optimal control of the energy assets. In reality, there is significant variation in these factors over time, as well as significant uncertainty in future conditions for which the microgrid controls need to optimize. To better understand how this uncertainty affects the performance of the microgrid, the study team performed a Monte Carlo simulation to quantify the performance of the PV, storage, and EVSE sizes produced by DER-CAM, under different environmental and usage conditions. The Monte Carlo simulation randomly generates sample house demand profiles, EVSE charging profiles, and solar generation profiles. From the randomly generated profiles it uses a basic decision model to optimize the use of electricity, minimizing energy cost and environmental impact. The performance metrics to be tested in this simulation were economic performance and energy performance. The economic performance is measured in electricity cost savings; the energy performance is measured in energy demand and energy generation.

Simulation Methodology

The Monte Carlo simulation is divided into two main components: (1) data generation and (2) simulation and control. The first program, data generation, is designed to address the stochastic nature of load generation and load demand by generating random scenarios of energy generation, house load demand profiles, and EVSE demand profiles. The second component of the Monte Carlo simulation, simulation and control, is design to make optimal decisions to control the assets (flywheel charging, EVSE fleet, and electricity from the grid) and to minimize cost.

Data Generation

The data are generated first by the Monte Carlo Simulator and then stored in one file with a protocol to access them, but to generate feasible random variables, we needed to have an idea of the statistical distributions of those variables. Thus, numerous real data was collected from the following sources:

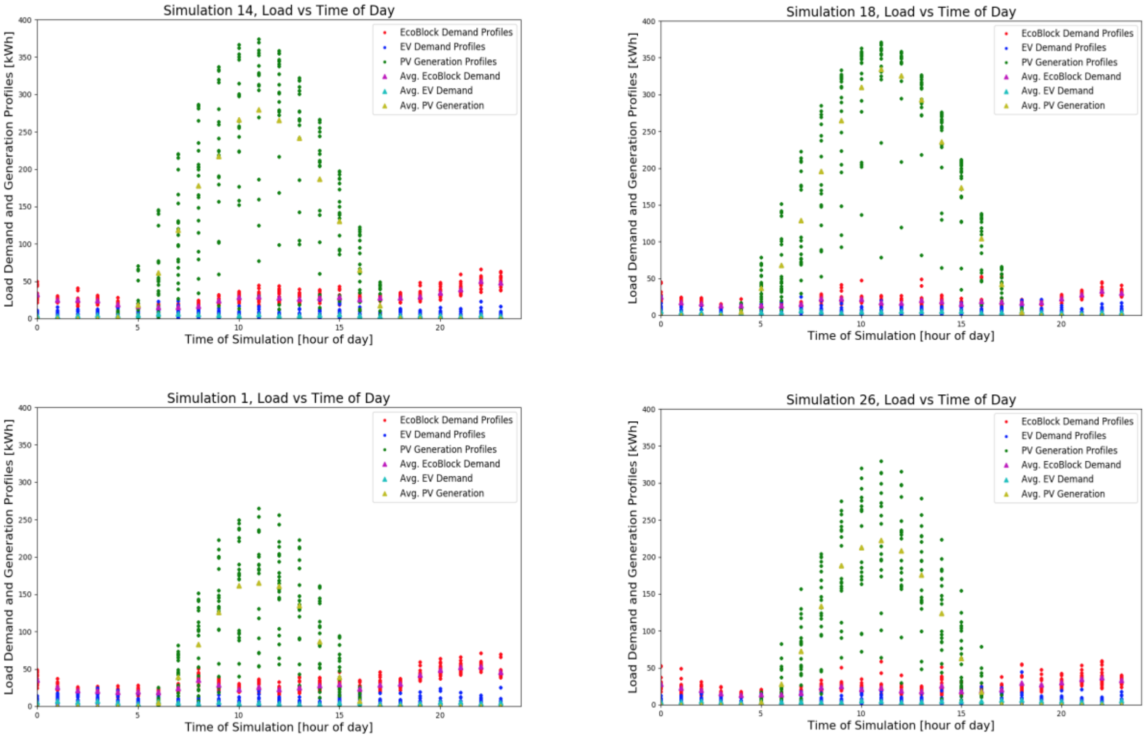
- **EcoBlock load demand profiles.** The project team periodically canvassed block residents, primarily to collect authorizations from them to release their utility data. The project team used various methods, including door-to-door canvassing, office hours, and cash incentives to collect the information. Twenty-three residents provided utility data to the project team via Utility API. The data that was gathered included historic electric consumption. The historic electric demand readings varied among residents, depending on when their service with PG&E started and when their smart meter was installed. For some residences, the team was able to obtain historic consumption in one-hour intervals, dating back to the first quarter of 2016.
- **EcoBlock EVSE load demand profiles.** The team used Pecan Street EVSE demand profile data to generate the EcoBlock EVSE fleet load demand profile. Pecan Street is a program focused on advancing university research and accelerating innovation in water and energy. The program is collecting considerable information of real consumption, including real EVSE load demand profiles. The team imported EVSE demand profiles for Pecan Street into the model, and from these profiles the model estimated the total EVSE demand of the 24-vehicle fleet proposed by DER-CAM.
- **PV generation.** This was computed by obtaining irradiance data from the National Renewable Energy Laboratory (NREL) and from Equation 1.

$$E=A*r*H*PR \qquad \text{(Eq. 1)}$$

Where:
E = energy produced in kilowatt-hours
A = solar panel area
r = solar panel yield efficiency (12 percent)
H = global horizontal irradiance per hour (data obtained from NREL)
PR = performance coefficient (60 percent)

The team generated and tested a total of 560 load-generation and load-demand profiles. To achieve heterogeneity, 28 different scenarios were analyzed with 20 simulations for each scenario. The scenarios were selected depending on different energy consumption and energy generation patterns in the data. An example of two different scenarios would be a 24-hour period during winter versus a 24-hour period during the summer. Figure 3-22 presents the results of the data generated from Simulation 1, Simulation 14, Simulation 18, and Simulation 26. Simulation 1 corresponds to a 24-hour period in winter, Simulation 14 corresponds to a 24-hour period in spring, Simulation 18 corresponds to a 24-hour period in summer, and Simulation 26 corresponds to a 24-hour period in fall.

Figure 3-22. Load vs. Time of Day for Four Simulations



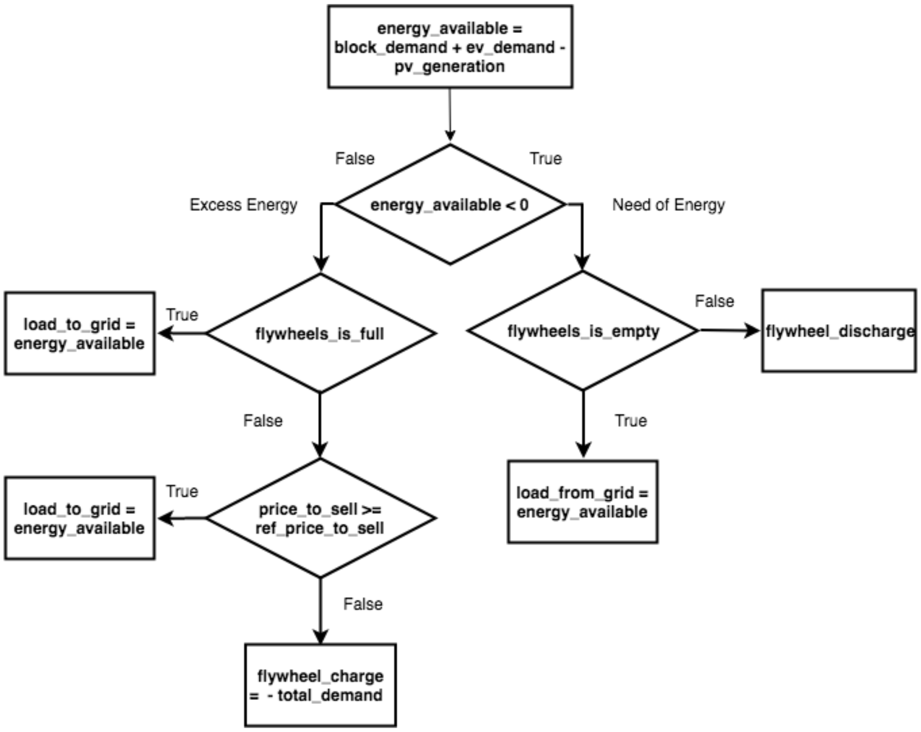
Green represents PV generation; red represents EcoBlock load demand, and blue represents EVSE fleet load demand. Simulations 1, 14, 18, and 26 correspond to 20 different scenarios performed for a 24-hour periods during winter, spring, summer, and fall, respectively.

Source: UC Berkeley

Simulation and Control

To conduct the analysis, a decision-making algorithm was used to balance supply and consumption at each hour. The main objective of the algorithm was to balance load demand by using PV generation, flywheel energy and, if needed, energy from the grid. Figure 3-23 illustrates the algorithm's control logic. The algorithm prioritizes the use of electricity generated by the PV array. This means that at every hour, the system will try to use the energy generated in the EcoBlock, regardless of the price of energy from the grid, thus minimizing environmental impact. If excess energy is produced, it will be stored in the flywheel for later use. Energy will be purchased from the grid when the PV generation and the available flywheel energy output are not able to satisfy the total energy demand.

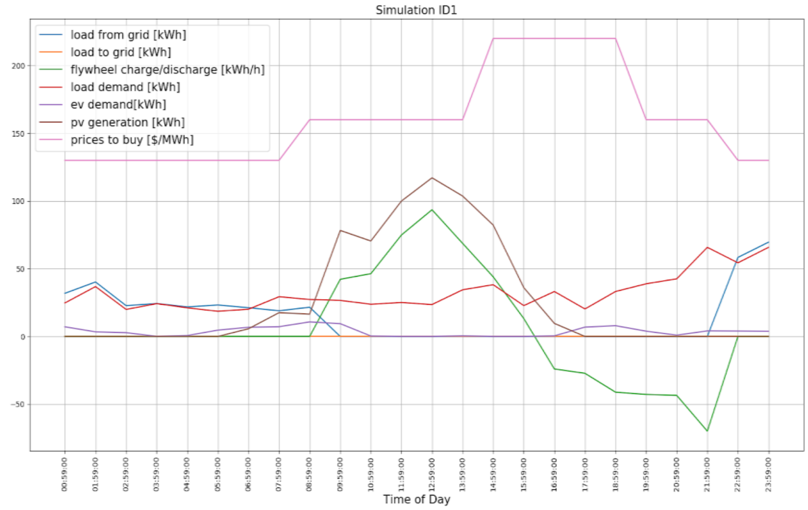
Figure 3-23. Control Scheme Overview



Source: UC Berkeley

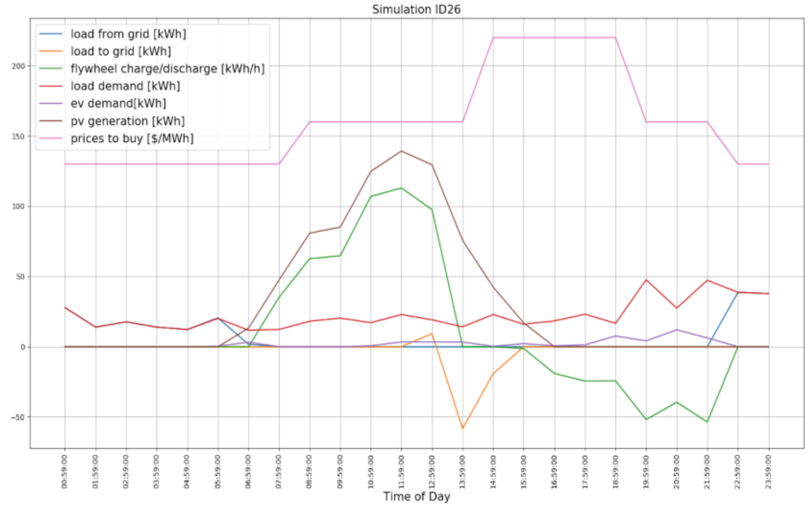
Each simulation was plotted and the results recorded in a database to obtain an aggregate set of results for the complete number of simulations performed. Figure 3-24 and Figure 3-25 represent the control scheme results for two of the 560 simulations performed. Figure 3-24 is a simulation performed during the winter and Figure 3-25 represents a simulation performed during the summer. At each hour the load demand from the houses and the load demand for the EVSEs was satisfied by using an aggregation of energy from PV generation, flywheel, and load from the grid. In the initial hours of the day, before energy from the sun is available for PV generation to start, all the electricity must be purchased from the grid. This follows the assumption that flywheel starts the simulation with no initial load. As PV generation starts, the energy purchased from the grid (load from grid) decreases. During days with enough solar radiation, the total energy demand is satisfied by PV generation and there is no need to purchase energy from the grid. As excess energy is available, the flywheel starts charging at a rate that increases as the available excess energy increases. In the simulation presented in Figure 3-25, the excess energy is sold as the flywheel reaches charge capacity. In both simulations presented below, the energy stored in the flywheel was used to satisfy the total load demand when PV production decreased. In both simulations, energy needed to be purchased at the end of the day, meaning that the energy stored in the flywheels was not able to satisfy the complete load demand or that price to buy energy from the grid was attractive enough to use energy from the grid.

Figure 3-24: 24-hour Stimulation During Winter



Source: UC Berkeley

Figure 3-25: 24-hour Stimulation During Summer

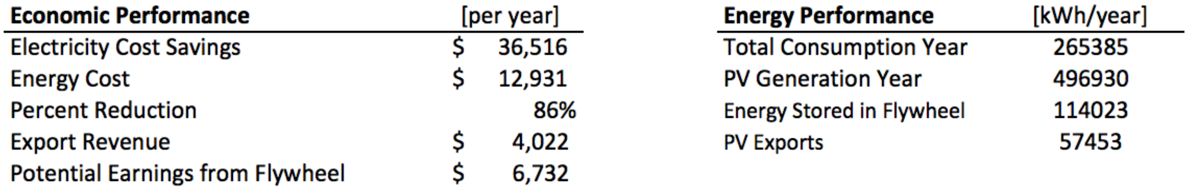


Source: UC Berkeley

Monte Carlo Analysis and Results

The objective of the Monte Carlo simulation was to comprehensively assess the performance of the PV, storage, and EVSE sizes produced by DER-CAM. To achieve the objective, the results of the simulation were recorded on a per-year basis and a per-day basis. The per-year basis was computed by normalizing the results of the 560 simulations into a calendar year. The per-day basis captured the different results obtained when performing the simulation during 24-hour periods in the different seasons of the year and presents the results as the average 24-hour period during the specific period of the year. Table 3-5 summarizes the results for the performance of EcoBlock on a per-year basis, and Table 3-6 summarizes results on a per-day basis.

Table 3-5. Economic Performance and Energy Performance on a Yearly Basis



Economic Performance	[per year]
Electricity Cost Savings	$ 36,516
Energy Cost	$ 12,931
Percent Reduction	86%
Export Revenue	$ 4,022
Potential Earnings from Flywheel	$ 6,732

Energy Performance	[kWh/year]
Total Consumption Year	265385
PV Generation Year	496930
Energy Stored in Flywheel	114023
PV Exports	57453

Source: UC Berkeley

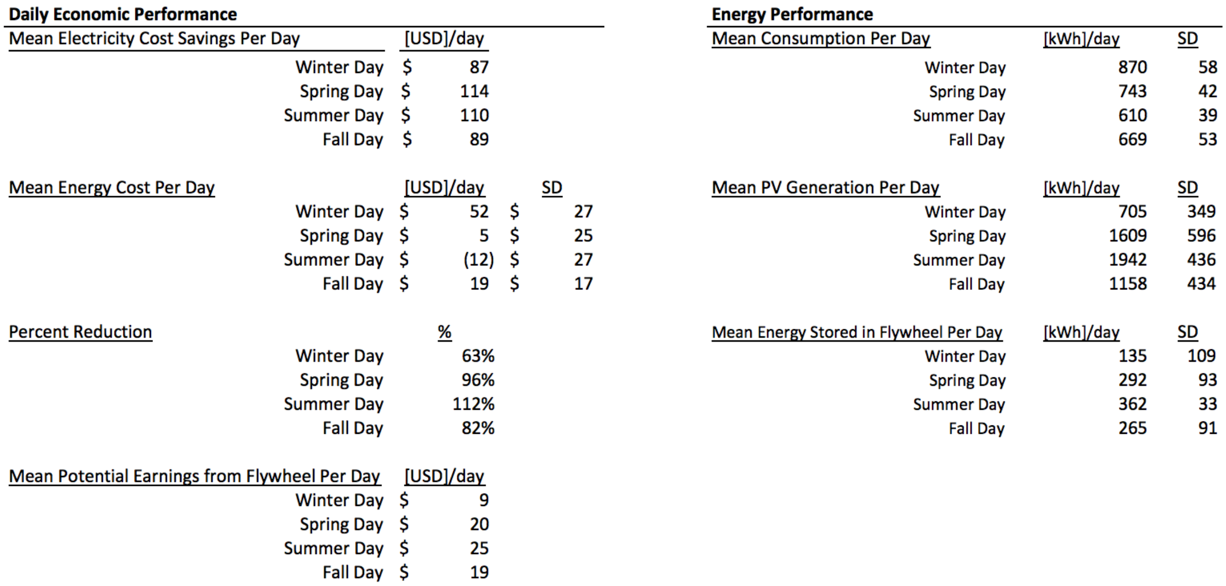
The economic performance of the EcoBlock's energy system is measured as electricity cost savings per year. The EcoBlock's economic performance is compared to a base case, which is the electricity cost of the EcoBlock without the PV generation and flywheel storage. The energy cost represents the cost of energy that needs to be purchased when energy stored and energy produced cannot satisfy total demand. The Export Revenue shows the total earnings from energy sold to the grid.

The energy performance is measured in energy demand, energy production, and energy stored for the total demand, PV generation, and flywheel charge, respectively. Total Consumption Year represents the aggregate house demand and the aggregate EVSE demand. It is worth mentioning that the Total Consumption Year was calculated using existing load demand readings from the smart meters in the EcoBlock, thus our estimates are valid for the existing conditions and not for projected demand after retrofits. An important difference between the retrofit scenario and the current EcoBlock is that the retrofit scenario will shift gas demand to electricity demand by replacing gas appliances with electric appliances. This would lead to an increase in electricity consumption that is not captured by our simulation.

Energy Stored in Flywheel and Potential Earnings from Flywheel captures the unaccounted performance in the form of energy not used and stored in the flywheel during each 24-hour simulation. In the functioning microgrid, energy would be carried to the next day and used as necessary but, since the simulation ends at the 24-hour mark, the energy that is not used represents an economic inefficiency in the simulation, as potential benefits could have been obtained from selling the electricity. Because of this, a decision had to be made on how to account for the excess energy stored in the flywheel at the end of the 24-hour period. Potential Earnings from Flywheel represents the total earnings that would be obtained if all the energy stored in the flywheel were sold before the simulation ended.

From the simulated scenarios, the EcoBlock's yearly economic performance represents a reduction in electricity charge close to $36,500. This represents an 86 percent reduction in the electricity tariff. Apart from the potential savings in energy cost, there is the potential to sell the excess energy in the flywheel at the end of each day, which would account to potential earnings of $6,700 per year. The electricity cost savings and revenue from energy sold to the grid come as a result of the PV generation being larger than the total grid demand. The excess energy is stored in the flywheel and used during the high energy cost periods of the day. This potential to store energy for later use provides a key economic benefit, as the system avoids purchasing electricity during points of the day with high electricity cost. Figures X2 and X3 demonstrate this benefit. At the high energy price moments during the day, when the cost of electricity from the grid is the highest, most of the electricity demand is satisfied from PV generation and flywheel energy. When the electricity price decreases to its lowest value, flywheel state-of-charge is low, and it is optimal to purchase electricity from the grid.

Table 3-6. Economic Performance and Energy Performance on a Typical 24-hour Period



Daily Economic Performance

Mean Electricity Cost Savings Per Day	[USD]/day
Winter Day	$ 87
Spring Day	$ 114
Summer Day	$ 110
Fall Day	$ 89

Mean Energy Cost Per Day	[USD]/day	SD
Winter Day	$ 52	$ 27
Spring Day	$ 5	$ 25
Summer Day	$ (12)	$ 27
Fall Day	$ 19	$ 17

Percent Reduction	%
Winter Day	63%
Spring Day	96%
Summer Day	112%
Fall Day	82%

Mean Potential Earnings from Flywheel Per Day	[USD]/day
Winter Day	$ 9
Spring Day	$ 20
Summer Day	$ 25
Fall Day	$ 19

Energy Performance

Mean Consumption Per Day	[kWh]/day	SD
Winter Day	870	58
Spring Day	743	42
Summer Day	610	39
Fall Day	669	53

Mean PV Generation Per Day	[kWh]/day	SD
Winter Day	705	349
Spring Day	1609	596
Summer Day	1942	436
Fall Day	1158	434

Mean Energy Stored in Flywheel Per Day	[kWh]/day	SD
Winter Day	135	109
Spring Day	292	93
Summer Day	362	33
Fall Day	265	91

Source: UC Berkeley

The Monte Carlo simulation lead to varying results, depending on the season when the 24-hour simulation was performed. In other words, the EcoBlock's economic and energy performance varies with the different seasons. During winter, we expect the system to have larger energy costs due to low PV generation and higher energy consumption. This leads to winter having the least favorable percent reduction in energy cost, at 63 percent. The mean energy available in the flywheel at the end of the simulation is also the lowest during the winter. In contrast, the economic performance is the highest during the summer. This comes as a result of having the highest mean energy generation and the lowest mean energy consumption. Flywheel charge available at the end of the simulation was also the highest during the summer months. During summer, savings of 112 percent are expected (which means earnings corresponding to 12 percent of daily energy cost). Spring and fall have 96 and 82 percent reduction in the total energy charge, respectively. The potential earnings from energy stored in the flywheel is comparable for the spring and fall months, with values of $20/day and $19/day, respectively.

The confidence intervals are summarized in the SD (standard deviation) column of Table 3-6. The main source of variance in the results are due to the difference in irradiance during the different seasons of the year. The standard deviation for energy generation ranges from 349 kilowatt-hours (kWh)/day to 596 kWh/day. These values correspond to the winter and spring periods, respectively. The variance in results from PV generation are expected as the weather forecast changes on a daily basis. The mean energy cost per day has a large variance when compared to other parameters. This is due to the difference in performance depending on

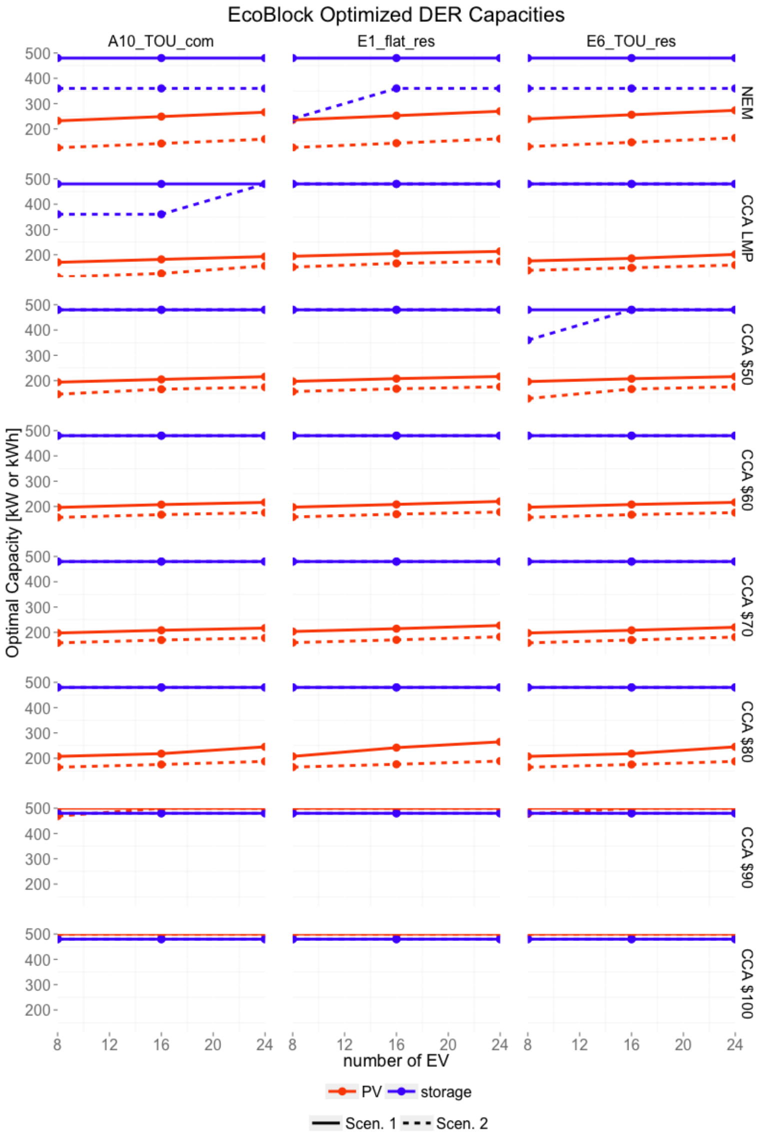
PV generation each day and the lack of a forecast algorithm that optimizes energy use. The results in the mean energy cost per day highlight the need to develop a microgrid control scheme that takes into account load demand forecast and weather forecast to optimize energy use during the day. Such a control scheme would optimize the use of the excess energy stored in the flywheel, to offset the variance in demand and energy generation in a daily basis. The benefit of a microgrid control scheme would increase reliability by offsetting extreme performance days.

DER Sizing Analysis

Optimal DER Capacities

For each permutation of tariff, export, and load input scenarios, a DER-CAM optimization was run to determine the optimal PV and storage capacities subject to all EcoBlock constraints. The optimal capacities from each run are shown in Figure 3-26. Optimal PV capacity (in kilowatts) is shown in orange, and optimal storage capacity (in kilowatt-hours) is shown in blue. Each column of subplots shows a different tariff scenario, while each row of plots shows a different export scenario.

Figure 3-26: Optimal DER Capacities for Each Tariff, Export, EV, and Equipment Retrofit Scenarios



As determined by DER-CAM optimization

Source: UC Berkeley

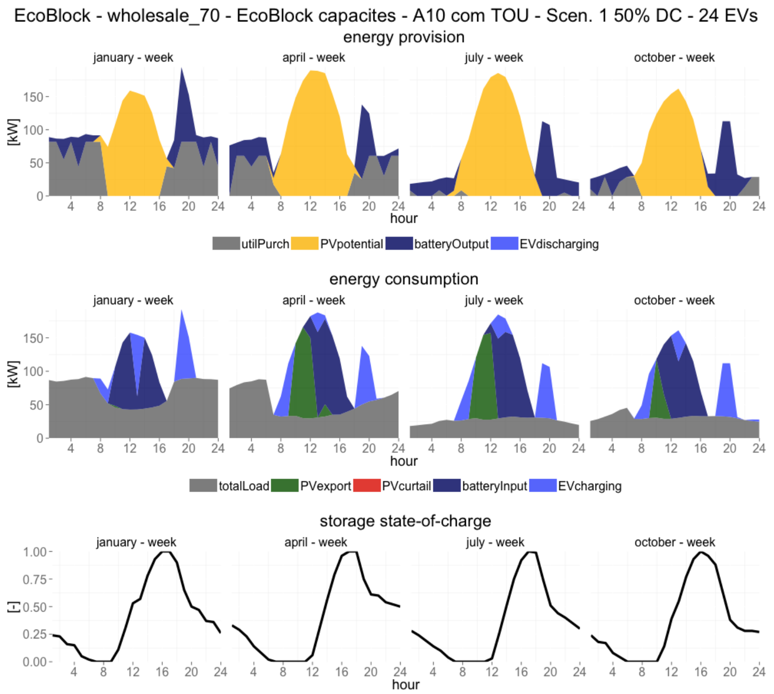
As these plots show, optimal DER capacities are not highly sensitive to the modeled tariffs (i.e., capacities do no change much column to column), nor to EV fleet size (i.e., plot lines are generally flat). In nearly every modeled scenario, the optimal number of flywheels is three (480 kWh). Given the discrete adoption constraints of storage, this is not unexpected. Optimal PV capacity, which can vary continuously, is generally between 200 and 300 kWh. Optimal PV capacity increases slightly as EV fleet size grows. It is also slightly higher for retrofit load Scenario 1 than for Scenario 2.

The largest impact on optimal DER capacities appears to come from the export scenario, and mostly affects PV capacity. For the low-price LMP scenario, the value of exported PV generation is reduced, so capacities are smaller. For CCA wholesale scenarios with prices between \$50–\$80/MWh, optimal capacities do not vary significantly. However, when the wholesale price exceeds \$90/MWh, the optimal PV capacity becomes the maximum allowed (500 kW). For prices below this, DER-CAM selected a capacity that reduces retail purchases and uses storage/export to manage midday over-generation. When prices exceed \$90/MWh, revenue from export alone is a strong enough incentive to drive increased investment in PV capacity.

Optimal Dispatch Profiles

Given significant differences in input values, it may be surprising that optimal DER capacities appear to change very little between scenarios. To understand the underlying reasons for this, it is helpful to inspect the hourly dispatch profiles for select days. A small subset of results is presented below to explore variations in each parameter. Hourly time series plots were generated for either energy supply or consumption within the EcoBlock. An example of these time series plots is given in Figure 3-27, which shows both energy supply (or “provision”) and consumption under the “most likely” reference case for typical weekdays during a month in each season of the year. Energy supply plots show the source of energy at each hour (with the abbreviated label in the legend of Figure 3-27): utility purchases (utilPurch), PV generation (PVpotential), battery discharging (batteryOutput), or EV discharging (EVdischarging). For this analysis, V2G discharging is not permitted. Energy consumption plots show the energy sink at each hour: building load (totalLoad), battery charging (batteryInput), EV charging (EVcharging), PV export to the grid (PVexport), and PV curtailment (PVcurtail). The last of these is PV energy that cannot be used locally nor exported.

Figure 3-27: Energy Provision and Consumption Profiles for the “Most Likely” Input Scenario



Note: utilPurch = utility purchases, Pvpotential = PV generation, batteryOutput = battery discharging, Evdischarging = EV discharging, totalLoad = building load, batteryInput = battery charging, Evcharging = EV charging, Pvexport = PV export to the grid, and Pvcurtail = PV curtailment.

A-10 tariff, $70/MWh export, 24 EVs, load retrofit Scenario 1.

Source: UC Berkeley

Figure 3-27 also includes a state-of-charge (SOC) profile for the flywheel during each of these days. SOC profiles are generally consistent across each scenario: storage is empty around mid-morning, when it is charged with excess PV generation until it is full or nearly full by mid-afternoon. Storage is then discharged to meet some or all building and EV loads in the evening and overnight, returning to empty by mid-morning. Given the consistency in this pattern across input scenarios, additional SOC profile plots are not included in this section.

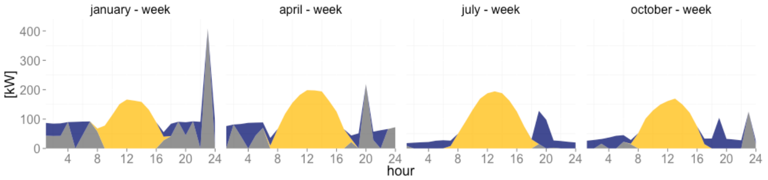
Input 1: Tariff

Across each tariff scenario, optimal PV capacity does not change significantly: 227 kW for the flat E-1 tariff, 220 kW for the residential TOU E-6 tariff, and 217 kW for the commercial TOU A-10 tariff. It appears there is some relationship between average energy rates and PV capacity; however, the time-variable rates of the E-6 and A-10 tariffs complicate this assessment. Optimal storage capacity remains a uniform 480 kWh across tariff scenarios. Figure 3-28 shows energy provision profiles for each tariff. Note that all other inputs remain the same as the “most-likely” case outlined above.

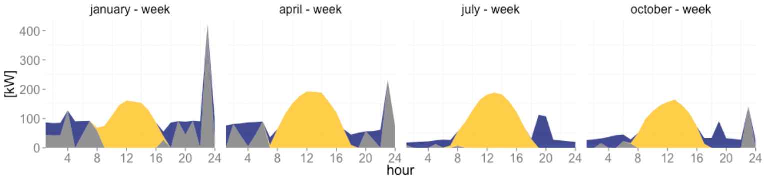
Figure 3-28: Hourly Energy Provision Profiles for Each Modeled Tariff

Energy Provision Profiles - Electricity Tariffs

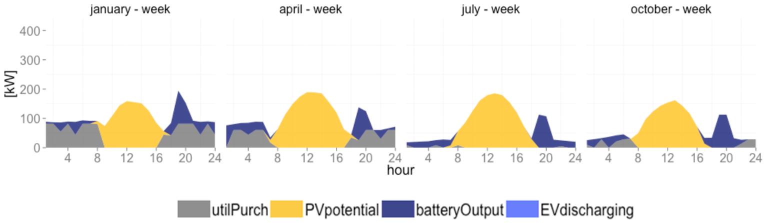
(a) E1 - flat residential tariff



(b) E6 - residential time-of-use tariff



(c) A10 - commercial time-of-use tariff with demand charges



Source: UC Berkeley

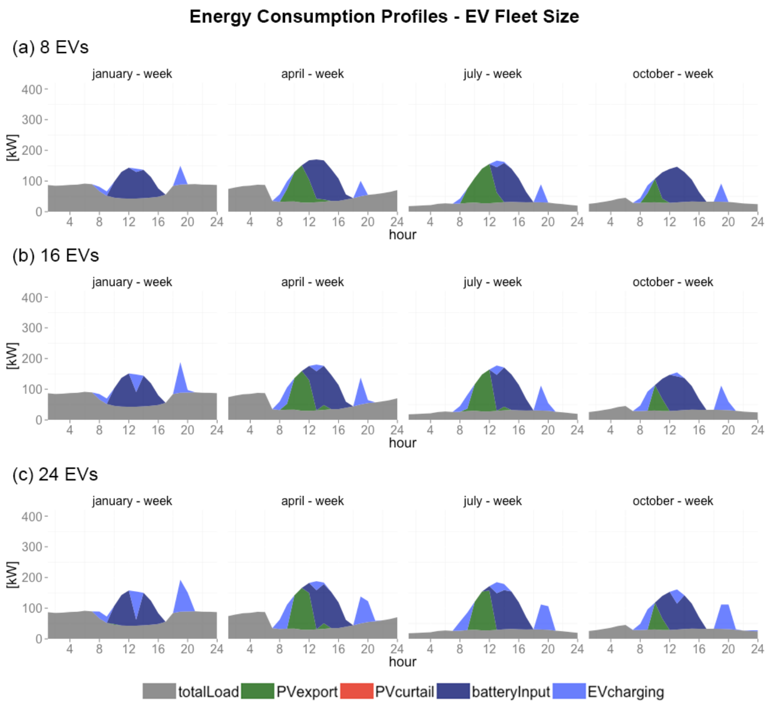
Examining these profiles shows the key differences in behavior between tariff scenarios, particularly related to when and how the EcoBlock purchases energy from the utility. In all scenarios, PV generation is adequate to meet all local loads during the middle of the day ("on-peak" hours for TOU tariffs). However, the presence of demand charges in the A-10 scenario (subplot c) drives the model to purchase electricity at a consistent, low level. Without this driver in the other scenarios, purchase spikes are observed late in the evening to charge EVs. In the A-10 case, EV charging is better distributed throughout the day. Storage is discharged to meet some off-peak loads during winter and nearly all off-peak loads during summer (when generation is high and loads are low).

Input 2: Electric Vehicles

Figure 3-29 shows hourly consumption profiles for EV scenarios with fleets of 8 (a), 16 (b), and 24 (c) vehicles. Varying fleet size across these scenarios does not impact optimal storage, and only slightly impacts optimal PV (8 EVs: 197 kW; 16 EVs: 208 kW; 24 EVs: 217 kW). The possible relationship between fleet size and PV capacity makes sense, as a larger fleet introduces larger charging loads. However, under the assumed usage patterns, charging for 24 EVs comprises only 20 percent of total consumption. This is evident in Figure 3-29, where the EV charging portion of the consumption plots changes between scenarios, and the changes are small relative to the building load profiles. Reducing the number of EVs to 8 represents about a 12 percent reduction in total consumption, and achieves a 9 percent reduction in optimal PV capacity.

Given the relative size of the building loads to the EV fleet considered, changes to EV charging appear to have only small impacts on the larger system performance.

Figure 3-29: Hourly Energy Consumption Profiles for Each Modeled EV Fleet



Source: UC Berkeley

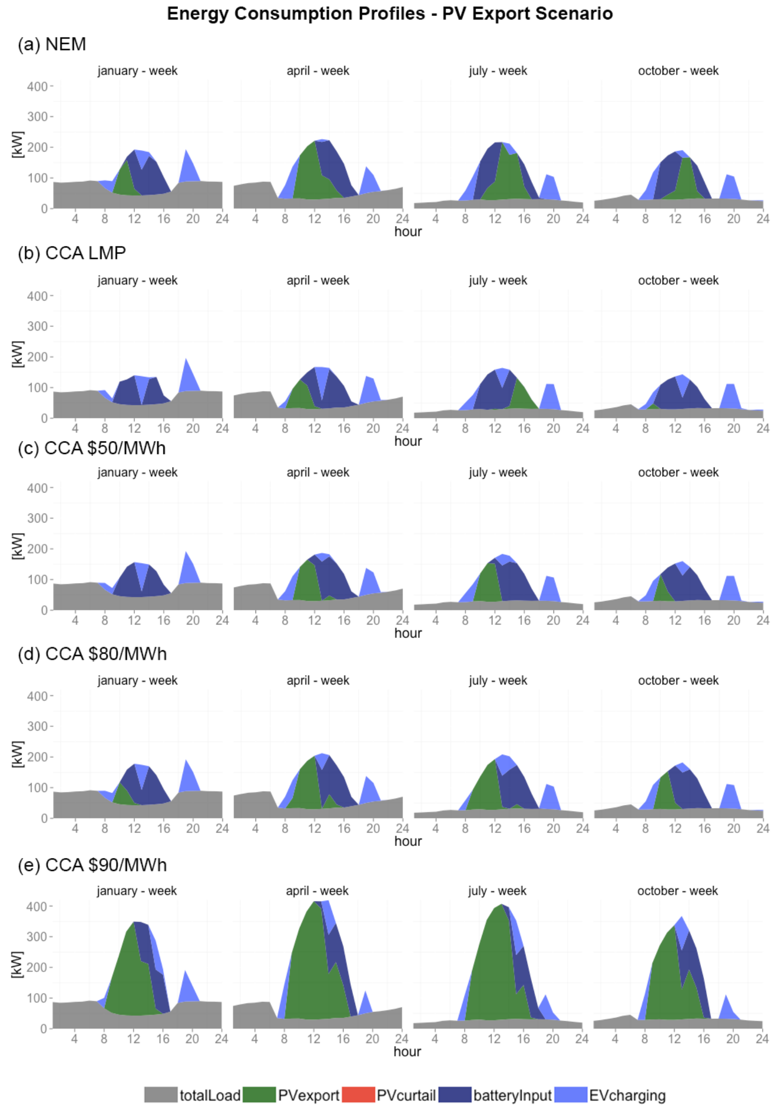
Input 3: PV Export

Figure 3-30 shows that the sizing decision within Oakland EcoBlock appears to be most sensitive to changes in the export scenario. This make sense, as changes to how PV exports are compensated and how much they are compensated will significantly impact the economically optimal PV capacity. Figure 3-26 shows the energy consumption profiles for a subset of the modeled export scenarios: NEM, and CCA models with prices of LMP (i.e., real-time marginal prices) and flat prices of $50, $80, or $90 per MWh.

Again, across each of these scenarios, the optimal storage capacity is 480 kWh. The PV capacities vary substantially across export scenarios. As stated earlier, PV capacity is selected as the maximum allowed when the wholesale price of PV export is sufficiently high, and thus is 500 kW in the $90 and $100 scenarios. PV capacity is also high under the NEM scenario (266 kW), because exported energy is compensated at retail prices. Effective NEM export prices are relatively high—$110 to $230 per MWh under the modeled tariffs—compared to CCA scenarios. However NEM exports are limited by total imports, and so an upper bound for economically feasible PV capacity exists below the technically maximum PV capacity that could be hosted at the EcoBlock site.

The capacity for \$50–\$70 scenarios are very similar (215–217 kW) and slightly higher for the \$80 scenario (245 kW). The LMP PV capacities are considerably lower (193 kW) due to the lower export price. As Figure 3-30 illustrates, the behavior for how PV generation is used does not vary much until export prices in the CCA model exceed a certain threshold. At that point optimal PV is sized almost exclusively to pursue revenue from energy exports, which dominate subplot e.

Figure 3-30: Hourly Energy Consumption Profiles for a Subset of Modeled Export Scenarios



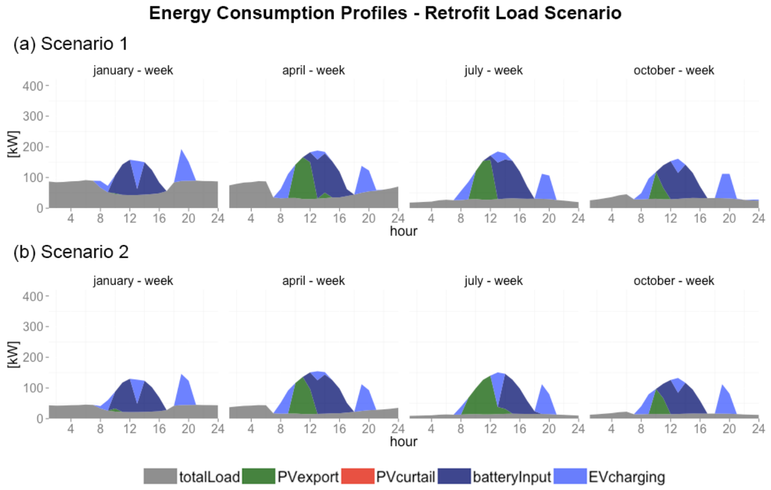
Source: UC Berkeley

Input 4: Residential Retrofits

Figure 3-31 shows the consumption profiles for each load scenario. The deeper retrofits of Scenario 2 produce a much lower overall load profile, and therefore result in a lower optimal PV capacity: 178 kW for Scenario 2 versus 217 kW for Scenario 1. In total, consumption (including EVs) under Scenario 2 is 40 percent lower than Scenario 1, while total PV generation is only

20 percent lower. Scenario 2, consequently, exports a higher fraction of its PV generation under these conditions. There are no other major differences in operation strategies between these load scenarios.

Figure 3-31: Hourly Energy Consumption Profiles for Load Scenarios



1 (standard retrofit) and 2 (deep retrofit).

Source: UC Berkeley

One significant difference due to load scenarios occurs under the NEM export scenario. Recall that under NEM, total energy exports cannot exceed total purchases per annum. Because total load (and therefore potential purchases) under load Scenario 2 are 40 percent lower than they are for Scenario 1, the opportunity for export is also 40 percent lower. Examining the NEM row in Figure 3-26, the optimal PV capacities for Scenario 2 are commensurately lower, given this constraint. Additional PV generation in this scenario could not be exported under the NEM rules (as defined in this analysis), and therefore would need to be curtailed. This obviously suboptimal behavior tightly constrains PV adoption in this case.

EcoBlock DER Capacity Selection

The analysis above is helpful in selecting a final DER portfolio that performs well across all the possible scenarios. Storage selection presents a simple decision: in nearly every scenario the DER-CAM optimization selected a 480 kWh system. Storage appears to be sized to allow for loads to be served by PV generation during off-peak evening and overnight hours. Only in some cases (see Figure 3-26) does the optimal storage system fall below this level, and only for the deep retrofit load Scenario 2.

Selecting the appropriate capacity for PV presents a more complicated decision, as PV sizes vary between 112 kW and 500 kW in the modeled scenarios. This range can be reduced by excluding some of the less realistic export scenarios. To be conservative, CCA export scenarios with very high prices (i.e., >$80 per MWh) are unlikely to accurately represent the long-term operational landscape for the Oakland EcoBlock. Without such scenarios, the upper bound is now 275 kW. The lower end of the range corresponds to scenarios with both low load (Scenario 2) and small EV fleets (8 EVs). If these scenarios are put aside, the median optimal PV capacity across remaining scenarios is 215 kW. Examining the range of optimal systems in Figure 3-26, this appears to be a reasonable selection, given the uncertainty in inputs.

Optimal EcoBlock DERs

With DER capacities selected, a full accounting of the benefits of the EcoBlock microgrid system can be quantified based on results from DER-CAM. The following tables include summary metrics for DER capital investment (Table 3-7), annual energy costs (Table 3-8), energy and demand performance (Table 3-9), and microgrid carbon dioxide (CO_2) emissions (Table 3-10). These are the results from the DER capacities selected above and applied to the "most likely" reference case.

Table 3-7 simply shows the capital costs for the selected DER capacities.

Table 3-7: Capital Costs for DER Deployment Based on Selected Capacities

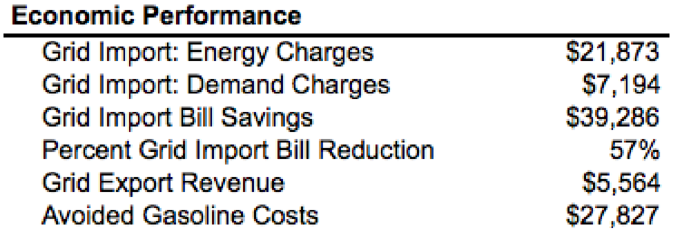
DER Capital Cost	
PV	$752,500
Storage	$180,000

Source: UC Berkeley

To translate these capital costs into a cost of power from the EcoBlock microgrid, the analysis used DER-CAM to calculate an annualized DER cost, based on variable investment costs ($3500 per kW PV, and $375 per kWh storage), assumed lifetimes, interest rate, and operations and maintenance costs. The annualized DER cost was then divided by the annual production to derive a cost per kilowatt-hour for the EcoBlock power.

The Oakland EcoBlock's proposed DER portfolio would allow it to reduce costs through a number of operational strategies: self-generation with PV, energy arbitrage when rate differences are present, demand management when demand charges are present, reduction in transportation fuel costs through smart EV charging, and revenue for exporting excess PV. DER-CAM optimized each of these strategies holistically to create an operations strategy that minimizes total costs. The results of this strategy are given in Table 3-8, representing the impact of the DER portfolio applied to the block after the homes have had energy retrofits and electrification of major end uses. As the table shows, the DER are capable of reducing electricity costs by nearly $40,000 per year versus the same load profile served only by a utility connection, representing a 57 percent cost reduction. In addition to these savings, the EcoBlock system also would generate over $5,000 in revenue from PV exports, and with the replacement of 24 vehicles with EVs, reduce annual gasoline costs by nearly $30,000. Note that this analysis assumes 30 miles per gallon for the vehicles being replaced, and gasoline costs of $3 per gallon, which generates a conservative estimate for this savings figure.

Table 3-8: Annual DER Energy Cost Performance Metrics



Economic Performance	
Grid Import: Energy Charges	$21,873
Grid Import: Demand Charges	$7,194
Grid Import Bill Savings	$39,286
Percent Grid Import Bill Reduction	57%
Grid Export Revenue	$5,564
Avoided Gasoline Costs	$27,827

Source: UC Berkeley

The energy performance of the Oakland EcoBlock can be explored in the energy consumption and provision metrics of Table 3-9. Total annual electricity consumption, which includes EV charging, is approximately 500 MWh, while total generation from the PV array is approximately 444 MWh. This means that 87 percent of the EcoBlock's electricity demand could be supplied by the PV arrays (which can also be expressed as a "provision-to-consumption ratio" of 0.87). Note that this metric relates indirectly to EcoBlock's zero net energy (ZNE) performance, but is not a direct measure of ZNE, because the boundaries do not include all energy consumption within the block (such as remaining internal combustion vehicles).

Examining the end-use destinations for PV generation, it appears that a large fraction (82 percent) would be used locally, while the remaining fraction would be exported. Exports would largely occur during summer and fall seasons, when insolation is high but total loads are low. In winter, when electric heating loads increase and insolation falls, there typically would not be much excess generation for export.

Table 3-9 also shows changes to peak demand. Recall that in the "most likely" scenario, the tariff (A-10) includes a demand charge. As such, the microgrid controller would be incentivized to reduce peak demand levels. Table 3-9 shows a peak observed demand of 93 kW—or 20 kW lower than the same loads without DERs. Note that the no DER case also does not include EVs, meaning that the EcoBlock microgrid would be able to reduce peak demand by nearly 20 percent while also adding charging loads from 24 EVs.

Peak demand under tariffs without demand charges is likely to be higher than in the A-10 tariff scenario. See Figure 3-28 for evidence of this. It should be clear, however, from the results of the "most likely" scenario, that the EcoBlock system has adequate capability to eliminate demand spikes when the right incentives are present.

Table 3-9: Annual DER Energy and Demand Performance Metrics

Energy Performance		
Total Consumption by Homes and EVs	509	MWh
PV Total Generation	444	MWh
PV Used On-site	365	MWh
PV Exports to Grid	79	MWh
PV Curtailment	0	MWh
PV Utilization Fraction	1.00	
Provision-to-Consumption Ratio	0.87	
Peak Demand for Grid Import	93	kW
Peak Demand Reduction	-20	kW

Source: UC Berkeley

Finally, the changes to CO_2 emissions from the Oakland EcoBlock microgrid deployment are outlined in Table 3-10 and Figure 3-32. Reductions in emissions from the homes would be caused by three factors: (1) consumption reductions due to efficiency measures, (2) substituting electricity for space and water heating currently powered by natural gas, and (3) replacement of most PG&E-supplied electricity with PV generation on site. Here, the carbon intensity of the replaced electricity was assumed to be 0.28 kilograms (kg) CO_2 per kWh, which is a standard value used by the California Energy Commission. For vehicles, reductions in emissions from gasoline would be due to a substitution in vehicle miles traveled from internal combustion vehicles to EVs. The carbon intensity of gasoline was assumed to be 8.89 kg CO_2 per gallon.[17] The conversion to EV charging from the Oakland EcoBlock microgrid would reduce the CO_2 emissions from passenger vehicles on the EcoBlock by about one-third. Additional reductions would be due to export of excess PV generation, which would replace generation originating from the grid. If we assume that the 24-vehicle EV fleet would replace all the conventional vehicles at the Oakland EcoBlock site, then this system would produce a 61 percent reduction in CO_2 emission from onsite energy use. If the EV fleet only replaced some fraction of the total transportation needs, then the percentage reduction in CO_2 would be smaller.

Table 3-10: Annual EcoBlock Microgrid CO_2 Emissions Performance Metrics

Emissions Reductions		
Electricity	92	MT CO^2
Natural Gas	158	MT CO^2
Gasoline (Autos)	82	MT CO^2
Grid Export—Offset Grid Power	22	MT CO^2

Source: UC Berkeley

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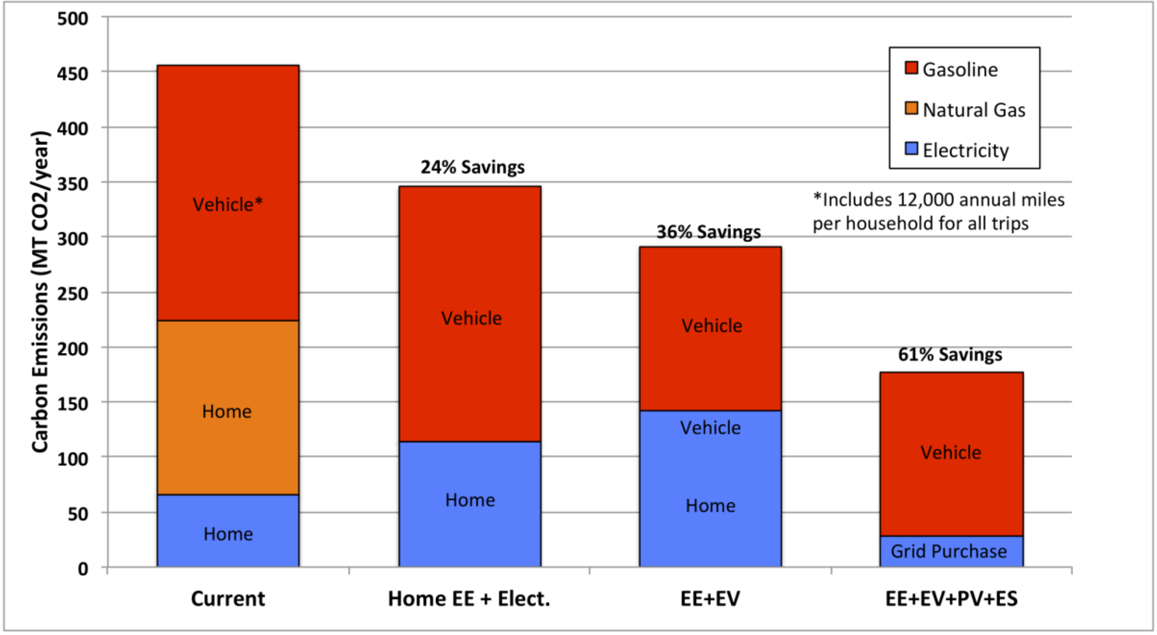
[17] Energy Information Administration (https://www.eia.gov/tools/faqs/faq.php?id=307&t=11).

Figure 3-32: Annual CO_2 Reductions Including All fuels (Electricity, Natural Gas, Gasoline)



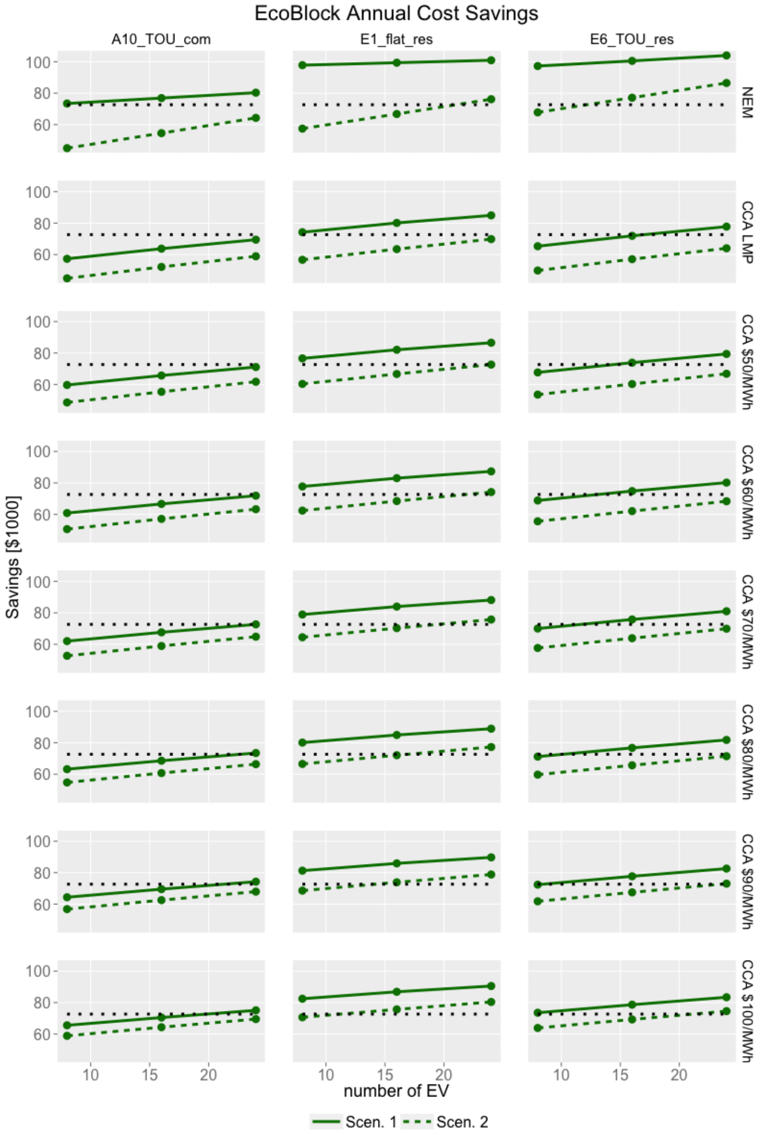
Source: UC Berkeley

Performance Under Varied Inputs

The values above represent only the performance of the selected DER portfolio under the inputs of the “most likely” scenario. However it is entirely possible that this exact scenario is not the one the Oakland EcoBlock will face when deployed. As such, it is important to understand how the selected DER portfolio might perform under different circumstances.

From a technical perspective, the system is capable of achieving the same level of energy and emissions performance, given that the same capacities of generation and storage are present. Economic performance is likely to be the most varied if conditions change. To explore this, the team generated Figure 3-33 to show the annual net cost savings for each tariff, export, EV fleet, and load scenario discussed in this analysis. This metric includes electricity cost reduction, PV export revenue, and avoided fuel costs from EVs versus the same conditions without DERs or EVs. The savings estimate from the “most likely” scenario is also plotted for reference in each subplot, to show whether savings increase or decrease under the specific conditions.

Figure 3-33: Annual Net Cost Savings From DER Deployment



Includes electricity costs savings, PV export revenue, and avoided fuel costs from EVs. Dotted lines indicate annual net savings under the "most likely" reference case.

Source: UC Berkeley

Net savings increase with the size of the EV fleet, due to increased avoided fuel costs. Under every scenario, charging EVs—either from PV generation or utility electricity–is lower cost than the assumed cost of gasoline on a mileage basis. Recall from Table 3-8 that roughly 37 percent of net annual cost savings come from avoided fuel costs from EVs.

Savings are also higher for the higher load Scenario 1, since a larger fraction of PV generation can be used to replace utility purchases, which has higher value per kilowatt-hour than export in most cases. Net savings also increase as export prices increase under CCA export models. Finally, savings appear to be highest under the flat-rate (E-1) tariff, then somewhat lower for the residential TOU (E-6) tariff, and then lowest for the commercial TOU (A-10) tariff. This order corresponds to a highest to lowest ranking of average energy rates.

If EV fleet size were held constant at the reference value of 24 vehicles, annual net savings would be pretty consistent: $69,000–$104,000 (median: $81,000) for retrofit Scenario 1, and $59,000–$87,000 (median: $70,000) for retrofit Scenario 2. This indicates that the DER capacities selected for EcoBlock are expected to perform reasonably well economically for nearly all of the potential circumstances in which it might be deployed.

Resiliency Performance

In addition to the economic and environmental benefits outlined above, the EcoBlock system also provides the value of improved reliability and resiliency for residents on the block. An EcoBlock with the DER capacities outlined above is capable of serving some or all local loads without disruption in the event of a grid outage, due to its microgrid capability. Utility availability in the area is generally very good, so under typical conditions the potential value of this functionality is limited. However, in the event of a prolonged and unexpected outage, such as from a natural disaster, the EcoBlock system could provide significant and potentially life-saving benefits to residents by serving critical loads through the duration of such outages. The key questions for EcoBlock design and operations are:

- How does the system perform in the event of unplanned outage?
- How long can the system serve local loads without a connection to the grid?
- When and how does the system fail during an outage?
- How do typical operation strategies affect the EcoBlock resiliency potential?
- How should these strategies be modified to increase resiliency?

While DER-CAM is well suited to characterize the optimal performance of DER under typical conditions, where loads and PV output can be predicted with reasonable accuracy and grid availability can be assumed. However, DER-CAM's use on typical conditions and foreknowledge of operational conditions makes it less appropriate to assess the performance of the EcoBlock microgrid in the event of a prolonged and unexpected outage.[18] Despite this limitation, the results from DER-CAM optimizations using the final EcoBlock configuration are a helpful resource in addressing the research questions above. While the results presented earlier assume 100 percent grid availability, outages can be introduced into the time series DER-CAM results to assess the outage performance when the EcoBlock system is forced to deviate from the typical, grid-connected operations strategy. The following sections explore the details of the modeling methodology and results.

Key findings from this analysis show that based on the operation strategies generated by DER-CAM, the EcoBlock is at risk of failure for outages that begin or extend to early morning hours. This is likely due to low PV output and high thermal loads at these times. Load flexibility or

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[18] Note that DER-CAM is capable of considering the possibility of short, unplanned outages and maintaining adequate reserves to sustain operations for outages of a defined length. This functionality is better applicable to outages of shorter lengths and has not been applied to this analysis of prolonged outages.

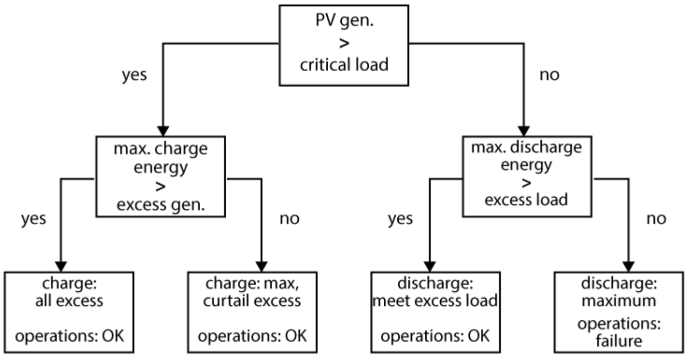
additional supply resources such as EVs could alleviate these risks by reducing the imbalance between energy supply and demand. Energy storage dispatch strategies under typical conditions could be modified to ensure higher level of reserves are maintained, however this will reduce overall microgrid performance during normal operation by decreasing the amount of PV power consumed onsite and increasing the amount of imported power. Outside of the early morning/late evening, the Oakland EcoBlock system typically would be capable of weathering outages ranging from tens of hours to multiple days in length. Furthermore, if critical loads can be reduced at critical moments, the EcoBlock would be capable of serving 79–99 percent of hours of a weeklong outage.

Outage Analysis Methodology

To conduct the outage analysis, unplanned outages were introduced into the time series results from DER-CAM for the final EcoBlock DER capacities (215 kW PV, 480 kWh storage). Using an external control logic, storage would be dispatched to balance supply and consumption of energy at each hour. Figure 3-34 illustrates the simple control logic used. For any hour where the system would be incapable of supplying the full hourly load, the system would be considered to have failed. The total successful hours up to that point would be logged as the maximum outage length (MOL) under the specific conditions. The team explored the following parameters related to the occurrence and conditions of the outage:

- Month or season
- Day of week
- Hour of day
- Type of week
- Critical loads

Figure 3-34: Schematic of System Control Logic Applied to Outage Operations of Storage



Note that maximum charging and discharging energy are constrained by both available energy and maximum charging rates.

Source: UC Berkeley

Rather than using a continuous time series to characterize a year of operation, DER-CAM uses discrete daytypes for each month to characterize typical weekday, weekend days, and “peak” days that represent the highest load days each month. In total, DER-CAM uses 36 daytypes (three for each month). For each of these daytypes, DER-CAM produces an hourly profile of utility purchases, PV output, storage SOC, etc. These daily time series results form the basis for this outage analysis.

To assess the system performance in the event of a prolonged outage, multi-day time series data are needed. To create these, typical week profiles were constructed from multiple daytype results from DER-CAM. The maximum outage modeled was one week (168 hours). The team assumed that if the system could weather one week of continuous outage, it could likely continue operations indefinitely. Of course, how the system responds will depend on when the outage begins, given that loads, PV output, and storage SOC vary significantly throughout each day. The exact month or season will also play a role, given seasonal changes in thermal loads and PV output. The day of the week when the outage starts will also matter, given that weekday and weekend load profiles are different. Finally, the characteristics of the week will also matter. Does the week contain high-load “peak” days? If so, how many and when do they occur? These characteristics will potentially impact outage performance. To adequately cover these factors, the team constructed 13 “weektype” profiles. The parameters of each are summarized in Table 3-11. The weight factors quantify the likelihood that a given week will fall into each of these weektypes. These likelihoods were scaled so that the expected number of “peak” days each month would match the DER-CAM model.

In addition to these parameters related to when outages occur, the critical load (i.e., loads that cannot be curtailed) profiles were also explored: four scenarios ranging from 25 to 100 percent of the total loads.

Table 3-11: Parameters of the 13 Weektypes Modeled for Outage Performance Analysis

number of peak days	permutations modeled	weighting factor
0	1	0.55
1	5	0.25
4	4	0.15
3	3	0.05

Weektype scenarios were used to capture load variations within each month.

Source: UC Berkeley

For each month, weektype, day of the week, hour of the day, and critical load scenario, an outage was introduced into the time series data, and using the storage control logic, the team determined the maximum outage length. The result was more than 100,000 individual outage simulations. Summary statistics were generated to explore the impact of each of the varied parameters on MOL, as presented in the Outage Analysis Results section below.

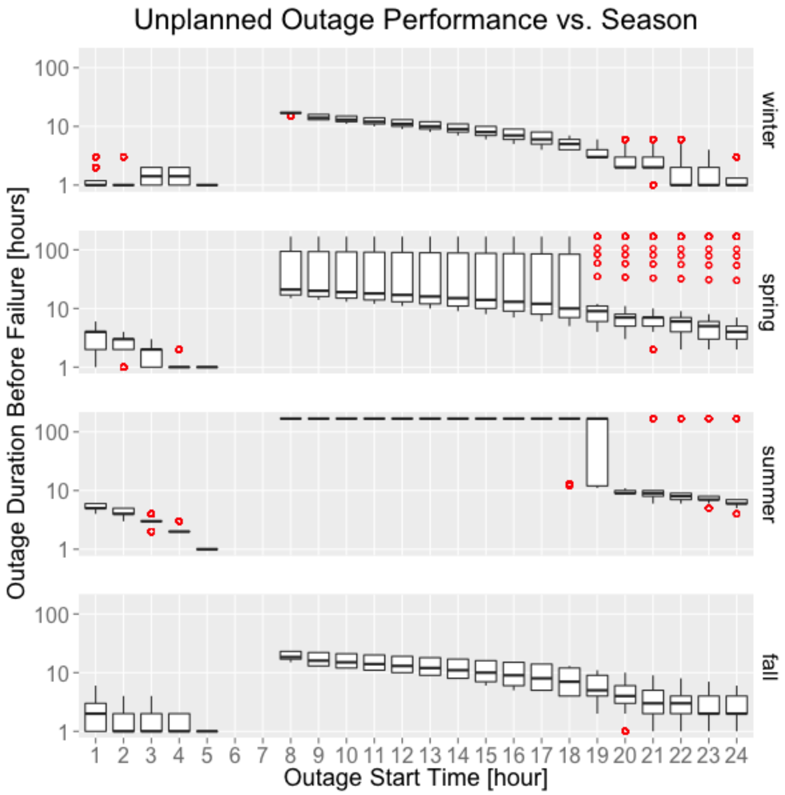
Simplifications and Assumptions

To define the critical loads profile, the analysis team simply applied fractional scalar multipliers (such as 0.5) to the typical overall load profile from when the system is grid-connected. This is a simplification, as critical loads do not necessarily have the same characteristics of typical load profiles. For instance, critical loads may only encompass end uses that are essential to maintain during an outage, such as lighting and refrigeration, and may drop entirely nonessential end uses. As a result critical load shapes may look substantially different from typical operation load shapes. This level of detail was not included in the following analysis. Furthermore, at this time EV charging is not considered during an outage, to simplify the outage control logic. Excess PV generation may exist to serve these loads, but it was not quantified. PV curtailment is used when storage is not capable of absorbing excess generation. It was assumed that curtailment could be continuously tuned rather than in discrete steps (i.e., by turning off entire circuits at the panel level).

Outage Analysis Results

Outage analysis results for the full load scenario (i.e., 100 percent of loads are assumed to be critical loads, therefore no load shedding is possible) are shown in Figure 3-35. This figure shows the distribution of maximum outage lengths (MOLs) by outage start time and season. To interpret these figures, the box-and-whisker plots at each hour along the x-axis represent the distribution of values for MOL if the outage started in that hour. The bounds of the boxes show the 25th to 75th percentiles, with the median (50th percentile) also indicated. The whisker lengths extend to the maximum and minimum observed values, and outliers are indicated as red points. In some instances the distributions are heavily skewed to the top or bottom of the range or tightly bunched somewhere in the middle. In these cases the features of the box-and-whiskers cannot be distinguished clearly, and appear simply as lines. Furthermore, because maximum outage lengths tend to fall into clusters: short (<5 hours), partial-day (5–20 hours), and multi-day (24–168 hours), a log scale was used on the axis to maximize clarity. Due to the log scale, no data could be plotted in instances where all observed MOL are 0, though the underlying data do exist.

Figure 3-35 Distribution of Maximum Outage Lengths (MOL) by Outage Start Time and Season



For a critical load fraction of 100 percent

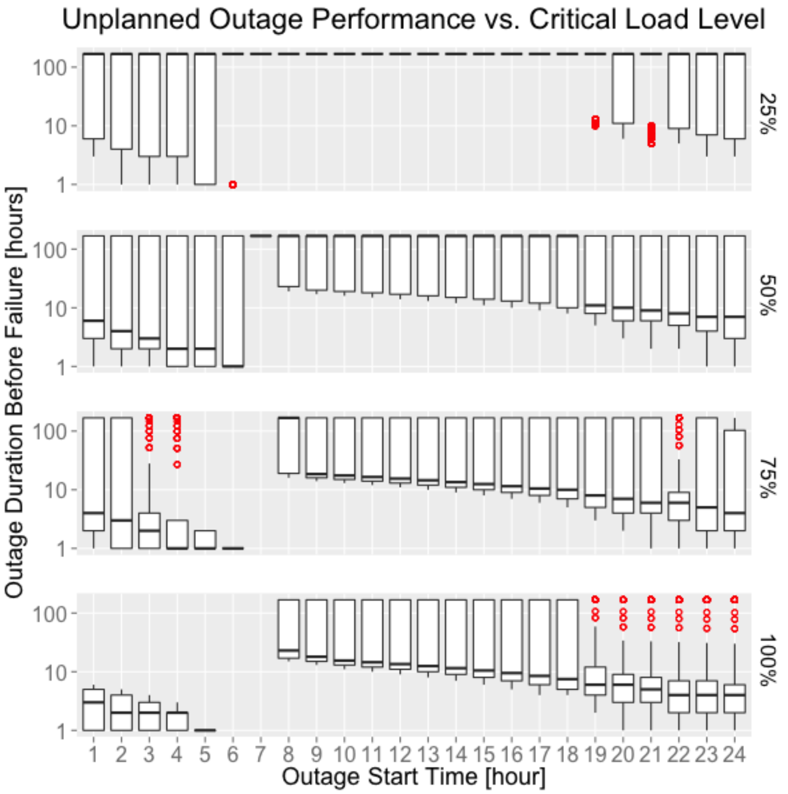
Source: UC Berkeley

Examining Figure 3-35, several important observations can be made. First, for outages that start in the early morning (midnight to 7 AM) the distribution of MOLs for all seasons would be low, typically below seven hours. This implies that if an outage occurs at these times, there would rarely be enough energy supply to serve all loads until PV generation began to ramp up in the late morning. The presence of high morning loads, no PV output, and storage that has been depleted overnight drives this pattern. The typical SOC profiles in Figure 3-27 illustrate how low energy in storage in these hours would reduce resiliency potential. Weathering these particular conditions would require lower critical loads or additional storage.

Outages that begin after 8 AM exhibit much higher MOLs, typically near 20 hours, implying that the presence of PV generation would allow the system to weather daytime outages until the early morning imbalance would again be encountered near 7 AM the following day. For later morning outages in summer, lower thermal loads and higher PV output would mean that the system would be capable of sustaining operations indefinitely (MOL = 168 hours). This would be true for some outages simulated in spring as well. Despite this higher potential for weathering outages, summer and winter performance appears equally poor for very early morning outages.

As the above exercise illustrates, for outages occurring at inopportune times, it may not be possible to dispatch storage in ways that would allow for all loads to be served. In these instances it may be useful to explore the impact of changing the amount of critical loads served on outage performance, i.e., allow some load to be shed during a grid outage. Figure 3-36 shows the MOL distributions by hour and critical load levels of 25 percent, 50 percent, 75 percent, and 100 percent of typical load levels. As one might expect, MOL distributions move upward as the required load levels fall. The issue of poor outage performance in morning hours remains, however. Only when critical load levels fall to 25 percent do more than half of simulations (weighted by likelihood) last through the initial hours of early morning outages.

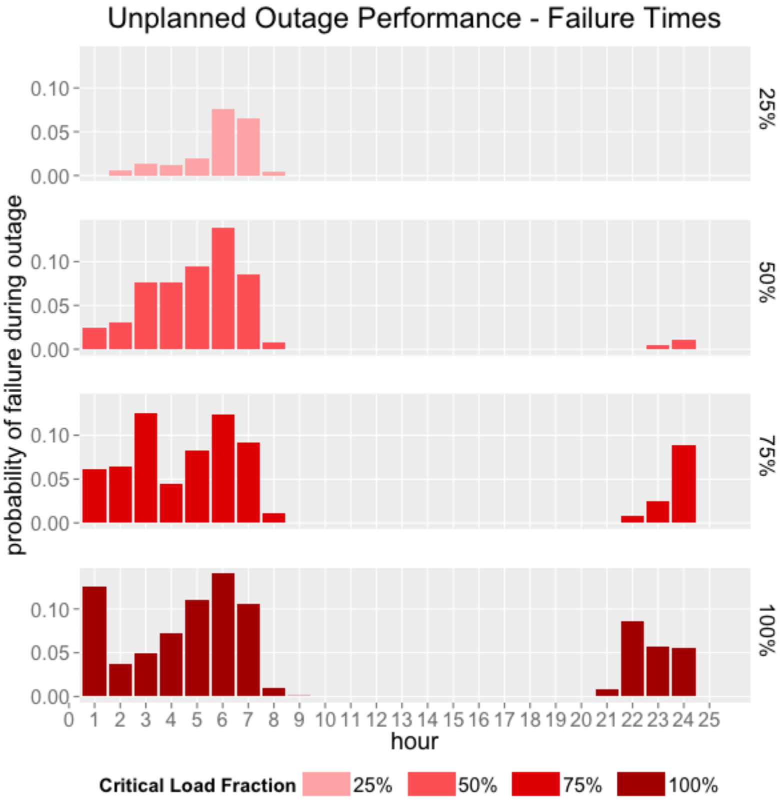
Figure 3-36: Distribution of Maximum Outage Lengths (MOL) by Outage Start Time and Critical Load Fraction



Source: UC Berkeley

The challenges of making it through the early morning conditions are also evident in Figure 3-37, which plots the probability a failure will occur at each hour. (Note there is an important distinction between hours when outages begin, as in Figures 3-35 and 3-36, and hours when a failure occurs.) For all critical load levels, failures peak between 4 AM and 7 AM (hours 5–7). As critical load levels rise, failures begin to occur in the late evening and early morning, but the characteristic morning peak remains.

Figure 3-37: Probability of Failure During an Outage for Each Hour and Critical Load Fraction



Source: UC Berkeley

It is clear that for outages that either begin or extend into early morning hours, the EcoBlock system would be at risk of failure due to depletion of storage. This would be less prevalent for lower critical load levels, but not eliminated entirely, even when critical loads fall to 25 percent of total loads. The implication is that without additional DERs, an EcoBlock system requires flexibility to control or shed loads at critical moments of prolonged outages. Note vehicle-to-grid (V2G) discharging could provide the necessary energy to meet these deficits, but this strategy has not yet been assessed.

To explore this point, one final exercise was conducted, to determine the fraction of hours where loads can be served fully without any shedding required. This exercise used a similar control logic as shown in Figure 3-34; however, when failure conditions were encountered, rather than stopping, the control logic depleted storage to the minimum allowed SOC, then moved to the next timestep until it simulated all 168 hours of each week. This was meant to capture the performance of an EcoBlock system capable of shedding loads as necessary to maintain operations. The fraction of hours where loads were fully served is provided in Table 3-12 for each loads level. These range from 79 percent of hours under full loads to over 99 percent when critical loads were reduced to 25 percent. This appears to indicate that the EcoBlock system would be generally well suited to weather unexpected outages, but that it would require additional load flexibility or generation resources under specific and challenging conditions.

Table 3-12: Fraction of Total Hours With a Fully Served Load During One Week of Outage

Critical Loads (%)	Hours Served Fraction
25	0.993
50	0.926
75	0.849
100	0.792

Source: UC Berkeley

Conclusions

Based on the analysis conducted here, it appears that the optimal operation strategy for the EcoBlock resources exposes the system to risk of failure when grid outages occur during the early morning under specific conditions. Outside of these times, the system would be able to serve a large fraction of hours during prolonged outages. It is possible to close this gap with the addition of resources on the supply side (such as EVs or increased capacity of the central storage system) or demand side (controllable/sheddable thermal loads). Changes also could be made to how the EcoBlock operates under typical conditions. For instance, maintaining higher states of charge in storage overnight to provide for morning outages would present less risk from the most problematic outages identified in this analysis. This strategy would of course reduce the performance in other areas (such as economics and emissions). That said, it appears that with small changes or additions, the Oakland EcoBlock system could very well become capable of sustaining unexpected outages indefinitely.

CHAPTER 4:
Integrated Water System Design and Evaluation

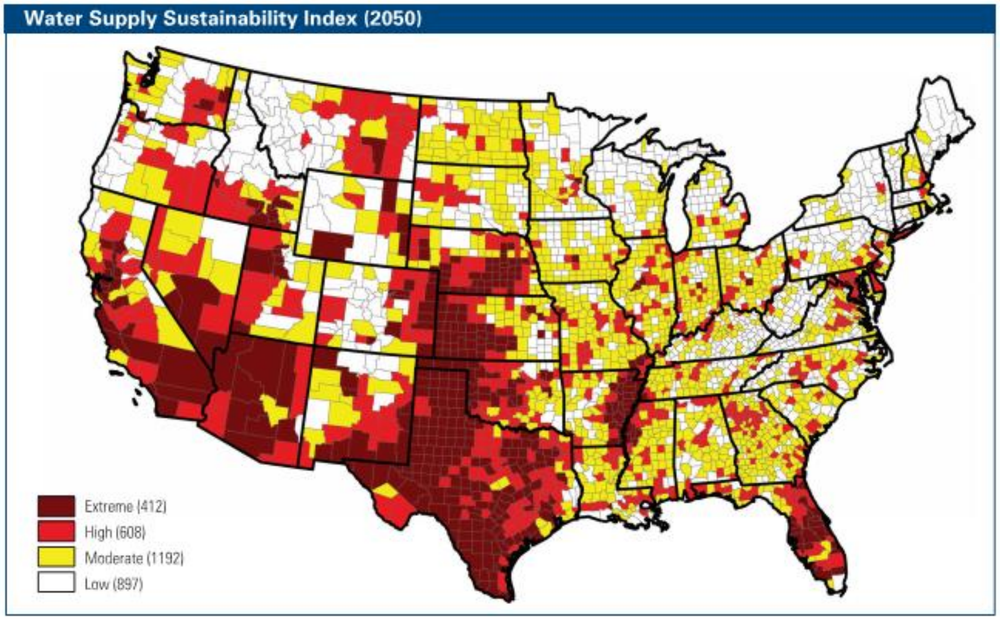
Abstract

The chapter provides a general overview of urban water systems and their components, ranging from rainfall and runoff to indoor water demands to sewers. It discusses conditions and issues specific to the Oakland EcoBlock and describes several potential alternative water source interventions, including rainwater harvesting, drought tolerant landscaping, and wastewater reuse. These interventions are analyzed to assess their suitability for the Oakland EcoBlock. Results are used to suggest possible paths forward for the Oakland EcoBlock and to provide guidance on how to determine what suite of interventions provide good value under a specific set of conditions.

Introduction

Demands on California's water resources continue to increase while climate models suggest that overall precipitation across the state is likely to decrease and become more variable. A greater proportion of the precipitation will arrive as rain, while the state's water infrastructure is designed to function best when snowpacks are substantial. A Water Supply Sustainability Risk Index developed by Roy et al. (2012) was coupled with a climate model and water demand projections to predict 2050 risk levels. As Figure 4-1 shows, water supplies in most of California are expected to be at "high" or "extreme" risk. California must focus on using water more efficiently, on reusing it, and on capturing both rainwater and stormwater that is generally discharged without benefit to people or the environment. As with energy, efficiency and decentralized (water) systems can play an important role in building a sustainable (water) future. The work herein discusses the issues associated with sustainable urban water systems. It describes a range of interventions; opportunities for, and barriers to, their implementation; and promising avenues for research and development.

Figure 4-1: Climate Change, Water and Risk



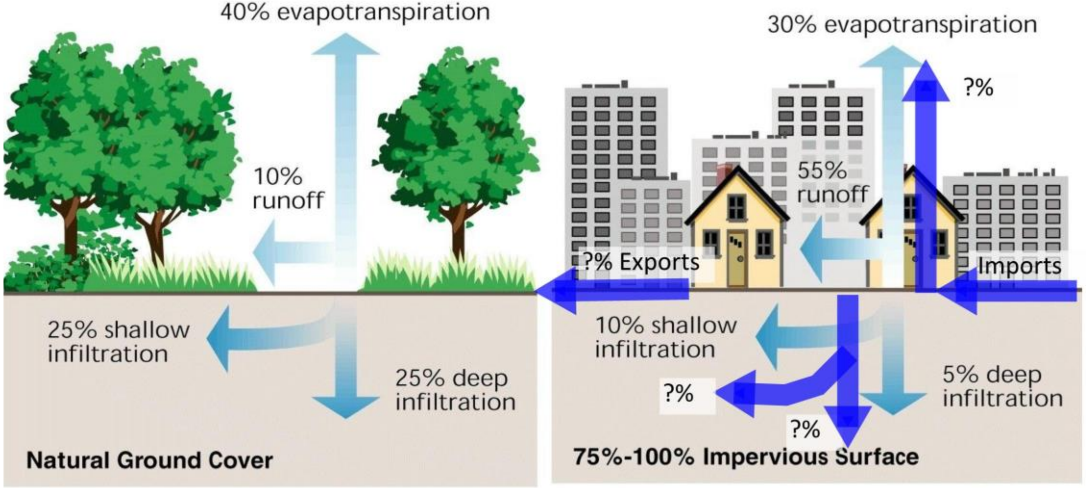
Source: Roy et al. 2012

Urban Water Background

Urban Water Overview

Human activities modify hydrologic cycles, and cities tend to disrupt them greatly (Figure 4-2). This is especially true of cities with conventional “grey” infrastructure (Campos et al. 2014; Jeong et al. 2016; Keeley et al. 2012), where pipes, culverts, and constructed channels collect and remove precipitation as quickly as possible.

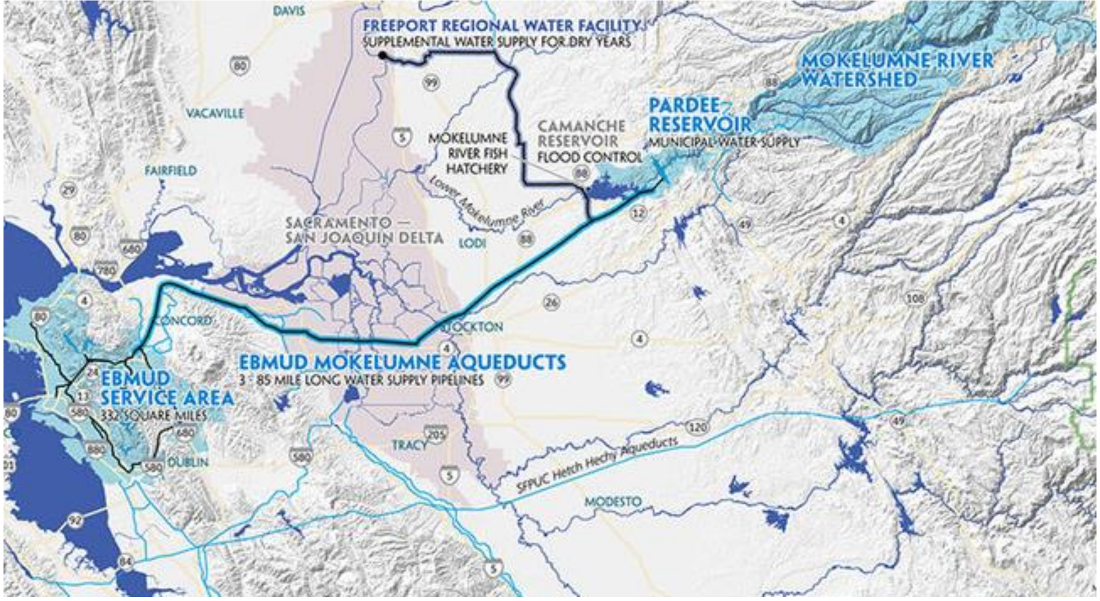
Figure 4-2: Urban Water Cycle



Source: Adapted from the Federal Interagency Stream Restoration Working Group

Groundwater supplies meet a substantial fraction of urban water demand across California, but surface waters meet the majority. These include supplies from local watersheds, but many urban centers, including most of the Bay Area and much of Southern California, rely on water imported from watersheds that may be hundreds of miles from the urban centers (Figure 4-3). Much of the water used in cities becomes degraded and contaminated, and then requires treatment before exporting it back to surface or ground waters.

Figure 4-3: EBMUD System



Source: http://www.ebmud.com/water-and-drought/about-your-water/water-supply/

While indoor water needs are largely independent of location, outdoor water demands are heavily climate dependent. Because of summer irrigation demands, the East Bay Municipal Utility District (EBMUD, the EcoBlock's water and wastewater utility) provides customers with over 200 million gallons daily (mgd) from July through September, as compared to roughly 130 mgd from January through March (EBMUD 2015). Irrigation demands depend heavily on climate. Four primary factors affect this demand:

1. Precipitation—both the amount and its timing (intensity and seasonal distribution)
2. Evapotranspiration (ET)—the rate at which water tends to evaporate and/or be taken up by plants and transpired
3. Water demands of particular plants
4. Amount of land irrigated

Oakland EcoBlock Background

Block Hydrology

Land Use

The Oakland EcoBlock (Figure 4-4) covers somewhat less than 4 acres, and includes four hydrologically relevant components: roofs, ground-level impervious areas (sidewalks, driveways), pervious areas (landscape), and streets (Table 4-1). The four components have important and differing impacts on hydrologic responses (timing and quantity of runoff, rainwater harvesting potential, and irrigation demands). These impacts are detailed below.

Figure 4-4: Site Coverage

Source: Google Maps (left); UC Berkeley (right)

Table 4-1: Site Coverage

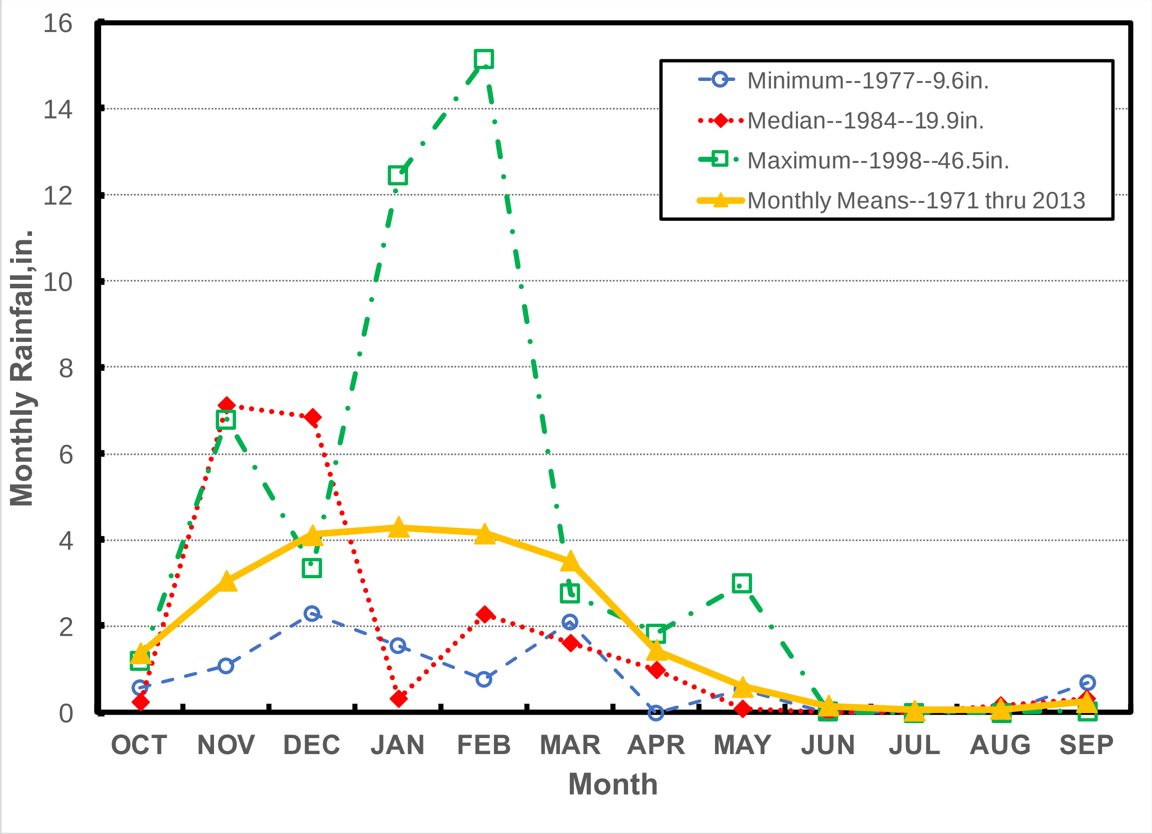
		w/o Street	w/ Street
Component	000 ft^2	%	%
Roof	40	29%	24%
Pervious	66	47%	40%
Impervious	34	24%	21%
w/o Street	**140**		
Street	25		15%
Total	**165**		

Source: UC Berkeley

Climate

The average annual rainfall at the EcoBlock is ~23 inches per year. Typically around 80 percent falls from November through March (Figure 4-5), a seasonal distribution typical of California. The figure also highlights rainfall's high variability both interannually and within the year.

Figure 4-5: Monthly Rainfall Distribution



Monthly precipitation data for water years 1971 thru 2013 at the Oakland Museum
Source: Western Regional Climate Center https://wrcc.dri.edu/cgi-bin/cliMONtpre.pl?ca6336

Irrigation demands tend to decrease with increasing precipitation and increase with increasing ET. Across California there is considerable variability—Oakland's 24 inches of average annual rainfall is four times that of Bakersfield but only 60 percent of Eureka's. Bakersfield is much hotter than Oakland in the summer, when irrigation demand is high. This higher average temperature is the primary reason that a Bakersfield resident needs to use ~50 percent more irrigation water than an Oakland resident on identical plots (same area, plant mix). Eureka residents would use half as much as their Oakland counterparts.

Existing infrastructure

Water

Potable water is supplied to the block by EBMUD, which serves 1.4 million water customers. EBMUD's water comes primarily from 575 square miles of mostly undeveloped public and private lands in the Mokelumne River watershed. The water is collected at the Pardee Reservoir, 90 miles east of the Bay Area (Figure 4-3). In addition, local runoff is stored in several East Bay reservoirs for treatment and delivery to customers and to assure emergency supplies are available when required.

The block has 34 water meters: 20 single-family residential meters, 13 multifamily residential meters, and 1 irrigation meter.

Wastewater

Wastewater generated on the block is transported via a public sanitary sewer to EBMUD's treatment plant located near the San Francisco-Oakland Bay Bridge. The plant serves 685,000 people along the eastern shore of San Francisco Bay.

Stormwater

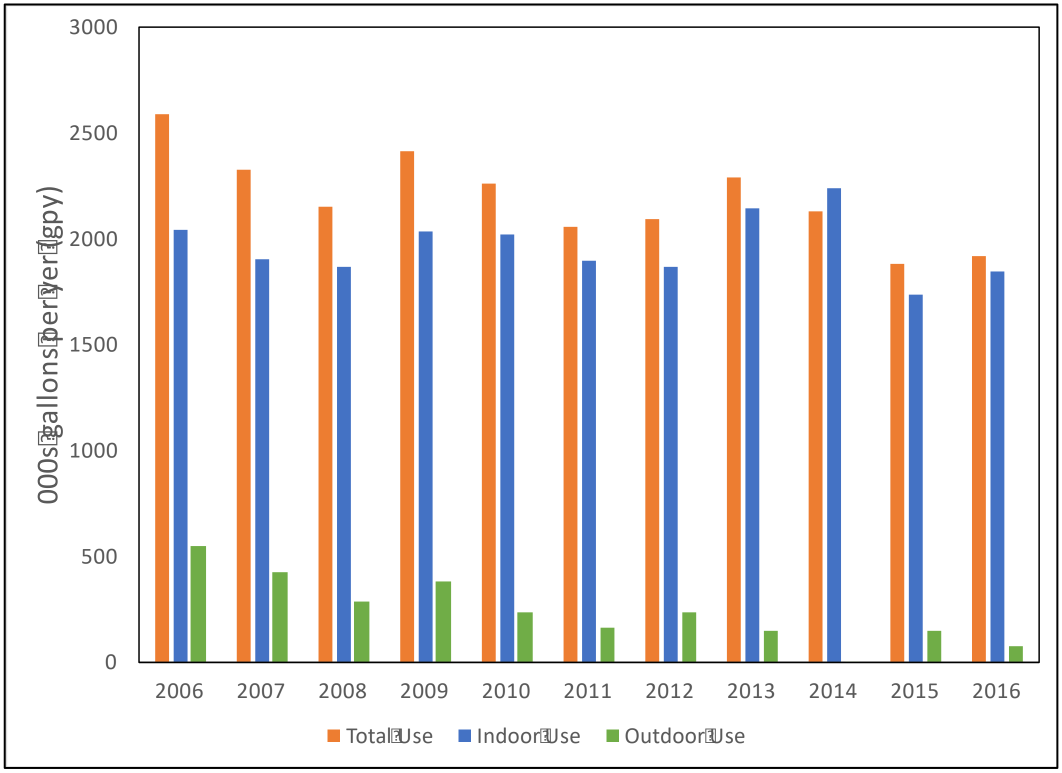
The EcoBlock does not have any piped storm drainage infrastructure. Downspouts from roofs discharge directly to grade. All runoff travels overland to the west and south until it enters downstream piped storm drain infrastructure in Emeryville.

Appendix H includes a more detailed description of existing infrastructure.

Current Block Water Use

Analysis of almost 12 years (thru September 2017) of water bill data provided by EBMUD suggests that block residents use ~2,000,000 gallons (+/- ~10 percent) annually indoors. Indoor usage has stayed roughly constant over the period. Outdoor water use has dropped substantially—from ~500,000 gallons annually in 2006 to ~150,000 gallons annually since 2013 (Figure 4-6).

Figure 4-6: Block-level water use estimates for water years 2006 thru 2016



Source: UC Berkeley

Indoor demand is ~55 gallons per person per day (gpcd). This is consistent with estimates from frequency of use studies and estimates of appliance performance (DeOreo 2016; Heberger et al. 2014; DeOreo et al. 2011; Wilkes et al. 2005; DeOreo et al. 2016; SFPUC 2017a; Koeller 2016). The decrease in outdoor use may well be a response to the recent drought and corresponding EBMUD conservation programs. Usage in water year 2006 is consistent with a block consisting largely of lawns. Estimates for the most recent years suggest that much of the irrigated landscape consists of native plants coupled with efficient irrigation systems, and that there may be considerable portions of the block's landscape cover that is not being irrigated. It is not known if current outdoor water use represents block residents' desired usage or is primarily a drought response.

Appendix H provides a more detailed analysis of existing water use data.

Decision-Making Framework Water Strategy Selection

The work focused on ways to sustainably reduce demand on, and supplement the supply of, current, centralized water infrastructures (EBMUD for the Oakland EcoBlock). Efficiency, wastewater reuse, and capture and use of precipitation were the initial candidates considered.

The team developed and conducted a decision-making framework (DMF) analysis of 24 alternative water source strategies, organized into five categories: (1) efficiency, (2) greywater, (3) wastewater, (4) rainwater, and (5) stormwater (Table 4-2). In the DMF analysis, groundwater recharge and extraction were included as a component of two strategies: (1) block sewage reclamation for infiltration + groundwater extraction, and (2) stormwater infiltration + groundwater extraction. Note that in subsequent analyses in this study, groundwater-only strategies were evaluated separately as a separate water source category.

Precipitation was divided into rainwater (precipitation collected from roofs) and stormwater (precipitation that has contacted ground surfaces) because rainwater is typically of high quality, whereas stormwater can be harder to collect and store and because it tends to pick up contaminants and thus requires more treatment before use. Both stormwater and rainwater can be infiltrated to replenish groundwater, a potentially important component of sustainable groundwater management.

The strategies also differentiated between block-wide strategies (those that require shared block infrastructure) and individual strategies (those that only require infrastructure on individual properties).

The following subsections characterize each alternative water source category.

Efficiency

Though perhaps not strictly a “source,” installation of low-water-using fixtures, appliances, landscapes, and systems can have a major impact on water demands. Installation of leading water-saving appliances can reduce indoor water demand from the current value of ~55 gpcd (based on EBMUD water bills to ~30 gpcd, a 45 percent reduction. Block residents have greatly reduced outdoor water use in recent years, but it is not known if they are content with this usage level.

Greywater

Greywater is wastewater minus its high pathogen potential components—wastewater from toilets and (typically) kitchen sinks/dishwashers. It can be treated and reclaimed for the same uses as wastewater. Additionally, many states, including California, permit belowground discharge of minimally treated greywater for irrigation. Greywater systems that divert water only from laundry machines, often referred to as “laundry to landscape” systems, in many locations may be installed without any treatment and without construction permit. Many municpalities and utilities (including EBMUD and the San Francisco Public Utilities Commission) are incentivizing these systems with programs and rebates. Individual-home greywater diversion (the greywater laundry-to-landscape strategy) differs greatly from other block-scale greywater and wastewater strategies because:

- It is implemented at individual residences, and capital costs are a few hundred dollars at most
- It involves essentially no treatment of the water
- Operation and maintenance (O&M) and monitoring costs are negligible
- Permitting is either not required or routine

All other greywater reclamation strategies considered in the DMF require substantial treatment, and must meet stringent regulatory standards. Capital costs for these systems are over $100,000 and O&M and monitoring costs are substantial.

Wastewater

Treating wastewater to a high level of purity and using this reclaimed water for non-potable uses is common practice for centralized wastewater treatment plants (including EBMUD). In recent years, decentralized systems producing water for non-potable uses have become more common (Phoenix 2017; Living Machine 2012). There is also considerable research being conducted by, and discussions among, water professionals on systems that can reliably produce potable-grade water (Tchobanoglous et al. 2011; National Research Council 2012).

Groundwater

Groundwater is a major water supply source throughout the United States for both potable and non-potable (i.e., irrigation) uses. Systems for extracting, treating, and distributing groundwater are widely used and well understood. The potential for utilizing groundwater is heavily site dependent. Important considerations include the following:

- The depth to the groundwater table, which impacts well-drilling costs and the pumping energy required to extract water
- Aquifer permeability, which affects the rate at which water can be extracted
- Contamination, which can make waters unfit for use or very difficult and expensive to purify
- Recharge rate—the rate at which water is added to the system; if extraction rates exceed recharge rates, the system is not sustainable in the long term.

Rainwater

In an average year, about 550,000 gallons of rainwater, roughly 20 percent of the block's current annual water use, land on its roofs. Many companies sell systems for capturing, storing, treating, and distributing rainwater. Use of rainwater for irrigation and other non-potable purposes is well established. California now allows local jurisdictions to adopt Appendix K of the plumbing code, which sets standards for residential rainwater systems that can be used for potable purposes.

Stormwater

About 2.3 million gallons of rain fall on the block and its surrounding streets in a typical year. As is typical for blocks of this vintage, most of the rainfall quickly exits the block as surface runoff (see Figure 4-2). This rapid runoff picks up contaminants, often floods streets, and strains storm drainage infrastructure and the water bodies that ultimately receive the runoff. Infrastructure that promotes collection, storage, and infiltration[19] of stormwater can decrease these problems substantially. In addition, infiltrated water that stays near the surface can

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[19] *Infiltration* is the process by which water enters and moves through the soil.

augment stream flows and be taken up by plants well after storms. Water that infiltrates deeply can recharge aquifers, becoming available for extraction and use as needed. Stormwater is generally more difficult to collect than rainwater, with below-grade storage and pumps typically required.

Table 4-2 presents the water strategies that were considered in the DMF process.

Table 4-2: Decision-Making Framework Water Strategies

Strategies		**Description**
EFFICIENCY (EF)		**Strategies that reduce either indoor or outdoor (irrigation) water demand**
EF1	Indoor efficiency	Upgrades to existing water fixtures (toilets, aerators, appliances, etc.)
EF2	Native planting	Replace lawns with native, drought-tolerant planting
EF3	Irrigation system efficiency	Improve irrigation efficiency via automatic timers, soil moisture sensors, etc.
EF4	Urine Diversion	Separate urine from wastewater and diversion of the urine to a collection tank for treatment and nutrient recovery off-site.
GREYWATER (G)		**Strategies that separate and divert or treat for reuse the less polluted wastewater components (greywater from laundry, bathroom sinks, bathtubs, and showers).**
G1	Greywater (laundry to landscape)	Divert greywater from laundry machines only to subsurface irrigation system. No treatment is required.
G2	Block greywater for non-potable	Separate greywater (clothes washers, bathtubs, showers, bathroom sinks) and collect at a central location on the block. Treat greywater and redistribute reclaimed greywater for non-potable uses. Includes treatment system and water quality monitoring.
G3	Block greywater for potable	Separate greywater (clothes washers, bathtubs, showers, and bathroom sinks) and collect at a central location on the block. Treat greywater and redistribute reclaimed greywater for potable uses. Includes treatment system and water quality monitoring.
WASTEWATER (WW)		**Strategies that reclaim wastewater by treating it to quality standards required for reuse for irrigation or potable demands. Wastewater includes water from all fixtures (toilets, dishwashers, clothes washers, bathtubs, showers, and bathroom sinks).**
WW1	Block sewage reclamation for non-potable	Reconfigure sanitary systems on the block to collect wastewater to a central wastewater treatment location. Distribute reclaimed wastewater to block for non-potable uses (irrigation and toilet flushing). Includes sewage treatment system and water quality monitoring.
WW2	Block sewage reclamation for potable (DPR)	Direct Potable Reuse (DPR) is treatment of sewage from the block for potable water demands. Includes wastewater treatment system and water quality monitoring.
WW3	Sewer mining / reclamation for non-potable	Sewer mining station installed on city sanitary sewer pipe, which "mines" and pumps wastewater to a centralized wastewater treatment system. Reclaimed wastewater to be used for non-potable uses (irrigation and toilet flushing). Includes a wastewater treatment system and water quality monitoring.
WW4	Block sewage reclamation for infiltration + groundwater extraction	Collect and treat block sewage. Infiltrate reclaimed water through field, injection well, or other method. Includes installation of a well for use on-site as a potable supply

Table 4-2 (cont.): Initial Water Strategies for Consideration

Strategies		**Description**
RAINWATER (RW)		**Strategies that collect precipitation falling on roof or above-ground surfaces**
RW1	Rainwater harvesting for potable	Harvest roof runoff (rainwater). Treat to potable standards for use within buildings.
RW2	Block rainwater harvesting for non-potable	Centrally located, shared storage of roof runoff (rainwater) from the block that is collected, stored and redistributed for non-potable uses (irrigation and toilet flushing)
RW3	Individual rainwater harvesting for non-potable	Storage of roof runoff (rainwater) at individual homes to be used for non-potable uses (irrigation and toilet flushing). Includes rain barrels and other small-scale solutions at individual homes.
RW4	Rainwater Infiltration	Direct roof runoff (rainwater) to infiltration trenches, subsurface infiltration systems, or other engineered infiltration systems
STORMWATER (SW)		**Strategies that collect and/or manage precipitation falling on ground-plane surfaces**
SW1	Stormwater Infiltration	Use of engineered stormwater facilities designed to infiltrate water into the subsurface
SW2	Stormwater Infiltration + Groundwater Extraction	Use of stormwater facilities that infiltrate water, along with extraction of groundwater from wells for irrigation
SW3	Stormwater Harvesting for non-potable	Centralized or partially centralized collection of stormwater runoff from the block to storage and treatment. Harvested water to be used for non-potable.
SW4	Stormwater mining for non-potable	Pumping of stormwater from existing City storm drain pipes to storage and treatment. Mined stormwater to be used for irrigation.
SW5	Public Green Infrastructure (Within existing vehicular zone)	Includes parklet, bulb out, tree canopy, pervious paving, bike paths, and other improvements that DO impact the existing roadway
SW6	Public Green Infrastructure (Within existing pedestrian zone)	Includes flow-through planters, swales, runnels, tree/forest cover and other improvements that DO NOT impact the existing roadway, but are within the public right-of-way
SW7	Shared Private Green Infrastructure	Shared stormwater treatment best management practices (BMPs) such as a water quality basin, extended biotreatment area, and/or tree well filters
SW8	Individual Private Green Infrastructure	Use of biotreatment area, tree well filters, porous pavements, and other stormwater treatment on private property
SW9	Reduce imperviousness	Reduce impervious surfaces by removing unnecessary hardscape and replaced with landscaped or other impervious surface

Source: UC Berkeley

Decision-Making Evaluation Criteria

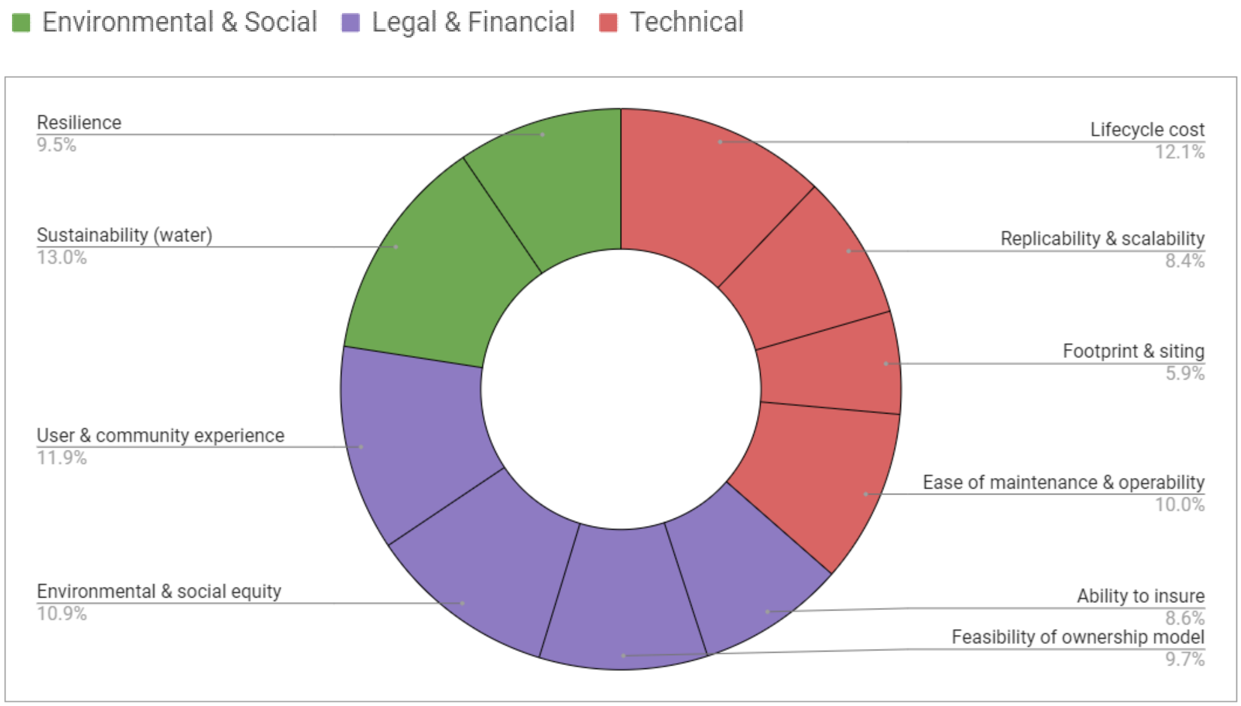
A decision-making framework enables decision makers to compare strategies using a range of quantitative and qualitative evaluation criteria, and to understand the relative strengths and weaknesses of the strategies under consideration. The Oakland EcoBlock team leads developed a list of evaluation criteria, which fell into three main categories: (1) technical, (2) legal and financial, and (3) environmental and social (Table 4-3). Team members ranked the relative importance of each criteria. Using these rankings, the team calculated the relative importance of each criteria (Figure 4-7).

Table 4-3 DMF Evaluation Criteria

	CATEGORY		
	Technical	**Legal & Financial**	**Environmental & Social**
Criteria	Lifecycle cost	Feasibility of ownership model	Environmental & social equity
	Replicability and scalability	Ability to insure	User and community experience
	Footprint and siting		Sustainability
	Ease of maintenance and operability		Resilience

Note: A full description of each of the evaluation criteria is included in Appendix I.
Source: Sherwood Design Engineers

Figure 4-7: Evaluation Criteria Weighting



Source: Sherwood Design Engineers

Strategy Selection

- Strategies were given a score from 1 to 10 for each evaluation criteria.
- Strategy scores were multiplied by the criteria weight to generate weighted scores.
- The weighted scores were summed across all the evaluation criteria.

Figure 4-8 shows the weighted scores for each strategy; the relative strengths of different evaluation criteria are apparent—for example, a larger green bar suggests that a strategy has strong environmental and social benefits.

In general, high-scoring strategies were selected for more detailed evaluation. Two groundwater-based strategies not included in the DMF analysis were also evaluated. The evaluated strategies are described the following sections.

Figure 4-8: Weighted Scores Used to Select Water Strategies

Decision-making framework results: Strategies ranked favorably (above red line) were, in general, included for more detailed analysis. See Table 4-2 for a description of each strategy.

Source: Sherwood Design Engineers

Alternative Water Sources Considered

Eleven strategies were selected for further evaluation. They included at least one representative of each of the five DMF categories. Two strategies from "groundwater," the sixth alternative water source considered, were also included.

Alternative Water Source Systems Analyzed for the Oakland EcoBlock

This section describes the specific infrastructure components (such as pipes, tanks, and treatment systems) that would be required on the Oakland EcoBlock to implement the strategies selected for further analyses.

- Efficiency upgrades
    - Appliance retrofits (indoor efficiency)
    - Native planting and irrigation systems (Outdoor efficiency)
- Greywater diversion—laundry to landscape
- Reclaimed wastewater for irrigation
- Groundwater for:
    - irrigation
    - potable use
- Rainwater harvesting for:
    - irrigation
    - potable use
        - treatment at individual residences
        - block-scale treatment
    - direct potable reuse (DPR)
- Green stormwater infrastructure in both the public and private realm

It is important to note the following:

- The EcoBlock might employ multiple alternative water systems. Both indoor and outdoor efficiency options can be combined with all the other options.
- One system may affect the value of using a second system. Efficiency improvements will decrease demand requirements of other systems.
- Some system combinations do not make sense. For example, there is no reason to use both sewer mining (reclaimed wastewater for irrigation) and groundwater for irrigation strategies to provide irrigation; one would suffice.
- Stormwater strategies promote infiltration and could enhance the performance of groundwater options.

The evaluated systems are described below.

Efficiency upgrades

Indoors

To lower indoor water use, current appliances could be replaced with water-efficient fixtures, such as toilets, showers, faucets, and dishwashers.

Outdoors

To lower outdoor water use, landscapes could be planted with native, drought-tolerant species. Irrigation efficiency could be increased with installation of drip irrigation systems, smart irrigation controllers, and other efficient technologies.

Greywater diversion—laundry to landscape

Piping would be connected to the washing machine outlet and directed outside. The greywater from the machine would be dispensed below the ground using a perforated pipe.

Sewer mining for irrigation

Wastewater would be collected ("mined") from a sewer manhole in the street adjacent to the block and pumped to a treatment facility collocated with the flywheel station. Treated wastewater would then be pumped through piping that encircles the block. This piping would have laterals at each residence where piping (including a meter) would connect to the residence.

Groundwater

Groundwater for Irrigation

Water would be extracted from a well on the block and pumped to piping that encircles the block. The block piping would have laterals at each residence where piping (including a meter) would connect to the residence. Little or no treatment would be required.

Groundwater for Potable Use

Water from the well on the block would be pumped to a treatment facility collocated with the flywheel station. After treatment, the water would be pumped through piping encircling the block. The block piping would have turnouts at each residence where piping (including a meter) would connect to the residence. This piping would connect to each home's potable water lateral (downstream of the EBMUD meter). The connection would have to be designed with adequate backflow prevention to eliminate the possibility of the treated groundwater accidentally flowing into the EBMUD distribution system.

Rainwater harvesting

All systems considered include capture and storage at individual residences; some options include additional shared storage tanks. Both strategies—rainwater harvesting for irrigation and rainwater harvesting for potable use using treatment at individual residences—would require each residence would have its own independent system.

The other two options—rainwater harvesting for potable use using block-scale treatment and rainwater harvesting for direct potable reuse—would include treatment at a central location (possibly the flywheel station). Storage could occur centrally or at individual residences. For both of these alternatives block-scale piping would be required for collection and distribution.

Rainwater Harvesting for Irrigation

Water captured from each roof would be stored in an aboveground tank until needed. Treatment would be minimal. A pump may be required to distribute water for irrigation.

Rainwater Harvesting for Potable Use Using Treatment at Individual Residences

Water would be captured and stored in an aboveground tank and used as needed for interior uses. Treatment at the tank would include filtration and disinfection. It could also include activated carbon adsorption and corrosion protection. A pump would distribute water to the residence's potable water piping and into the house. This piping would connect to each home's potable water plumbing system downstream of the EBMUD meter. The connection would have to be designed with adequate backflow prevention to eliminate the possibility of the treated rainwater accidentally flowing into the EBMUD distribution system.

Rainwater Harvesting for Potable Use Using Block-scale Treatment

Water would be captured and stored in aboveground tanks at each residence and pumped to the central treatment facility as needed. Treated water would be stored at the facility until needed when it would be pumped to the homes for use (see the Groundwater for Potable Use description above).

Rainwater Harvesting for Direct Potable Reuse (DPR)

Rainwater would be captured and stored in aboveground tanks at each residence and pumped to the central treatment facility as needed. Wastewater from the homes would be collected and pumped to the central facility for reclamation. Both water streams would be treated, and the treated water would be sent to the homes (see the Groundwater for Potable Use description above). After passing through the reclamation processes, a fraction (15 to 20 percent) of the reclaimed water would be removed and distributed to the block's landscaping. Fresh rainwater would replace the water distributed to landscaping. Replacing 15 to 20 percent of the water each cycle would keep salt concentrations in the system's water supply from exceeding acceptable levels.

Stormwater Management

Green stormwater management interventions are designed to make the hydrology of urban systems more closely match that of natural systems. In particular the systems work to slow and reduce runoff and maximize infiltration (SRCD 2015). Best management practices (BMPs) (Alameda County 2017) include the following:

- Replace impervious surfaces with landscaping and permeable pavements within the block.

- Construct rain gardens that collect, cleanse, and infiltrate stormwater runoff and excess water from rainwater harvesting systems. They can be placed on private property or in the public right-of-way (street corner bulb-outs for instance) and can be connected to storm drain systems.
- Use permeable pavement for streets and/or parking lanes.

These interventions can lower peak discharge rates, total discharge volumes, and contaminant loadings while infiltrating water that may, for a substantial period after a rainfall, provide water for plant uptake, inflow to water streams and ponds, and aquifer recharge.

Cost Analysis and Discussion

A capital cost/NPV analysis provides a sense of whether an intervention is likely to make economic sense. Capital costs are the easiest costs to quantify. Costs of water supplied by the utility also can be calculated/estimated. If capital costs themselves exceed the value of the utility's water not needed, then the intervention will not make sense unless other benefits are great. If the NPV exceeds an intervention's capital cost then examination of operating, maintenance, and replacement costs is warranted.

However, as discussed in the Decision-Making Framework section above, many other factors also come into play, and the benefits of some may be indirect and possibly difficult to quantify. Possible indirect benefits include:

- Rainwater harvesting systems could substantially lower stormwater runoff and the costs of its management.
- Reliance on local groundwater could decrease EBMUD's water treatment operating costs and capacity requirements.
- Both rainwater and groundwater systems could decrease EBMUD's need to search out and develop additional, more expensive water supply sources.

A more detailed discussion of some of the indirect, often difficult to quantify costs and benefits follows the NPV analysis.

The NPV analysis presented here is specific to the Oakland EcoBlock. Results could be very different in different climates, in utility situations where water pricing and supply adequacy are different, and at a different scale—for example, 1000 residents instead of 100.

Net Present Value Analysis

Estimated capital costs for the water systems considered were computed and compared with the estimated NPV of water saved or produced over the life of the system, using a discount rate of 1.5 percent. For all but the efficiency upgrades and greywater diversion, the team assumed a useful life of 30 years.

Two water value estimates were included. In the first, the price of water remains constant over the 30-year period. In the second, water prices rise at an 8 percent annual rate—an increase that is within the range of price increases at many California utilities over the last several years (EBMUD 2017a; City of Sacramento 2017; City of Santa Barbara 2017). Combined, these two assumptions provide reasonable bounds. The "year 0" value of water—$6.10/1000 gallons—equals EBMUD's current base level volumetric charge for residential customers (EBMUD 2017b).

Results

The impacts of efficiency interventions are discussed first because they can substantially decrease water demand and are often the most cost-effective interventions (Cooley and Phurisamban 2016a). Analyses of the all other interventions considered assume that effective efficiency interventions are in place.

The discount rate employed here, 1.5 percent per annum, is a rate currently applicable to green bonds. Industry analysts consider that with its investment-grade credit rating of Aa2, the City of Oakland could issue property-secured Green Municipal Bonds, backed by a CFD tax cash flow stream on the basis of an interest rates between 1.5 to 3.5 percent. That interest rate spread would change depending upon the credit-rating of different municipalities in California. This low rate maximizes the NPV of the water saved/produced. Rough estimates of NPVs for other discount rates can be calculated using Equation 2:

$$NPV_{x,y} = NPV_{1.5\%,y} * C_{x,y} \qquad \text{(Eq. 2)}$$

where *x* is the discount rate, *y* is the number of years, and $C_{x,y}$ is a constant. For lifetimes of 3, 15, or 30 years,

$C_{3\%,y}$ = ~0.98, 0.9, or 0.8

$C_{5\%,y}$ = ~0.95, 0.77, or 0.6

Efficiency

Table 4-4 summarizes the expected per capita indoor water use where highly water-efficient appliances are assumed to be in place. Current estimates of indoor use on the block are ~55 gpcd. The projected value of 29 gpcd represents a 45 percent demand reduction.

Table 4-4: Projected EcoBlock Indoor Water Use with Efficient Appliances

Fixture	Flow Rate	Rate Units	Duration	Uses/day	gpcd
Toilet(1)	0.80	g/flush	-	5.0	4.0
Bathroom Faucet(2)	0.50	g/min	0.50	3.0	0.75
Bath Tub(3),(4),(5)	18	g/bath	-	0.32	5.8
Showerhead(1)	0.70	g/min	7.8	0.69	3.8
Dishwasher(4)	1.7	g/cycle	-	0.32	0.55
Kitchen Faucet(2)	0.50	g/min	7.8	1.0	3.9
Laundry(3)	7.0	g/cycle	-	0.32	2.2
Leaks(6)	7.9	g/day	-	1.0	7.9
Total					**29**

[a] gpcd: gallons per capita per day

Sources: [1] DeOreo 2016; [6] SFPUC 2017b [3] Heberger et al. 2014; [4] DeOreo et al. 2011; [5] Wilkes et al. 2005; [6] DeOreo et al. 2016

Table 4-5 provides an assessment of the net present value of these efficiency savings. Note three things:

- The NPV values are per person—in many residences at least some toilets, showers, dishwashers, and other facilities are shared.
- For showers, dishwashers, and laundry, the *$ Saved* column includes the energy savings associated with the fact that less water is heated (EERE 2017).
- The numbers do not include any subsidies provided by utilities, governments, or other entities.

Table 4-5. Efficiency Upgrades, Net Present Value

Fixture	Useful Life (yrs)	gpcd		Capital Cost	Annual Savings		NPV[1]	
		Current	Projected		gpc	$_[2]	0%	8%
Toilet	25[a]	6.4	4.0	$150	880	$5.5	$90	$240
Bathroom Faucet	10[b]	1.8	0.75	$10	380	$2.3	$19.6	$20
Showerhead	15[c]	10.8	3.77	$350	2,600	$36	$420	$760
Dishwasher	9[d]	1.1	0.55	$1,500	210	$3.5	$27	$39
Kitchen Faucet	10[b]	14.1	3.9	$10	3700	$23	$190	$280
Laundry	10[d]	4.5	2.2	$1,200	820	$9.4	$80	$117
Total				**$3,200**	**8,600**	**$80**	**$830**	**$1,460**

gpc: gallons per capita, d: day, y: year

[1] NPV discount rate = 3.5%. At 0%, the water price stays constant; at 8%, the water price increases 8%/year.

[2] $ saved in 2017 at EBMUD rates; includes energy savings for dishwasher, laundry, and showerhead

Sources: a: Koeller & Company 2005; B: PG&E 2014; c: California Statewide Utility Codes and Program 2011; and d: NAHB 2007

Benefits are greater than costs for the faucet interventions, and probably for toilet and shower replacements (use by more than one person). Costs substantially exceed benefits for dishwasher and laundry replacements.

Current outdoor water use appears to be approaching what would be expected for a drought tolerant landscape with a highly efficient irrigation system. The team assumes that landscaping interventions would not be part of the interventions.

Other alternative water sources

Table 4-6 summarizes costs, water savings, and other issues associated with nine of the alternative water systems. For all analyses, it is assumed that water efficiency steps have been taken so that indoor water use is ~30 gpcd.

Currently it is not known what the residents' desired outdoor water use is; it could be anywhere from 200,000 to 800,000 gallons per year. Our cost analyses assume 300,000 gallons per year, which is somewhat greater than current, possibly drought impacted, use. Costs for the two block-scale irrigation systems considered (sewage and groundwater) are essentially independent of how much water is produced. The NPVs are directly proportional to the amount of water produced, so calculating the value of water supplied for different irrigation quantities is straightforward. The rainwater irrigation assessments differ only in the amount of storage (1,000 or 10,000 gallons) at each residence.

Table 4-6: System Net Present Value Summary

		Capital	Annual		Net Present Value					
		Cost	Production	Value	water saved $,000[2,3]		O& M	Regulatory		Public
System	Identifier	$,000	,000 gallons	$,000[1]	0%	8%	Costs[4]	Barriers[4]	Governance[4]	Acceptance[5]
Greywater Diversion	GD	$5.9	55	$0.3	$3.9	$7.0	1	1	1	1
Sewer Mining Irrigation	SMI	$1,240	300	$1.8	$34	$111	5	4	4	4
Groundwater Irrigation	GWI	$330	300	$1.8	$34	$111	1	2	2	1
Groundwater Potable	GWP	$350	1,500	$17	$310	$1,000	4	4	3	3
Rainwater Irrigation 1000[6]	RWI	$68	30	$0.18	$3.4	$11.1	1	1	1	1
Rainwater Irrigation 10,000[6]	RWI	$189	300	$1.8	$34	$111	1	1	1	1
Rainwater Potable Private[7]	RWP-P	$240	330	$2.0	$38	$122	3	2	2	3
Rainwater Potable Block[7]	RWP-B	$860	330	$2.0	$38	$122	4	4	3	3
Rainwater DPR	RWDPR	$1,900	1,100	$30	$570	$1,840	5	5	5	5

[1] Based on 2017 EBMUD prices / 1000 gallons: $11 for Groundwater Potable, $27 for Rainwater DPR, and $6.10 for all others; see text for details

[2] Discount rate: 3.5%; useful life 15 years for greywater diversion; otherwise, 30 years

[3] 0% column assumes the water price stays constant; 8% assumes water price increases 8% annually

[4] Scale 1 to 5. 1: inconsequential, 5: critical consideration

[5] Scale 1 to 5. 1: well-accepted, 5: no acceptance

[6] Assumes that all 27 residences put in a 1,000- or 10,000-gallon tank per residence

[7] Assumes a total of 40,000 gallons of storage at the residences

Source: UC Berkeley

The value of each unit of water produced depends on the system being considered. For all but two systems, block residents would continue to use (and pay for) the current potable water and wastewater infrastructure, and therefore the value of water saved is equal to EBMUD's 2018 volume charge of $6.10 per thousand gallons. The value of the water produced by the groundwater for potable use system is $11 per thousand gallons because block residents would be disconnected from EBMUD's potable water system and not subject to the monthly connection fee (currently $20.75 per month for single-family units). Residents would continue to use (and pay for) the wastewater infrastructure. If the rainwater-based DPR system were employed, the block would be completely independent of both the water and wastewater infrastructure resulting in a water value of about $27 for a single-family unit.

The NPV analysis suggests that benefits from the greywater diversion—laundry to landscape, groundwater for potable use, and rainwater-based direct potable reuse (DPR) strategies could exceed capital costs. Of the options considered, greywater diversion would offset EBMUD supplies the least, but it is quite simple to apply (it is quite possible that several of these systems already exist on the block). For Oakland residents the greywater diversion systems look even better since they can claim a $50 rebate, lowering capital costs by ~20 percent (EBMUD 2018a).

Though the groundwater for potable use system looks promising, the system would require metering, fee collection, water quality testing, and the formation of a utility. In addition, the block's groundwater may exceed secondary drinking water standards (500 milligrams per liter) for total dissolved solids (TDS) (U.S. EPA 2017a). Secondary standards deal with "nuisance" constituents. Waters with constituents that exceed the standards do not endanger health, but may affect aesthetics, such as taste, odor, and color. High salt (TDS) contents may give the water an unpalatable taste and thus be unacceptable to residents.

If water rates continue to rise rapidly the net present value of rainwater-based DPR could exceed the NPV of capital costs. However, just as for groundwater for potable use systems, there would be significant recurring expenditures (at least $50,000/year for O&M). In addition these systems are not currently permitted in California, and the block residents would not accept this option.

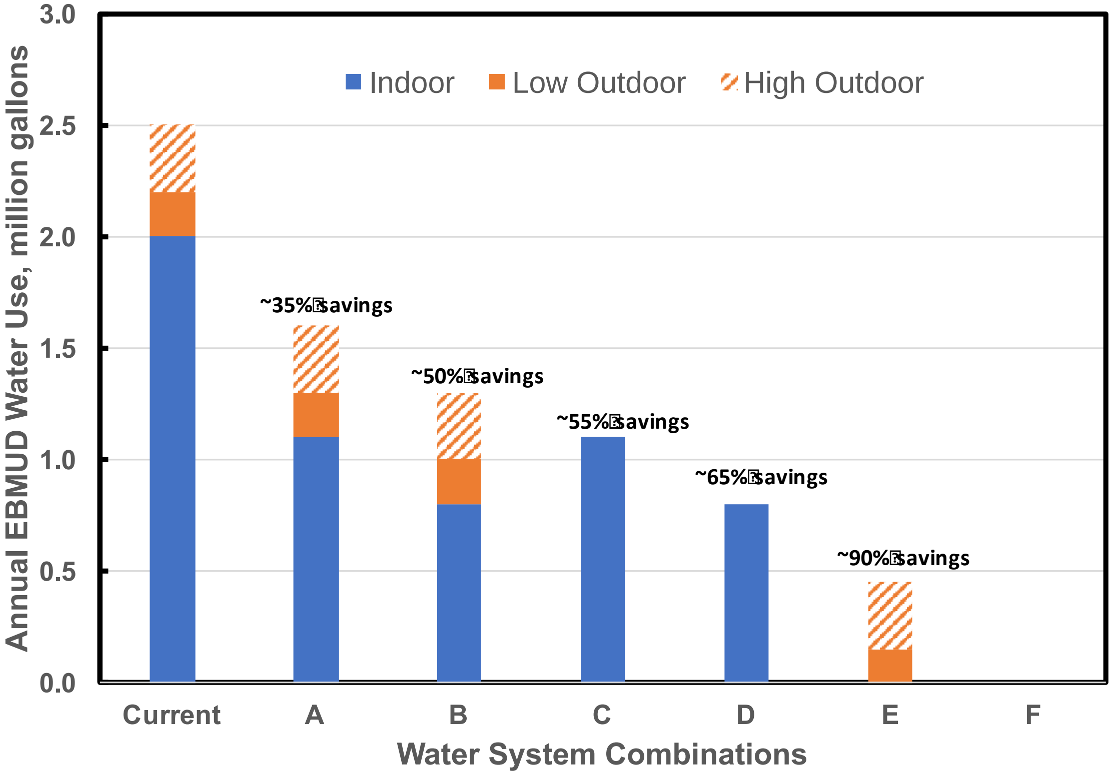
For all other systems shown in Table 4-6, capital costs alone appear to exceed the NPV of strict economic benefits. Indirect benefits, subsidies, or rebates (Oakland's laundry-to-landscape rebate, for instance) may, in some cases, increase the benefit/cost ratio to a value greater than 1. Rainwater harvesting can provide stormwater benefits and can increase the sustainability and resilience of existing water supply systems. The city of Austin, Texas, will cover up to half the cost of a rainwater harvesting system (up to a maximum rebate of $5,000) (Austin Water 2018).

Though most of the systems evaluated do not appear to make economic sense for the EcoBlock, it is worth considering the following questions:

- Could the block achieve zero net water?
- Could the block go completely off the water grid?

Figure 4-9 and the ensuing discussion shows the potential of various combinations of efficiency interventions and one or more of the systems shown in Table 4-6 to decrease the block's reliance on EBMUD. Given the uncertainty discussed above regarding outdoor use, its value is shown by the range 200,000 (solid orange) to 500,000 (dashed orange) gallons per year. The greywater diversion—laundry-to-landscape strategy can be a component of any of the six possibilities shown.

Figure 4-9: Block EBMUD Water Use for Various System Combinations



Source: UC Berkeley

A shows the effect of installing highly efficient appliances. The reduction, approximately 900,000 gallons per year represents over one-third of residents' current consumption.

In **B,** installation of highly efficient appliances is coupled with large-scale adoption of potable rainwater use (either through rainwater harvesting with treatment at individual residences, or through block-scale treatment). This reduces the EcoBlock's annual EBMUD water use by an additional 330,000 gallons per year (1.2 million gallons per year in total).

In **C,** appliance upgrades coupled with irrigation demand met by groundwater or reclaimed wastewater drop annual demand for EBMUD water to ~1.1 million gallons per year. Outdoor efficiency upgrades (such as drip irrigation and native landscaping) could be part of this scenario, decreasing demands on the irrigation water source (sewer or groundwater).

In **D,** EBMUD demand drops to ~800,000 gallons per year. Here the interventions of **C** are coupled with use of rainwater for potable uses through rainwater harvesting with treatment at individual residences, or through block-scale treatment.

E shows the impact of employing a rainwater-based direct potable reuse system coupled with appliance upgrades. The direct potable reuse system would meet all indoor demands. EBMUD water would be used **only** to meet outdoor demands.

In **F, no** EBMUD water is required, except for fire protection. This could be achieved in one of two ways. In the first, groundwater for potable use would be used to meet all of the block's water supply needs. The block would **continue** to use the sanitary sewer system and EBMUD would treat its wastewater. In the second alternative, rainwater harvesting for direct potable reuse would meet indoor demands, and outdoor demands would be met by either groundwater for irrigation or reclaimed wastewater for irrigation extracted from a nearby manhole. Here the block would **not** use the sanitary sewer system to transport its wastewater, **nor** would it require EBMUD to treat its wastewater.

F suggests that achieving zero net water **and** going off grid are theoretically possible. To do so would be expensive, require overcoming substantial regulatory barriers, and would likely be unpopular (the public is not ready for direct potable reuse, and local groundwater could well be less palatable than the water provided by EBMUD.

Stormwater

The benefits of green stormwater management infrastructure differ from those of the other system analyzed in one major way—there are typically **no** direct, quantifiable water savings. Benefits can be substantial, but:

- they can be hard to quantify and value
- they tend to accrue across the community as a whole, **not** primarily for the block

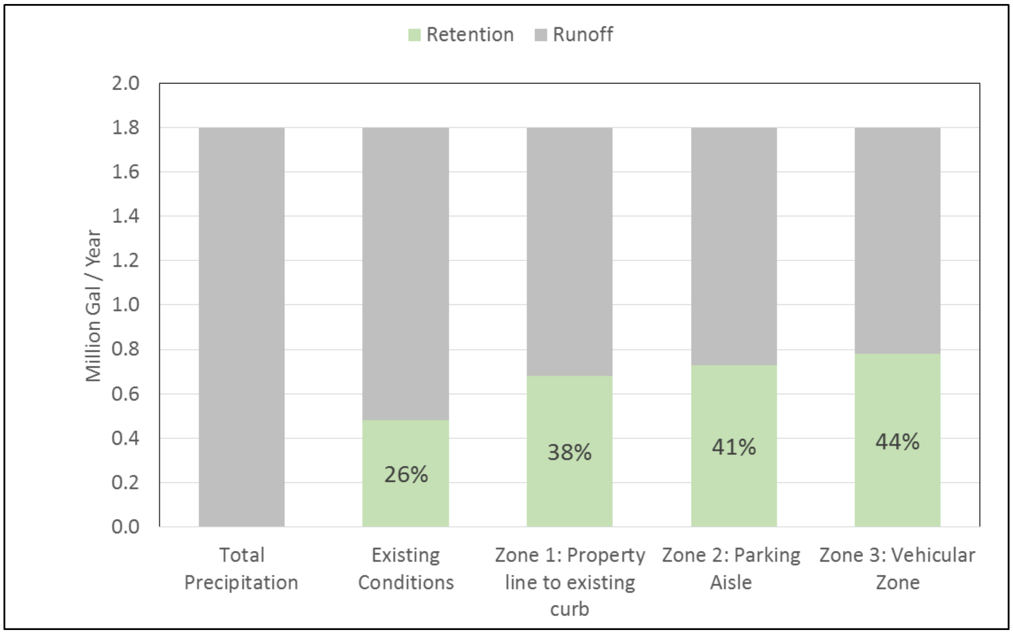
Decreased and delayed surface runoff lessens impacts downgradient from the block (flooding, for instance), decreases demands on drainage infrastructure, lowers peak stream flow rates and total volumes, and decreases contaminant loadings (Nylen and Kiparsky 2015; SFEP 2017). Infiltrated water that vegetation can extract benefits the block; water that recharges aquifers may benefit the block, but may also be used by the larger community. Similarly, while the primary benefit of rainwater harvesting is to provide water for human use, rainwater's capture and storage also decreases stormwater runoff and the contamination associated with it.

Predicting the performance and value of stormwater interventions is difficult because soil properties and hydrologic conditions strongly affect performance and are highly site specific, and these conditions are often not well understood.

Local governments and agencies value green stormwater systems. New developments and major site renovations typically require use of BMPs designed to manage stormwater quality and the rate and volume of runoff from the site (U.S. EPA 2017b). Finding funding to do the same for existing sites can be difficult.

Figure 4-10 provides a rough estimate of the current average runoff on the block (1.3 million gallons per year), compared to the runoff and infiltration expected after implementation various BMP combinations. Figure 4-11 shows where the interventions occur.

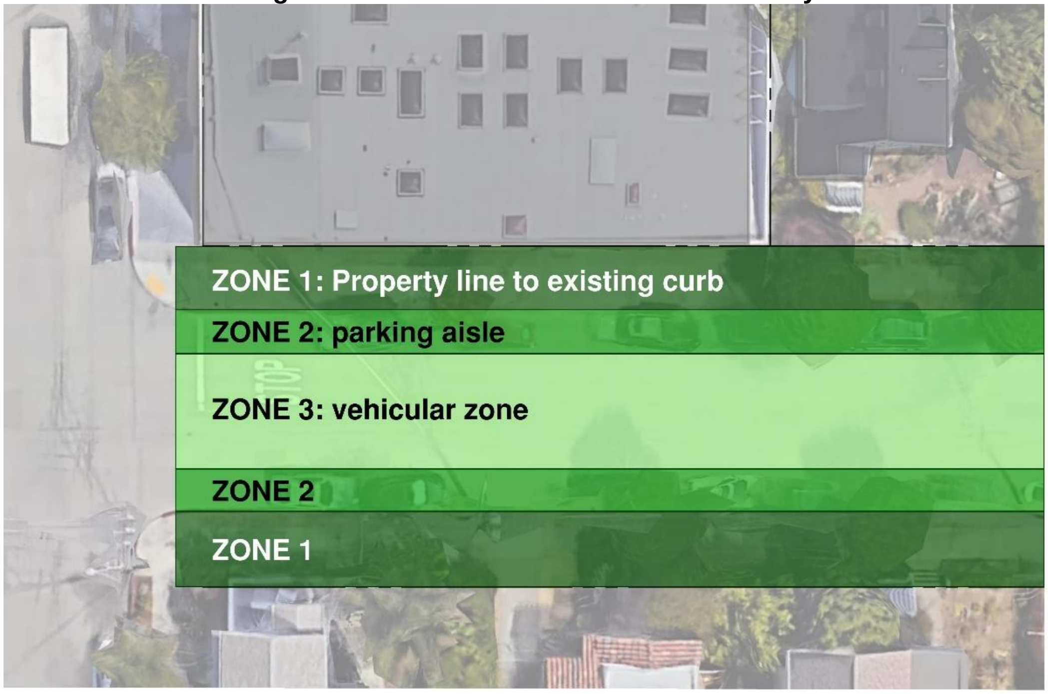
Figure 4-10: Stormwater Retention versus Runoff



The zones are additive, meaning that the Zone 2 runoff vs. retention calculation also assumes that improvements were made in Zone 1; Zone 3 represents BMP implementation in Zones 1, 2, and 3.

Source: Sherwood Design Engineers

Figure 4-11: Green Infrastructure Case Study



Zone 1 assumes no disruption beyond the existing curb line. Improvements include reducing imperviousness by replacing sidewalks and driveways with porous paving and increasing landscaping and street trees. Zone 2 assumes the parking aisle is replaced with pervious pavement. Zone 3 assumes the full street redesign with permeable paving across the full width of the street.

Source: Sherwood Design Engineers

Results Discussion

From the analyses presented above, the team arrived at the following key conclusions:

- Efficiency upgrades make economic sense, have high public acceptance, and reduce water demand by about 35 percent.
- Greywater diversion could replace ~2 percent of current EBMUD use at a reasonable cost.
- Use of groundwater to meet all EcoBlock water demands (that is, potable use) appears to be promising economically; however, for this system there are important, additional considerations and costs.
    - It is not yet known if a well on the block could provide water of sufficient quality and quantity.
    - There will be substantial operation and maintenance (O&M) costs—probably greater than $20,000 per year (Janzen et al. 2016).
    - The system would be considered a public water system, subject to a range of organizational, reporting, regulatory, and operational requirements (Santa Rosa SWRCB 2014; California Water Boards 2017a,b).
    - The block would have to collect water meter data and bill residents.

    - As California's Sustainable Groundwater Management Act comes into effect, controls on groundwater extraction may be imposed (EBMUD 2017c; CDWR 2018.
- The rainwater harvesting for potable use through block-scale treatment and rainwater harvesting for DPR systems would also be considered public water systems and therefore subject to the requirements for such systems.
- All of the systems that distribute water throughout the block will require an organization to collect meter data and bill residents.
- O&M and monitoring costs for the rainwater harvesting for DPR and reclaimed wastewater for irrigation systems are likely to be ~$60,000 per year ($50/month/resident) (CSA 2012).
- The benefit/cost ratio for the groundwater for irrigation system would look much better if there were one or more large users (parks, for instance) or users with year-round non-potable needs (cooling water).
- Treatment costs for small wastewater reclamation systems show a large dependence on scale. Overall treatment costs per 1,000 gallons can drop by 50 percent when going from a 10,000 gpd plant to 25,000 gpd plant (CSA 2012).
- Utility and local government rebates programs (Austin Water 2018; LADWP 2018) can often cover a substantial fraction of the costs of purchasing and installing water saving appliances and systems.

Indirect benefits

Many of the systems provide indirect benefits that are often hard to quantify. Any of the systems providing irrigation water could benefit water utilities like EBMUD by reducing capital cost requirements that result from having to supply 40 to 50 percent more water in summer than in winter (EBMUD 2015).

Much of the precipitation captured by rainwater harvesting systems would otherwise become stormwater runoff, with its associated problems. The rainwater harvesting for potable use through treatment at individual residence or thorough block-scale treatment systems could capture ~15 percent of the precipitation that falls on the block. Coupling rainwater tanks with smart stormwater control measures (Melville-Shreeve et al. 2016) could increase this benefit. In cities with combined sewer systems,[20] such as San Francisco and Sacramento, reducing stormwater runoff is of particular importance. Additionally, these systems would lower demand on EBMUD during winter and spring months, which could permit the utility to bank more water in aquifers. This banked

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[20] A combined sewer system is a sewer that accepts storm water, sanitary water/sewage, and most likely industrial waste water. This type of gravity sewer design is no longer used in building new communities (because current design separates sanitary sewers from storm water runoff), but many older cities continue to operate combined sewers

water could then be extracted and used in summer months, and also be a reserve source during droughts (EBMUD 2015).

Location impacts

Utility rates and rate structures can strongly influence the quantifiable benefits of a particular intervention. EBMUD's lowest tier for residential volumetric water charges (~$6.10/1000 gallons) is lower than that of many utilities. San Francisco's are 80 percent higher. Santa Barbara's are 30 percent higher while its charges for the next tier are almost three times higher than EBMUD's (and the higher rate begins at a lower use level). At the other end of the spectrum, Bakersfield residents served by California Water Service (Cal Water) currently pay about $2.50/1000 gallons.

Temperature and rainfall vary greatly across California. Oakland receives roughly four times as much rain as Bakersfield, but only 60 percent of that in Eureka. Eureka's rainfall is also spread out over a greater part of the year. Thus rainwater harvesting will make more sense in Eureka that in Bakersfield. For identical plots Bakersfield's hot, dry summers cause irrigation demands to be much greater than Oakland's. In cooler, rainier Eureka irrigation demands are considerably less in Oakland.

The EcoBlock has about 400 square feet of roof per person. In more suburban areas, roof area per person may be much higher; in areas dominated by multi-story, multifamily structures, per capita roof areas may be substantially lower. All else being equal, rainwater harvesting systems will have more value where the roof area is higher.

Integration

Urban water landscapes are complex, interacting mixtures of (human-impacted) natural systems and human-made infrastructure. Development of "sustainable urban water systems" requires an integrated, systems-wide approach that includes inputs from, and meets the needs of, many parties. These parties include residents; businesses; water and wastewater utilities; local transportation, public works, and planning departments; and state and federal regulatory agencies. Actions at an EcoBlock will affect systems and conditions in neighboring areas both directly and indirectly. Similarly, neighbors' actions will affect an EcoBlock.

Stormwater management provides a clear example of this interconnectedness. In cities with conventional stormwater systems, most precipitation becomes surface runoff, picking up contaminants and moving quickly out of the system. This is in contrast with natural systems, where most precipitation is held in the system and slowly released to plants, to surface waters, or to groundwater basins (Figure 4-2). Green stormwater infrastructure attempts to mimic natural systems, storing precipitation and releasing it slowly; decreasing pollution and lowering storm drain demands. If Oakland could infiltrate an additional 10 percent of annual rainfall, an additional 3 billion gallons (on average) of water annually would be available for plants, to increase dry weather flow in streams and to recharge groundwater. Additionally, contaminant loadings from surface runoff would decrease. In most cases the primary beneficiary of green infrastructure on a block will be the community at large, not the block itself. Block residents will benefit from similar actions on other blocks, and overall benefits will be maximized when actions are coordinated across a larger system.

Stormwater management can benefit greatly from rainwater harvesting systems. At the EcoBlock about 20 percent of precipitation falls on roofs. Its collection and utilization would provide direct value to residents and would lower demand on the centralized potable water system. It would also decrease runoff and could be coupled with green infrastructure to increase infiltration and recharge, thereby increasing groundwater supplies.

The choice and design of EcoBlock water interventions should always include collaboration with local agencies to ensure that efforts mesh with system-wide plans and goals, and to obtain support (rebates, for instance) for interventions that substantially benefit the larger community.

Water System Framework

Because local conditions (such as water supply source, capacity, and climate) vary widely across California, the appropriate mix of water system interventions is site specific. The team proposes a framework that starts with a set of **core elements** that:

- are likely to be applicable throughout the state, and
- face few, if any, permitting, regulatory, or organizational hurdles.

One or more site-specific "bolt-ons" could be added to the Core Project if found to be viable and fundable. The bolt-ons:

- typically require community action and/or development of site-scale infrastructure.
- often include significant permitting, regulatory, and/or operating requirements, and
- may primarily generate community-wide benefits.

Three (A thru C) of the four bolt-ons discussed below could well be viable and fundable in places other than the Oakland EcoBlock. The fourth (D) could be a component of a citywide stormwater management program. The bolt-ons provided relevant, concrete examples that other project teams (finance, legal, regulatory) could use in their analyses.

Core Project

The proposed Core Project for the Oakland EcoBlock would provide significant water savings and include elements that are cost-effective and implementable in many places and at many scales. The Core Project emphasizes rainwater harvesting and demand reduction actions that are well accepted by the public and are implemented at individual residences. This Core Project meets the criteria of the EPIC grant that funded this project—that is, it includes technological advancement and ratepayer benefits—and is integrated with the proposed energy scenarios. It includes the following:

- **Efficiency upgrades (indoors):** Fixture and appliance retrofits within homes (coordinated with the proposed deep energy retrofits).
- **Efficiency upgrades (outdoors):** Native planting and efficient irrigation systems within private properties (as necessary).
- **Greywater diversion:** Private "laundry to landscape" greywater diversion for irrigation.
- **Individual rainwater harvesting:** Private rainwater harvesting for irrigation and rainwater harvesting for potable use through treatment at individual residences.

Figures 4-13 and 4-14 illustrate these components at the individual home and block scale.

The only part of the Core Project that pushes boundaries is rainwater harvesting for potable use through treatment at individual residences. As of January 2017, these systems are permitted in California jurisdictions that adopt Appendix K of the 2016 California Plumbing Code. Though Table 4-6 indicates that costs exceed direct benefits for private potable rainwater systems at the Oakland EcoBlock, they are included in the Core Project because:

- They may be able to provide important indirect benefits that have not yet been quantified.
- They could be valuable in other parts of California and beyond.
- They are not currently widely used in California. Use on the EcoBlock could provide valuable information on performance of such systems, how to improve performance, and how to ensure proper operation and maintenance, which could lead to a better understanding and acceptance of these systems.

Use of rainwater for potable purposes on the EcoBlock would occur only after extensive testing of a residence's system ensures that it produces water that meets drinking water standards, and only if the household chooses to do so.

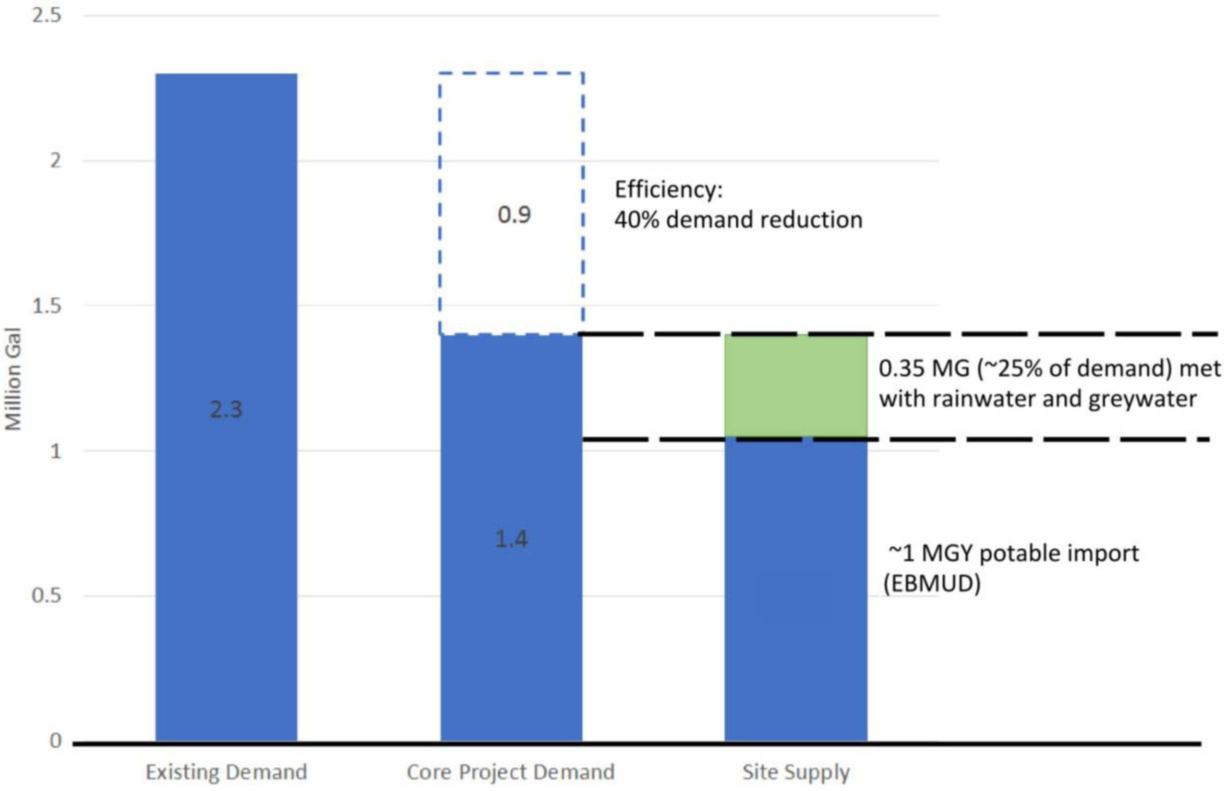
Figure 4-12 shows the estimated water savings that could be realized in comparison to existing block water demands. By incorporating the proposed efficiency and alternative water systems proposed in the Core Project alone, our analysis suggests that in a typical year the EcoBlock could:

- Reduce potable demand from the existing block demand of ~2.3 million gallons per year (MGY) to approximately 1.4 MGY (an approximately 40 percent demand reduction).
- Widespread adoption of rainwater harvesting for two strategies—potable use through treatment at individual residences and greywater diversion–laundry to

landscape—would lower potable water demand by an additional 0.35 million gallons per year (~25 percent of the block's demand, after efficiency measures are implemented).

The remaining EBMUD demand is estimate to be ~1 MGY, less than half of the block's estimated current demand.

Figure 4-12: Core Project Water Balance



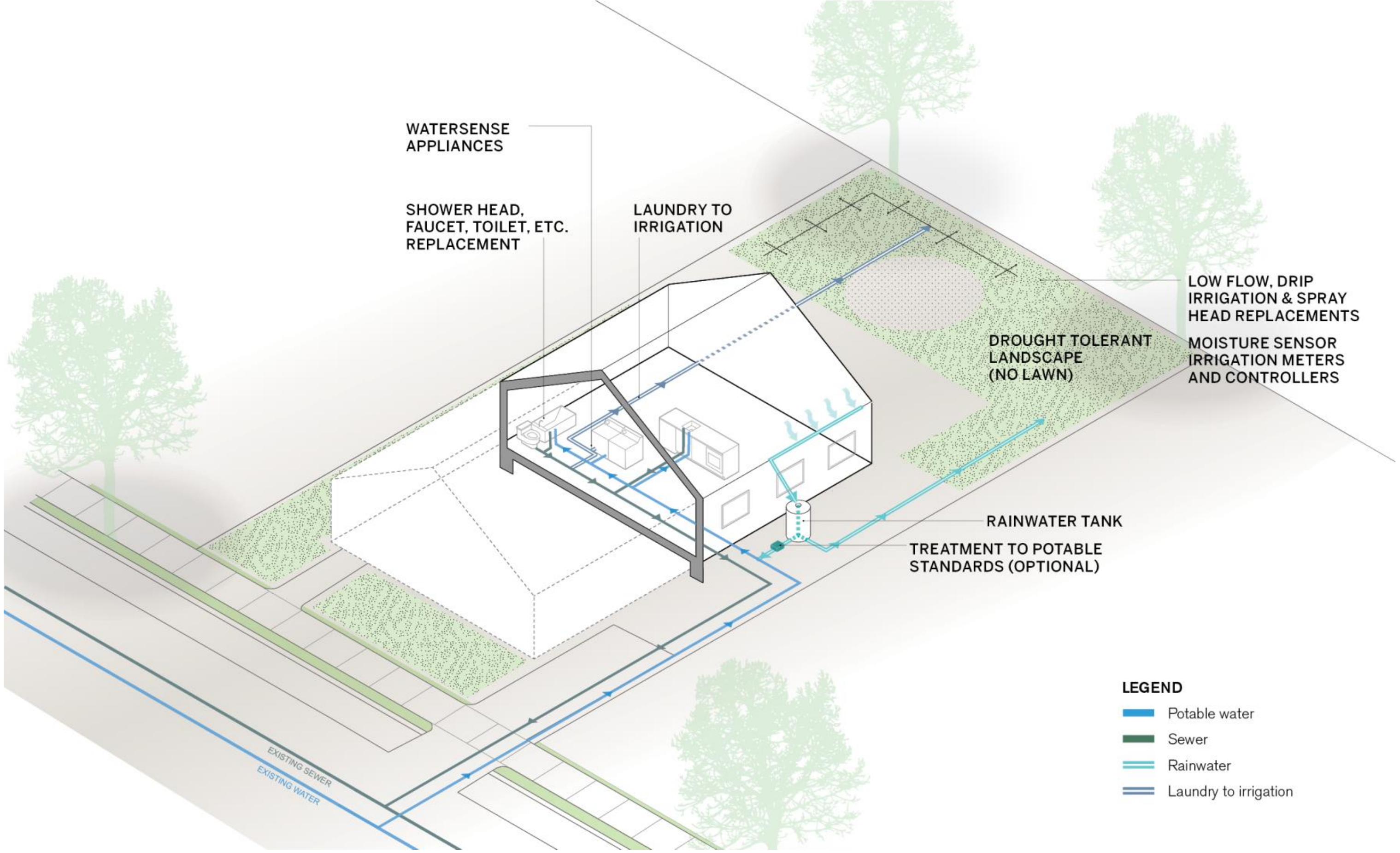
The core project incorporates indoor and outdoor water efficiency measures that reduce the existing block demand from ~2.3 MGY to ~1.4 MGY. The alternative water sources (rainwater and greywater) included in the core project could supply up to ~0.35 million gallons year (~25 percent of the projected demand).

Source: Sherwood Design Engineers

Figure 4-13 shows the house-scale water components included in the Core Project.

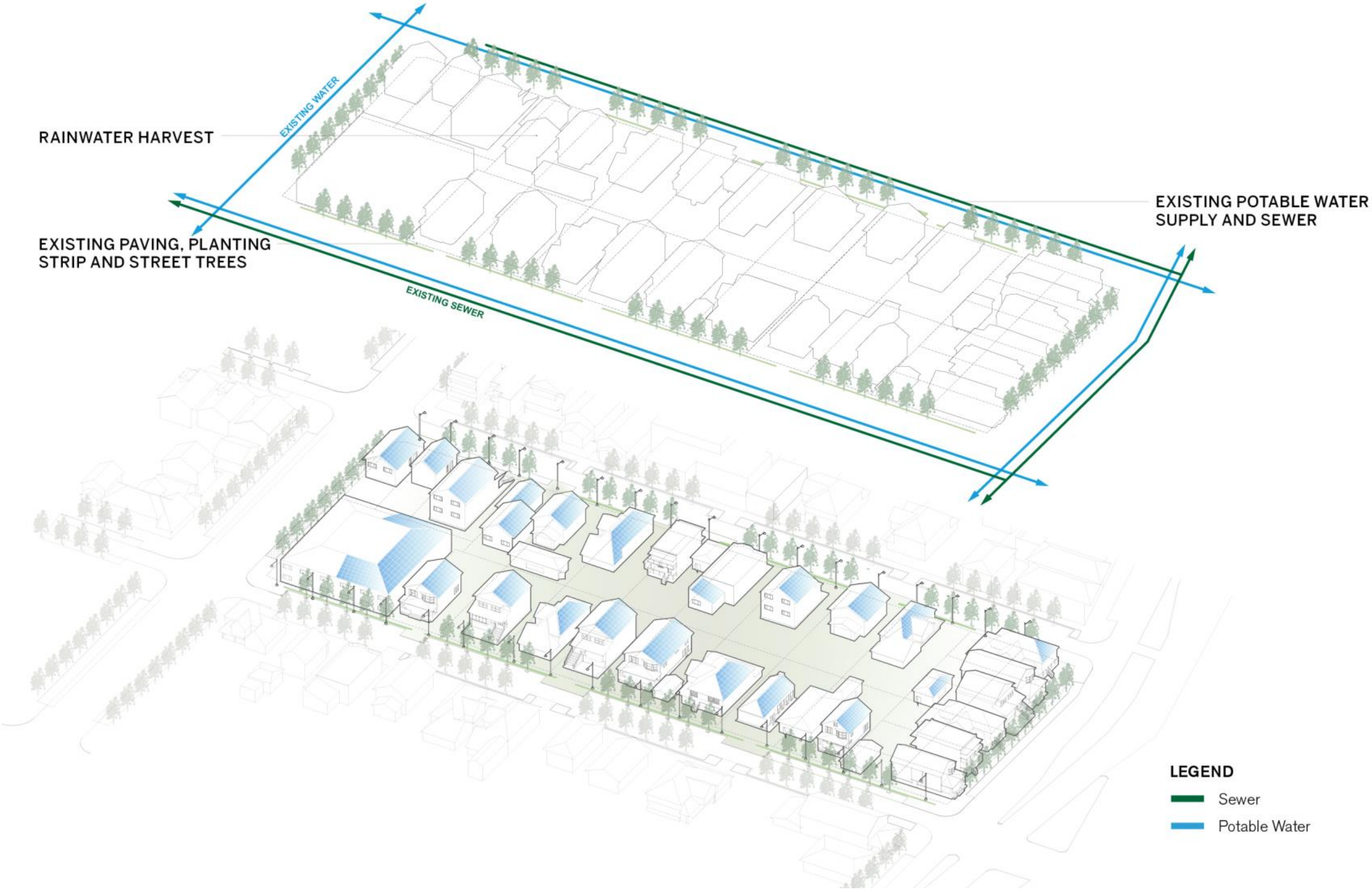
There are no block-scale water components included in the Core Project. Figure 4-14 shows the existing conditions and infrastructure on the block, all of which will remain as currently configured.

Figure 4-13: Core Project – House Diagram



Scenario 1w - Core Project. Efficiency and alternative water supply at individual homes, including greywater diversion (laundry to landscape) and rainwater harvesting for irrigation demands or potable interior demands (optional)
Source: Skidmore, Owings & Merrill, LLP

Figure 4-14: Core Project – Block Diagram



Core Project includes: efficiency and alternative water supply at individual homes, including greywater diversion (laundry to landscape) and rainwater harvesting for irrigation demands or potable interior demands (optional)

Source: Skidmore, Owings & Merrill, LLP

Bolt-ons

All the systems included in Table 4-6 could be "bolt-on" candidates. A variety of factors must be considered before deciding whether to incorporate a particular bolt-on for a particular project:

- It must meet the project scale. Some bolt-ons work best at small scales, some at large scales, and for some, value is relatively independent of scale.
- Supplies must continue to meet the project's needs, given growth expectations and possible climate change effects.
- The produced water must be of acceptable quality, and the source(s) must reliably provide enough water.
- It must meet regulatory and institutional requirements.
- It must meet governance and organizational requirements.
- It must be publicly accepted.

The following sections discuss four possible bolt-ons for the Oakland EcoBlock, as well as considerations to be taken into account when assessing them.

Bolt-on A: Block-Scale Management of Rainwater Systems

A common challenge for rainwater harvesting systems is to design the system to collectively meet both water reuse and stormwater management goals. Systems often require unnecessary redundancy (for example, two storage tanks instead of one) to meet these simultaneous goals.

Active controls could be coupled with the Core Project's rainwater harvesting systems to increase their efficiency. These "smart" stormwater management systems (OptiRTC, for example) couple local weather forecasts and local system knowledge (such as roof area, tank capacity, current storage, and regulatory requirements) to determine when and how much water to release before a storm event. This type of system can minimize wet-weather discharge and increase infiltration while maximizing the volume of rainwater available for beneficial use.

At the Oakland EcoBlock, a "smart" system would include active control mechanisms installed at individual rainwater harvesting systems and a remote (web) management system and dashboard, which would enable collective control of the block's systems.

The team would further examine the technical feasibility, cost, and benefits of such as system at the Oakland EcoBlock in Phase 2 of this project.

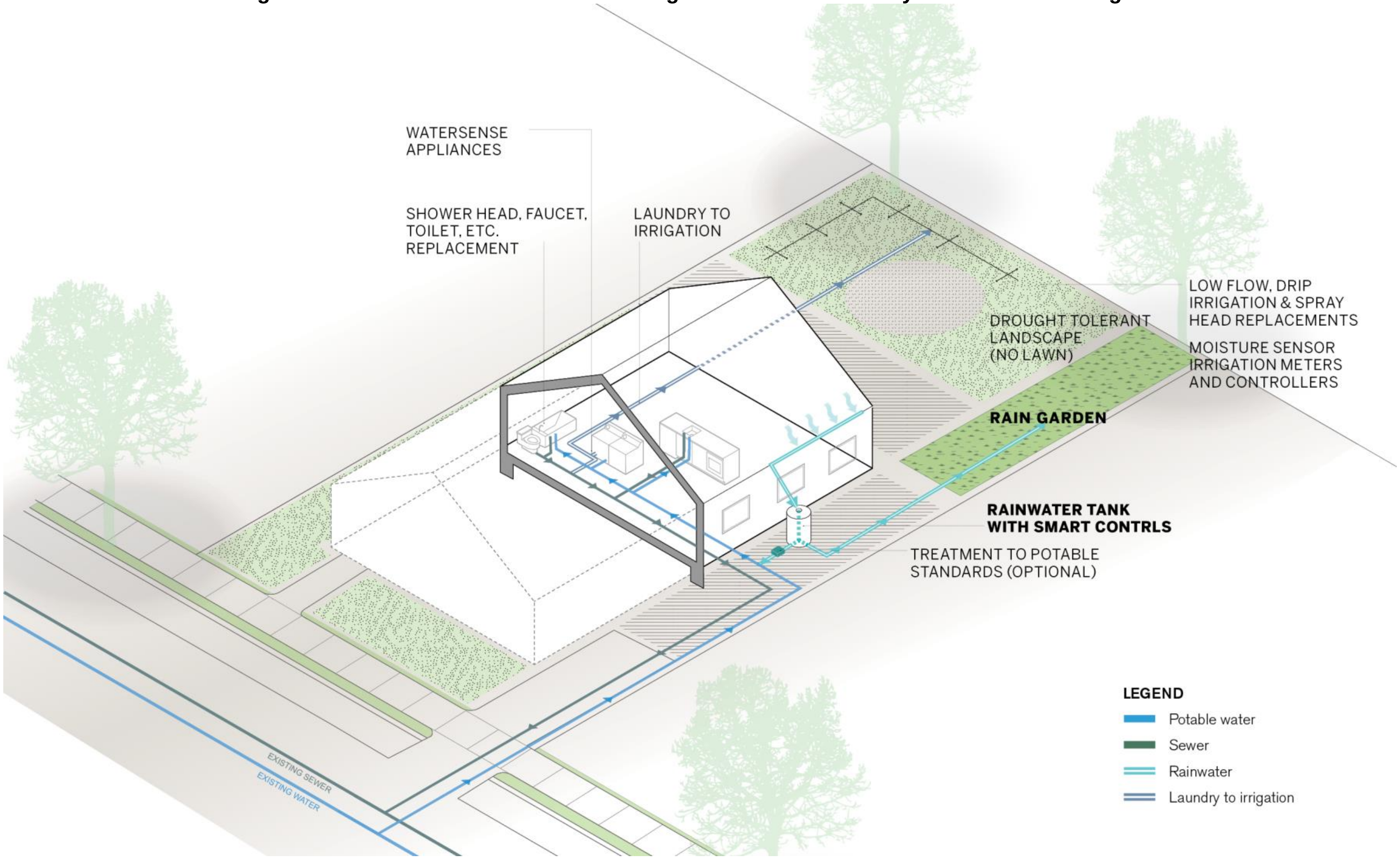
Key Implementation considerations:

- At the Oakland EcoBlock, rainwater harvesting tanks could be privately owned and operated at the individual residence. The management, however, could be collective, and require an entity or third party (see Chapter 6 for discussion). Extensive private property participation, collaboration, and buy-in would be required.
- These systems are increasingly common for new construction, but have yet to be tested in retrofit scenarios such as the Oakland EcoBlock. Third-party partnerships could be leveraged to implement and test the effectiveness of such systems in a residential/retrofit scenario.
- Smart stormwater systems can be optimized to meet a specific site's goals and requirements, including:
    - **Stormwater regulations**: The systems can help projects meet regulatory requirements for stormwater discharge rates and volumes.
    - **Rainwater harvesting**: The systems can maximize the amount of rainwater used at the site, while meeting stormwater management requirements and minimizing required storage volumes.
    - **Combined sewer overflows:** In cities with combined sewer (CS) systems (such as San Francisco and Sacramento) reducing peak wet weather flow rates by retaining water during storms and releasing it after the peak flow has passed can substantially reduce discharge of raw sewage to receiving waters.
    - **Hydromodification**: Rapid urban runoff to rivers and creeks can cause environmental damage. Smart stormwater systems release water slowly, more closely mimicking natural systems.
    - **Water quality**: Smart stormwater systems can decrease contaminant uptake and also remove contaminants.

      Water quantity: The systems can increase the quantity of rainfall infiltrated. This infiltration can decrease local irrigation needs, increase dry weather flow in local streams, and increase aquifer storage

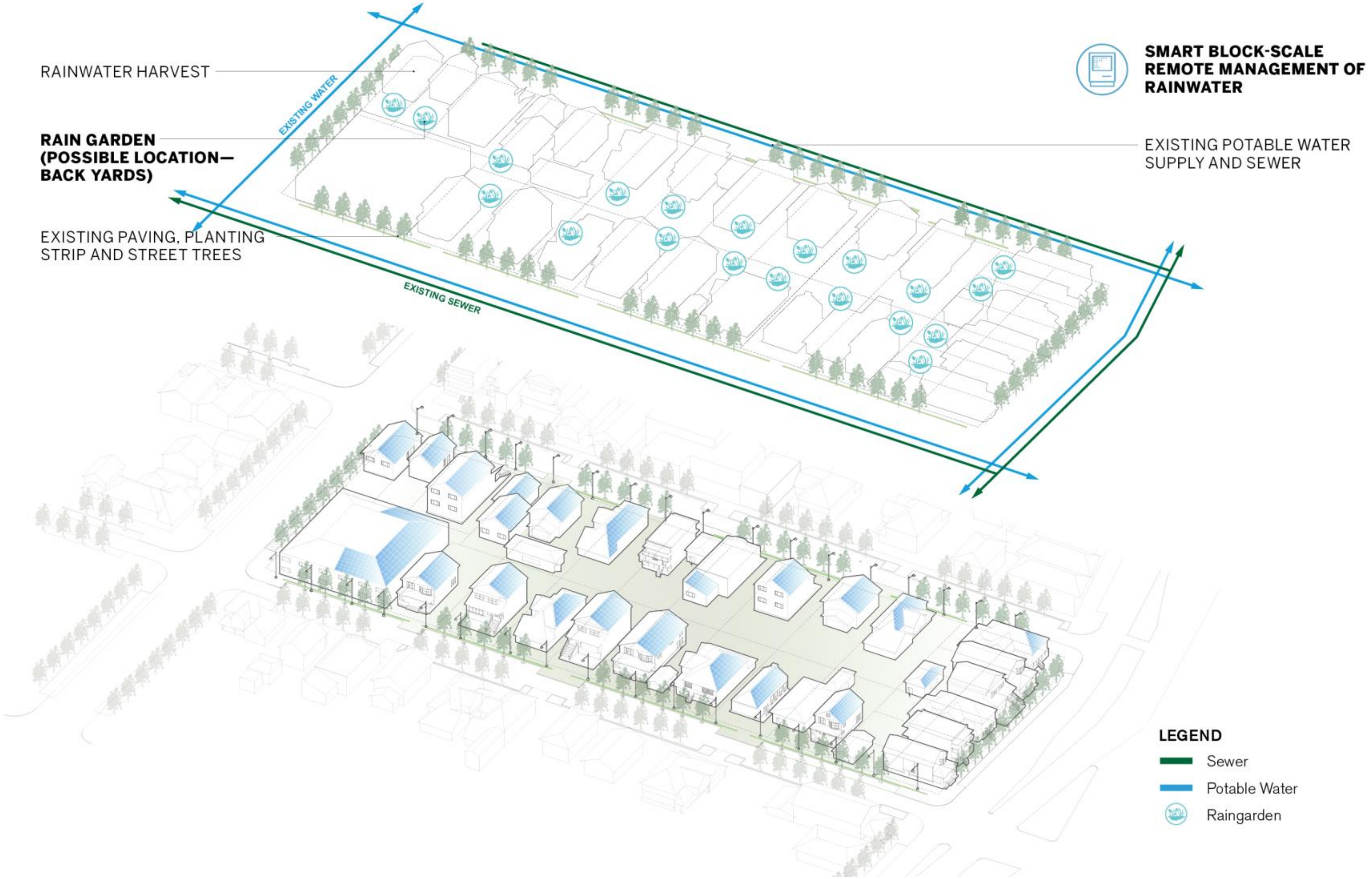
Although implementation of Bolt-on A (Figure 4-15 and Figure 4-16) would improve efficiency of the rainwater harvesting system, it would not directly affect the water balance, so no water balance figure is provided here as it is for the others.

Figure 4-15: Bolt-on A: Block-Scale Management of Rainwater Systems – House Diagram



Bolt-on A: Block-Scale Management of Rainwater Systems.
Source: Skidmore, Owings & Merrill, LLP

Figure 4-16: Bolt-on A: Block-Scale Management of Rainwater Systems – Block Diagram



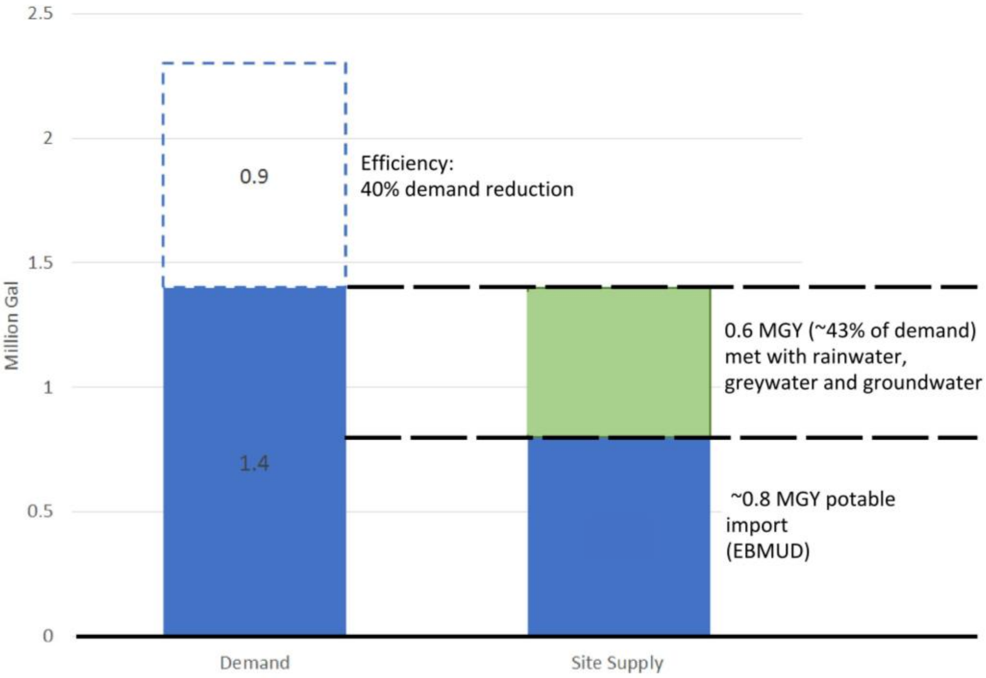
Bolt-on A: Block-Scale Management of Rainwater Systems.
Source: Skidmore, Owings & Merrill, LLP

Bolt-on B: Groundwater for Irrigation

Figure 4-17 shows the Bolt-on B water balance. Groundwater can be utilized as on-site water supply and reduce potable demand. Laterals (including a meter) at each residence connect the system to the block piping (Figure 4-18). A well extracts groundwater which is then pumped into non-potable distribution piping encircling the block (Figure 4-19).

Assuming that rainwater harvesting systems described in the Core Project are utilized for potable interior uses, the addition of groundwater as a resource could offset the remaining irrigation demand (~0.25 MGY). The remaining block potable demand is estimated to be ~0.8 MGY, approximately one-third of the existing demand.

Figure 4-17: Bolt-on B Water Balance



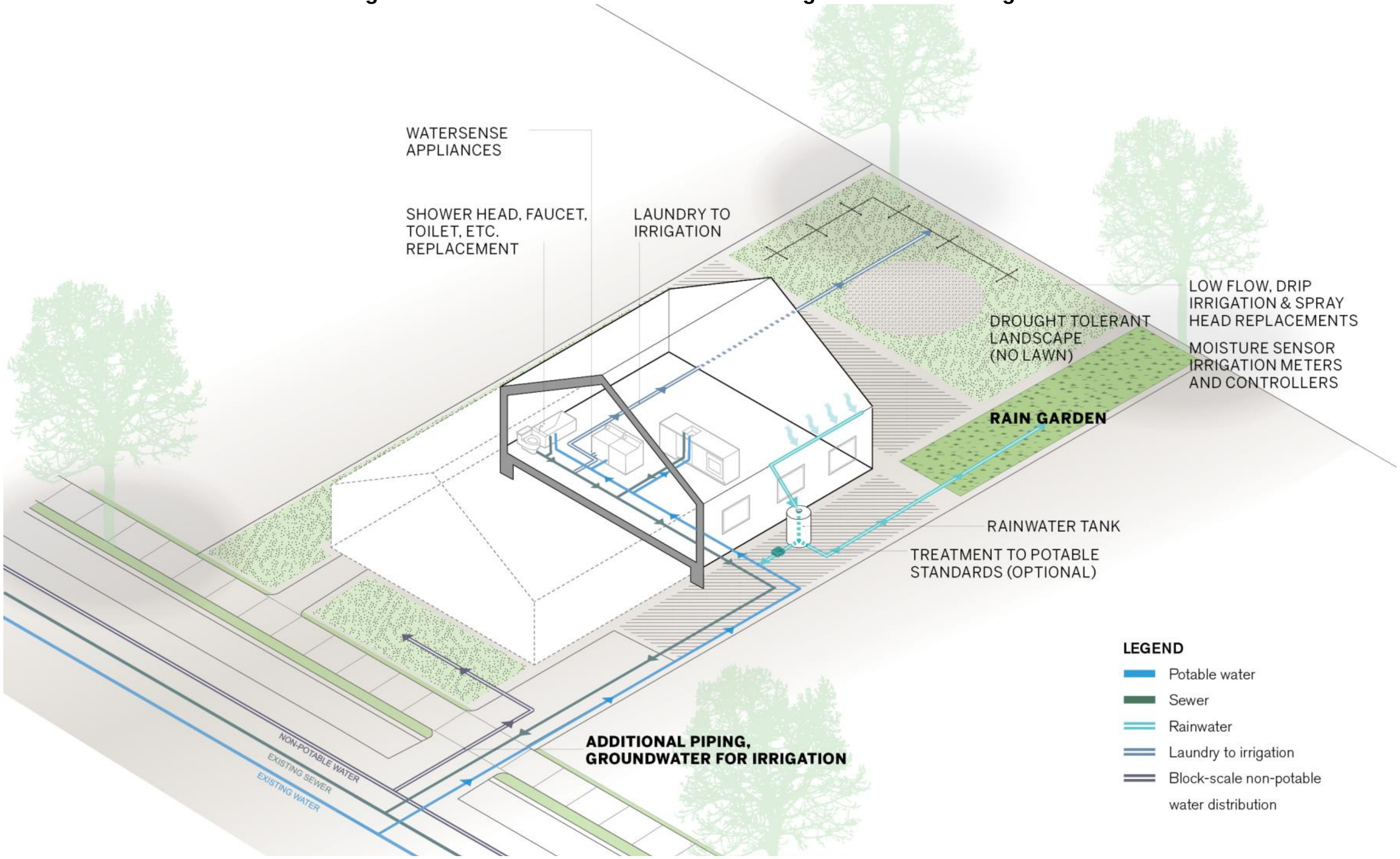
Bolt-on B adds groundwater as an alternative water source for irrigation. Assuming that rainwater harvesting is utilized primarily for potable interior demands, the addition of groundwater has the potential to offset an additional ~0.25 MGY. With this addition, site-sourced alternative water supplies rise to 0.6 million gallons per year (~43 percent of the projected demand after efficiency measures).

Source: Sherwood Design Engineers

Key Implementation Considerations:

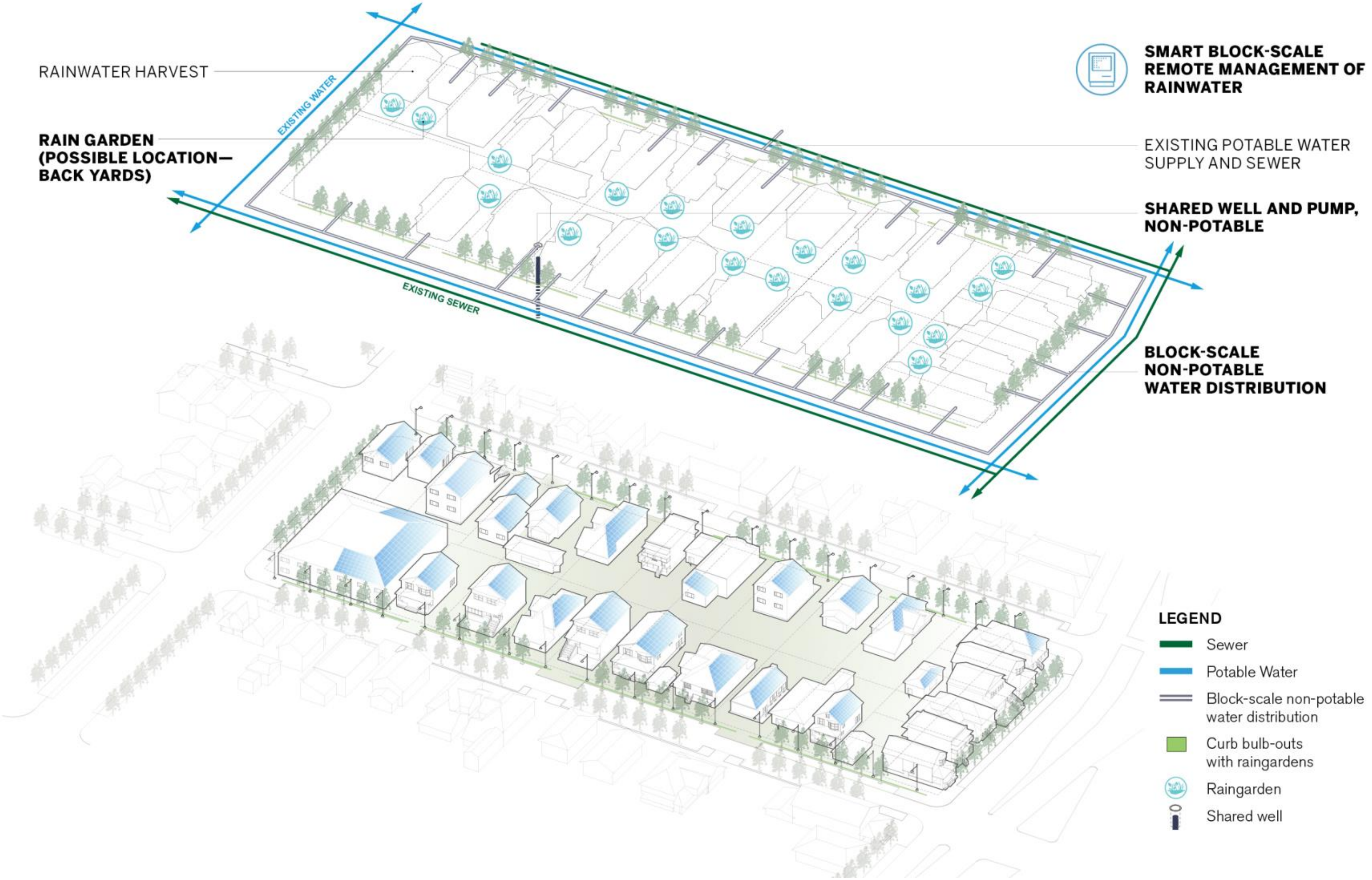
- Regulatory requirements for treatment and ongoing operation and monitoring are low for non-potable groundwater systems.
- Cost analysis indicates that piping costs typically dominate costs for non-potable groundwater systems and that the unit piping costs do not show significant scale dependence. Sites that have a higher non-potable demand within a relatively small area—for example, large parks and/or year-round industrial process water users—could see much lower per-gallon costs that would increase the financial viability of such a system.
- Implementation is highly site-specific. Implementation requires a site where groundwater resources are present and can be extracted at sustainable rates and good water quality.
- Implementation depends on development of a shared well and shared distribution infrastructure. Block-scale distribution of non-potable water will require piping within the public right-of-way or agreement for creation of a private utility easement within the interior of the block; the implications of this are discussed in Chapter 5.
- Groundwater extraction must be considered within the context of watershed-scale initiatives and requirements of the Groundwater Sustainability Act (EBMUD 2018b; CDWR 2018). Groundwater extraction could be coupled with green infrastructure that promotes stormwater infiltration and aquifer recharge (Bolt-on D, below) to ensure sustainable groundwater extraction. A watershed approach is likely to best ensure an optimal coupling of infiltration enhancements and groundwater extraction.

Figure 4-18: Bolt-On B: Groundwater for Irrigation – House Diagram



Bolt-On B: Groundwater for Non-Potable uses (Irrigation).
Source: Skidmore, Owings & Merrill, LLP

Figure 4-19: Bolt-on B: Groundwater for Irrigation – Block Diagram



Bolt-on B: Groundwater for Irrigation at Neighborhood Scale with Possible Green Infrastructure in a Public ROW.
Source: Skidmore, Owings & Merrill, LL

Bolt-on C: Sewer Mining—Reclamation for Irrigation

Reclaimed wastewater is another possible source to expand on-site water supply for irrigation. Figure 4-20 shows the Bolt-on C water balance. Unlike groundwater, which is highly dependent on site-specific hydrogeologic conditions and can be seasonally variable, wastewater offers the benefit of being a consistently available source year-round. Sewer mining is included over other wastewater reclamation strategies considered because it is less invasive (and less expensive) to mine wastewater from an existing city sewer main than to reconfigure sewer systems from homes.[21]

Wastewater is collected from the public sewer line at a manhole in the street adjacent to the block and pumped to a small-scale wastewater treatment facility, collocated with the flywheel station. The reclaimed wastewater is then pumped through non-potable distribution piping encircling the block (Figure 4-21). Laterals (including a meter) at each residence connect to the block piping (Figure 4-22).

The impacts of sewer mining on potable water demand are identical to those of groundwater for irrigation (either groundwater or reclaimed water would be used for irrigation demand, but not both). Assuming that the rainwater harvesting systems described in the Core Project are used for potable interior uses, the addition of reclaimed wastewater could offset the remaining irrigation demand (0.25 MGY) (Figure 4-20). The remaining potable demand is estimated to be ~0.8 MGY.

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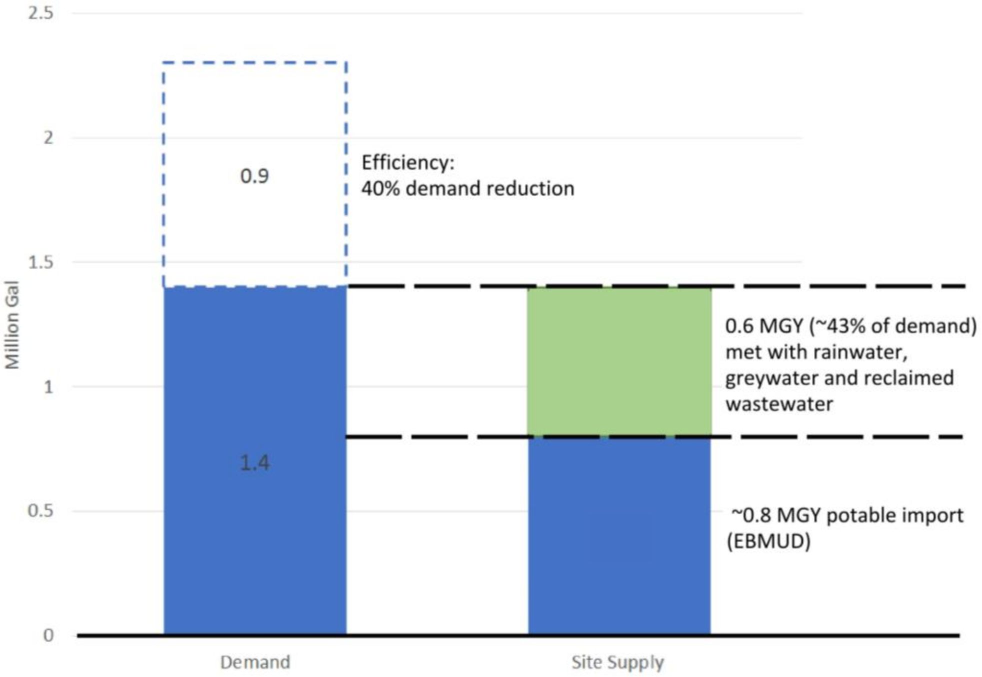
[21] It should be noted that the ability to mine wastewater is dependent on the presence of a sanitary sewer main with sufficient flow to be able to extract wastewater to serve non-potable demands, while also maintaining adequate flow rates and velocities within the sewer pipe.

Figure 4-20: Bolt-on C Water Balance



Bolt-on C adds reclaimed wastewater as an alternative water source for irrigation. As with Bolt-on B (groundwater), reclaimed wastewater is estimated to offset approximately 0.25 MGY. With this addition, site-sourced alternative water supplies rise to 0.6 MGY (~43 percent of the projected demand after efficiency measures).

Source: Sherwood Design Engineers

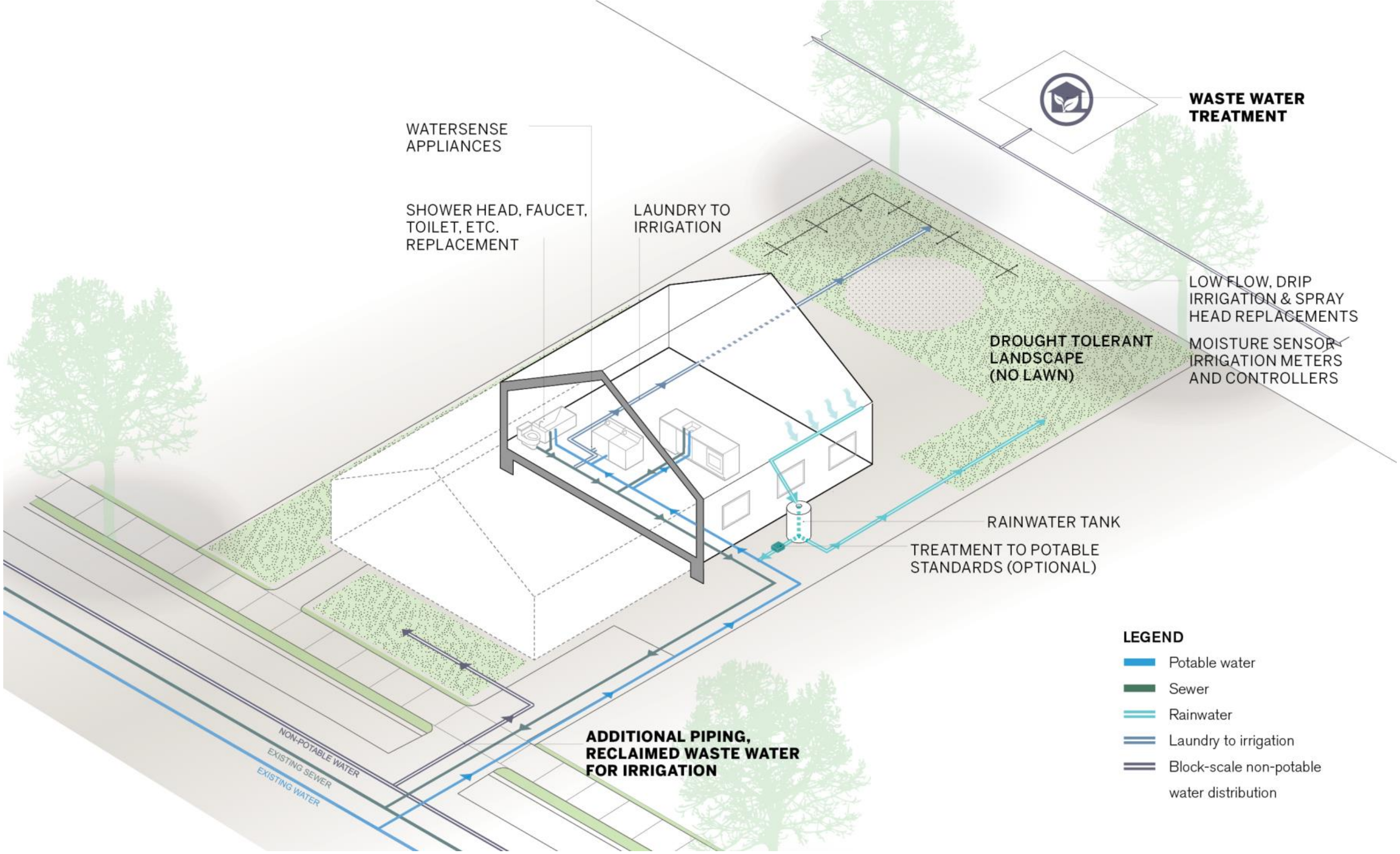
Key Implementation Considerations:

- Use of recycled wastewater was met with some hesitance from residents, even for non-potable uses (see discussion in Chapter 11). Implementation would be dependent on community buy-in to use reclaimed wastewater as a source.
- EBMUD does not have current plans to extend municipal recycled water to the Oakland EcoBlock. However, in the Bay Area many wastewater utilities—including Palo Alto, San Jose, and EBMUD—provide tertiary-treated waters to large water-using customers for irrigation, cooling, and other non-potable purposes. Where municipal recycled water facilities are planned, decentralized systems such as these may not make sense.
- The system requires availability of sufficient wastewater at a nearby sewer main. Extraction would have to have no impact on downstream sewer flow and velocity.
- Financial viability requires that the project be of adequate scale. Capital, O&M, and monitoring costs of wastewater reclamation systems show substantial economies of scale. Most current reclamation systems typically rely on large users (EBMUD 2015; Lee et al. 2013). Sites that have users with high non-potable water demand—such as a large park and/or a year-round industrial user—could

lower unit costs substantially and increase the project's financial viability (Figure 4-23).

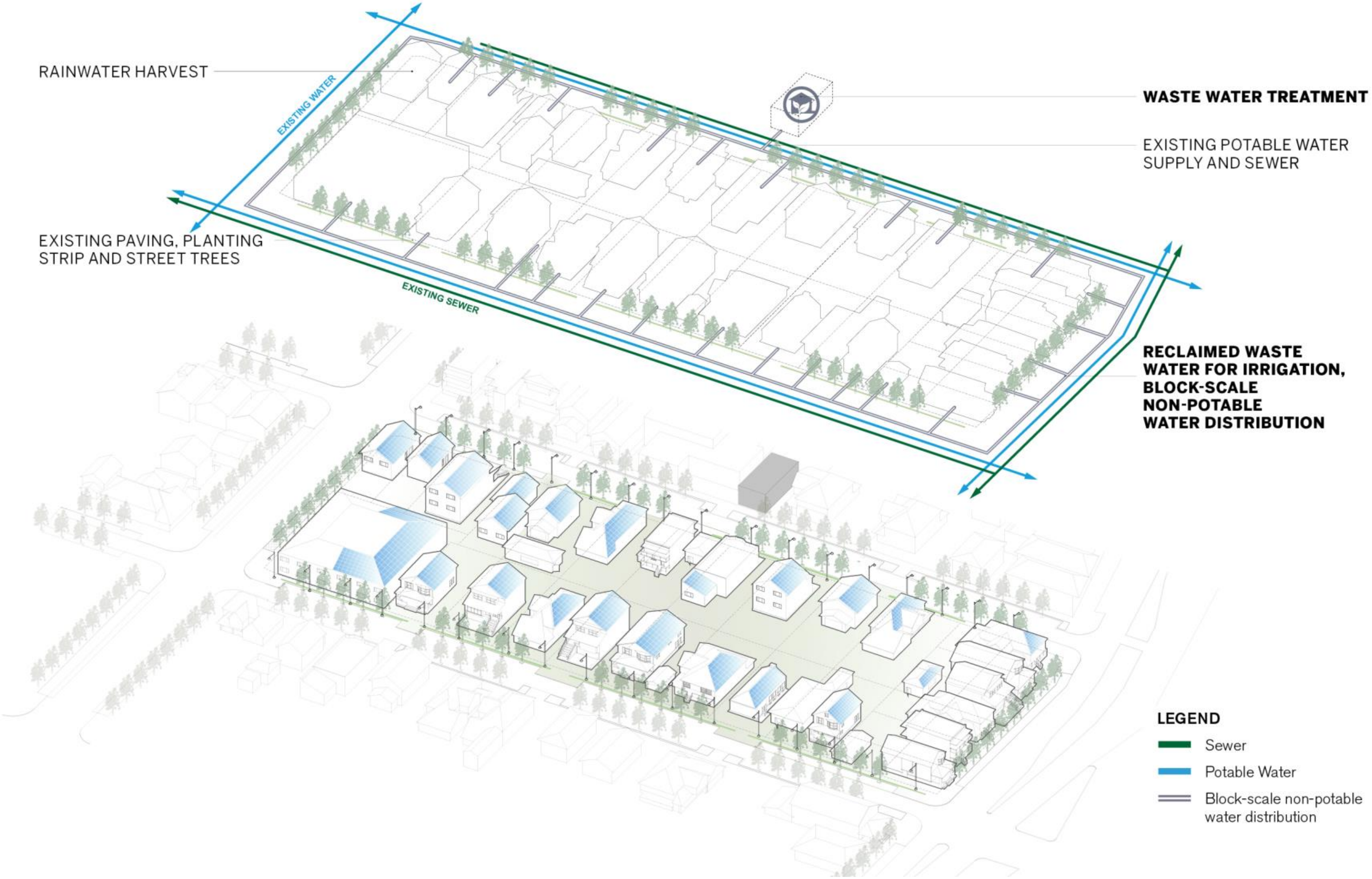
- California has strict water quality regulations/standards regarding reclamation and reuse of treated sewage, governed by Title 22 of the California Code of Regulations. System status and performance are closely monitored; frequent, often daily, testing of produced water is required. Technological advancements (such as real-time remote monitoring) could also substantially lower the cost/per gallon and increase the financial viability of such a system in the future.
- On-site reuse technologies are advancing rapidly. Third parties such as Veolia, Aquacell, Living Machines, Nexus eWater, and others have built businesses on providing treatment systems for recycling sewage at building and district scales (Phoenix 2017; Living Machine 2012; Nexus eWater 2017). Broader participation and coordination with third parties and the wastewater utility (EBMUD in this case) would be required to develop a viable financial and ownership model (this is discussed further in Chapter 6.

Figure 4-21: Bolt-on C: Sewer Mining—Reclamation for Irrigation – House Diagram



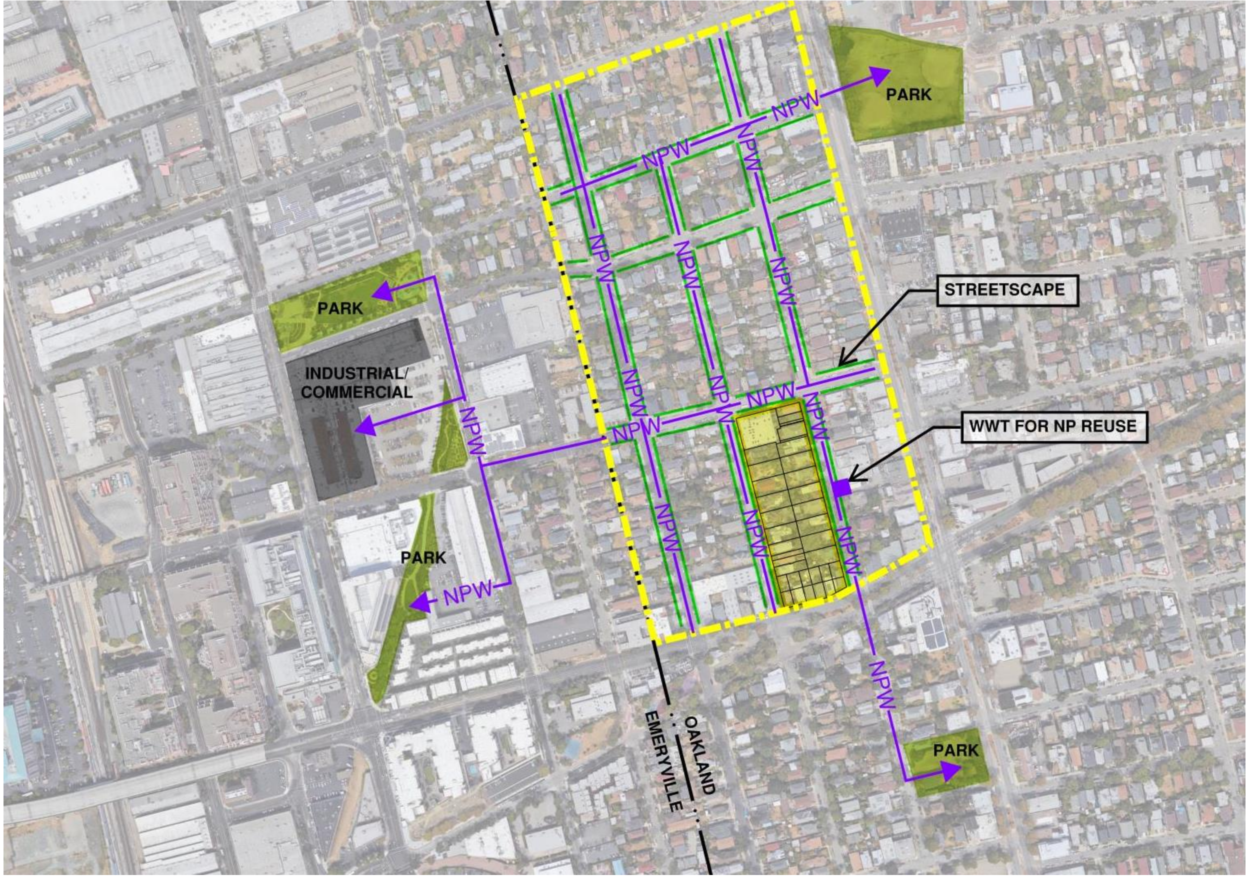
Bolt-on C: Sewer Mining—Reclamation for Irrigation for Non-Potable Water at Neighborhood Scale.
Source: Skidmore, Owings & Merrill, LLP

Figure 4-22: Bolt-on C: Sewer Mining—Reclamation for Irrigation – Block Diagram



Bolt-on C: Sewer Mining—Reclamation for Irrigation for Non-Potable water at the Neighborhood Scale.
Source: Skidmore, Owings & Merrill, LLP

Figure 4-23: Eco-Neighborhood



Treatment components of reclamation systems show substantial economies of scale. This diagrams suggests such a scaling opportunity, where the initial project at block scale is expanded to serve a variety of residential blocks, industrial users, and parks through the distribution network that extends over a greater service area.

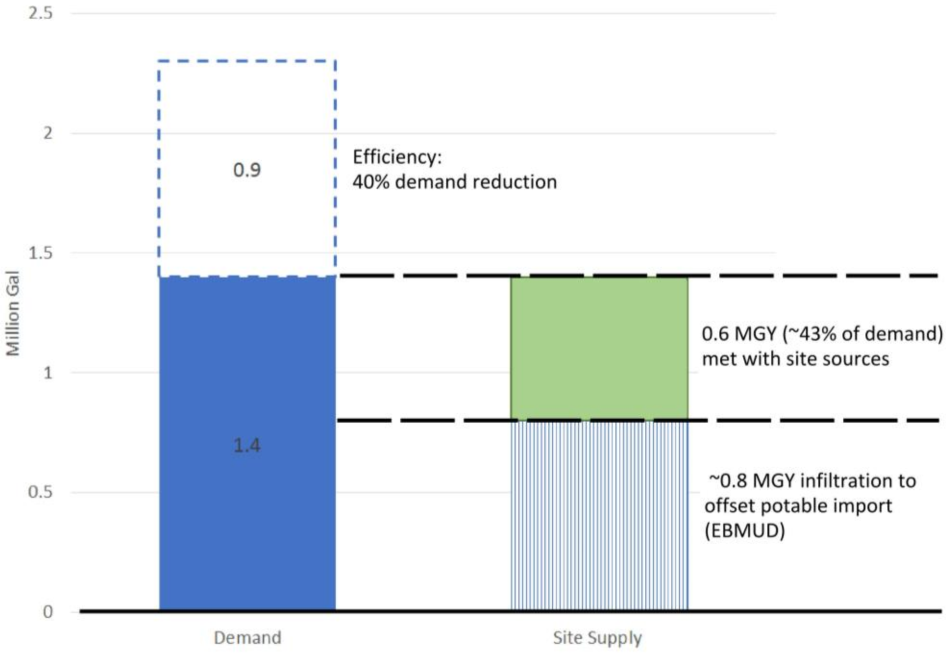
Source: Sherwood Design Engineers

Bolt-on D: Green Infrastructure

Green stormwater infrastructure is proposed with the primary aim of slowing surface runoff, and lessening the potential for flooding and contaminant runoff on and downgradient from the block. Water retained in the soil that vegetation can extract directly benefits the block; water that infiltrates and recharges aquifers may benefit the block, and may also benefit the larger community. Additional groundwater recharge could provide greater net on-site supply, and would be especially important if groundwater is proposed as a source for irrigation (see Bolt-on B).

Widespread implementation of green infrastructure on the block could increase on-site retention by an average of roughly 0.3 million gallons per year (Figure 4-10). By comparison, an estimated 0.8 MGY increase in infiltration over existing conditions would offset the remaining EBMUD potable demand (Figure 4-24). If engineered facilities were incorporated into the green infrastructure design to further enhance infiltration, the block would have the potential to fully offset potable demands and achieve a zero net water balance.

Figure 4-24: Bolt-on D Water Balance



Bolt-on D allows for enhanced retention of stormwater on site. Increasing infiltration by ~0.8 MGY over existing conditions would offset an amount equivalent to the remaining EBMUD potable demand. Analysis suggests that, for this block, specifically designed infiltration facilities would be required to achieve this metric.

Source: Sherwood Design Engineers

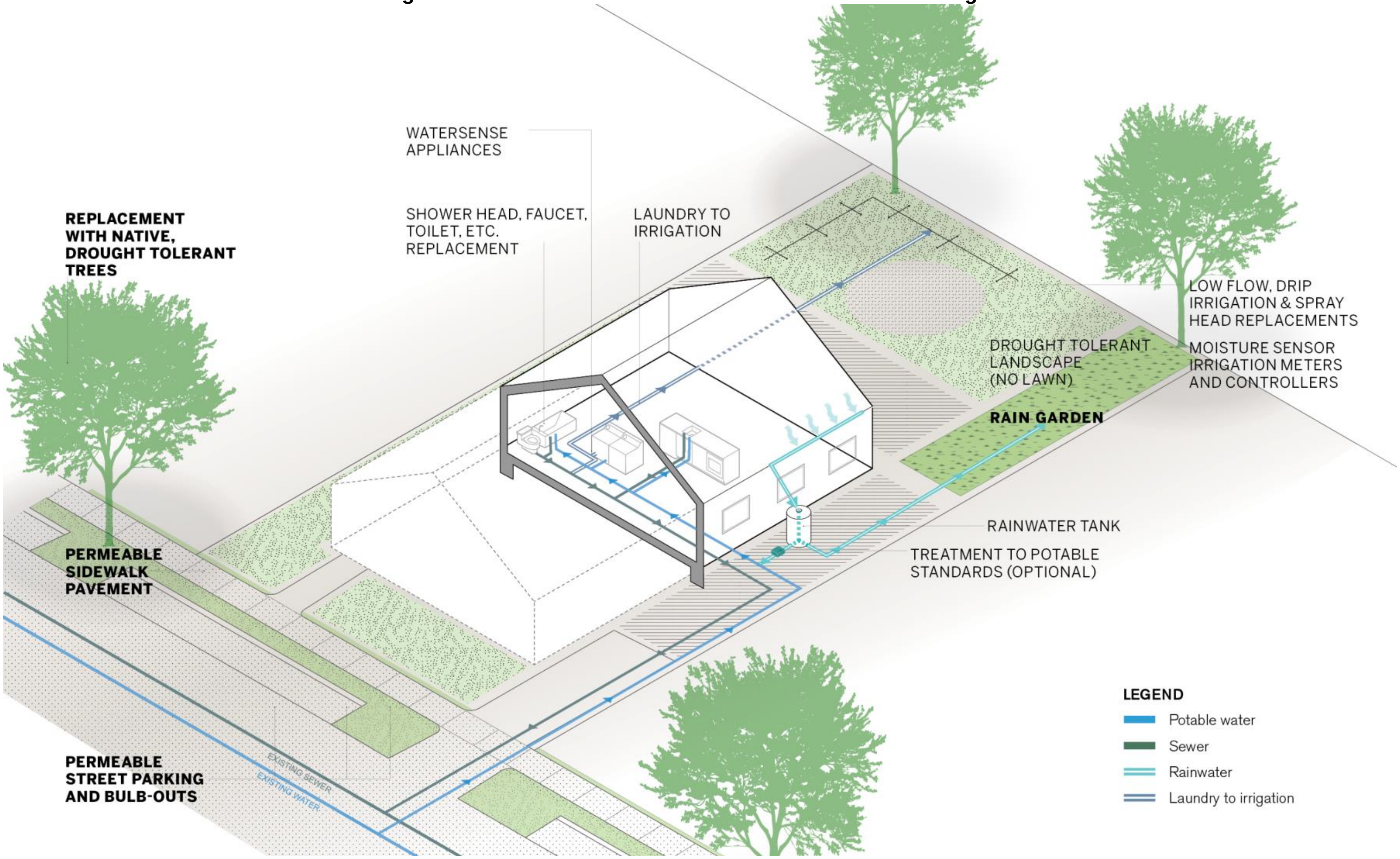
Green stormwater management strategies could be implemented on the EcoBlock within three zones of improvement shown in figures 4-25, 4-26, and 4-27.

Key implementation considerations:

- The benefits of green stormwater projects tend to accrue to the community at large, not just to residents of the project site. In addition, the benefits are location dependent; for example, cities with combined sewer systems, such as San Francisco and Sacramento, will have greater regulatory and financial incentives to decrease stormwater flows than those with separated systems.
- Facilitating infiltration may recharge aquifers, increasing their sustainable yield. These efforts may align with Groundwater Sustainability Act (GSA) initiatives and should be coordinated with the local agencies responsible for the GSA's implementation. There may be opportunities to leverage GSA funding.
- Creating green streets is not just about managing stormwater but is also about creating streets that promote biking, walking, and transit in a way that makes communities more livable. Retrofitting streets for livability is a key component in creating healthy and vibrant communities. Creating green streets provides an opportunity to transform a neighborhood's character and help the environment at multiple levels (SFEP 2017). There may be opportunities to leverage funding sources for projects that realize these multiple benefits.
- The benefits of green infrastructure are typically accounted for and paid for as a part of municipal-scale improvements and programs. Cities require and incentivize decentralized green stormwater infrastructure to mitigate the hydrologic impacts of urbanization. Funding opportunities can range from the federal to the local level and can include funds directed towards traditional gray infrastructure, rate-based fees used by cities to encourage programs, grants for specific projects, or others. An example of a local funding program is the City of San Francisco Wastewater Enterprise's Urban Watershed Management Program, which has partnered with the city's Community Challenge Grant Program (CCG) to offer grants for community-based projects that help manage stormwater using green infrastructure. These grants promote small actions by community members to realize cumulative benefits for San Francisco's watersheds and sewer infrastructure (SFPUC 2018).
- Stormwater bolt-ons will be viable when supported by, and integrated with, efforts of local governments and agencies. For the Oakland EcoBlock, coordination with the City of Oakland would be required to identify promising interventions, and to determine if and how to:

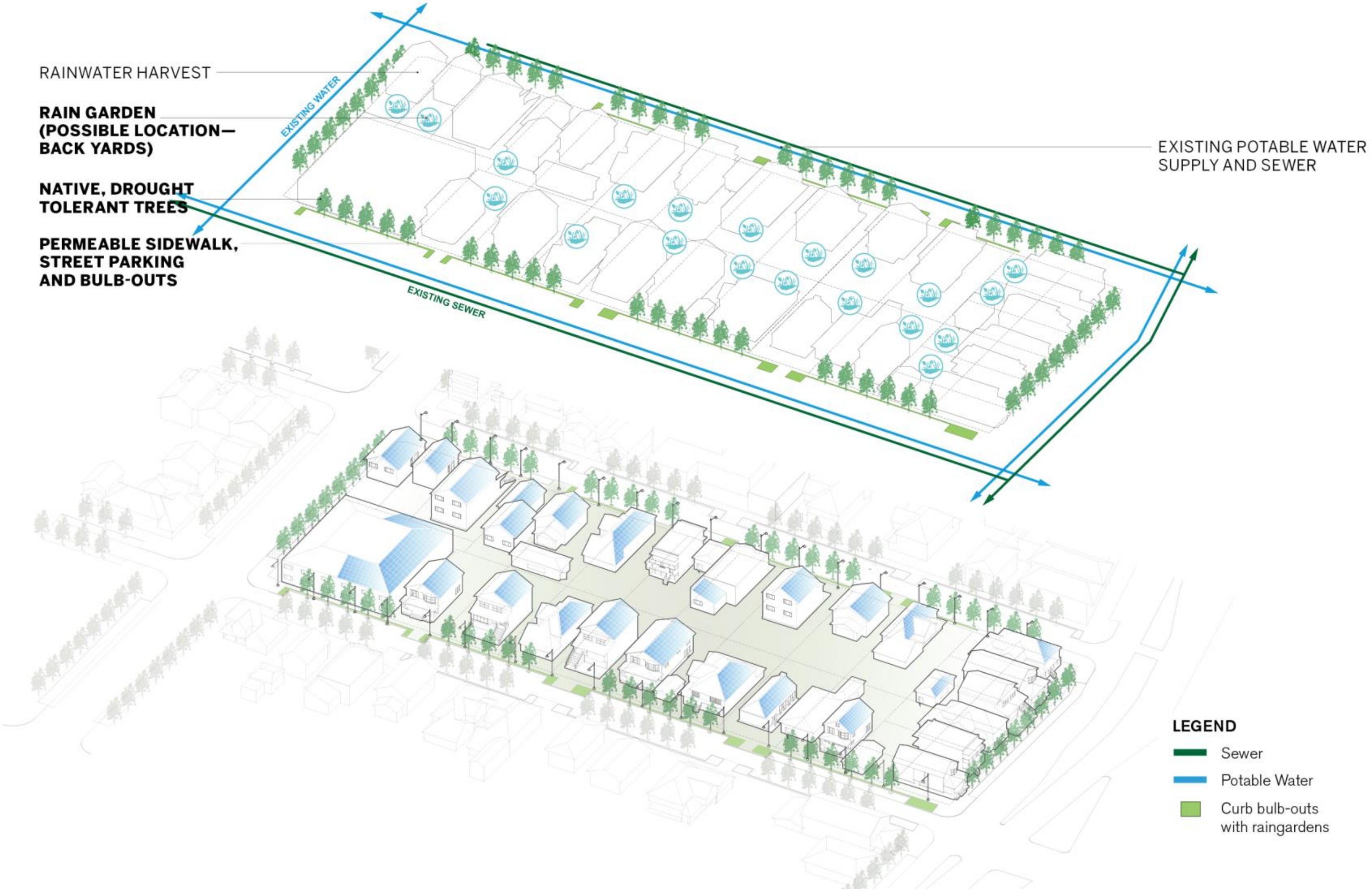
- Incorporate these interventions in coordination with maintenance and infrastructure replacement programs
  - Develop incentives and funding options, such as flood mitigation funds, green infrastructure grants, street repaving funds, and stormwater credit opportunities.

Figure 4-25: Bolt-on D: Green Infrastructure – House Diagram



Bolt-on D: Green Infrastructure in a ROW at Neighborhood Scale.
Source: Skidmore, Owings & Merrill, LLP

Figure 4-26: Bolt-on D: Green Infrastructure in a ROW – Block Diagram



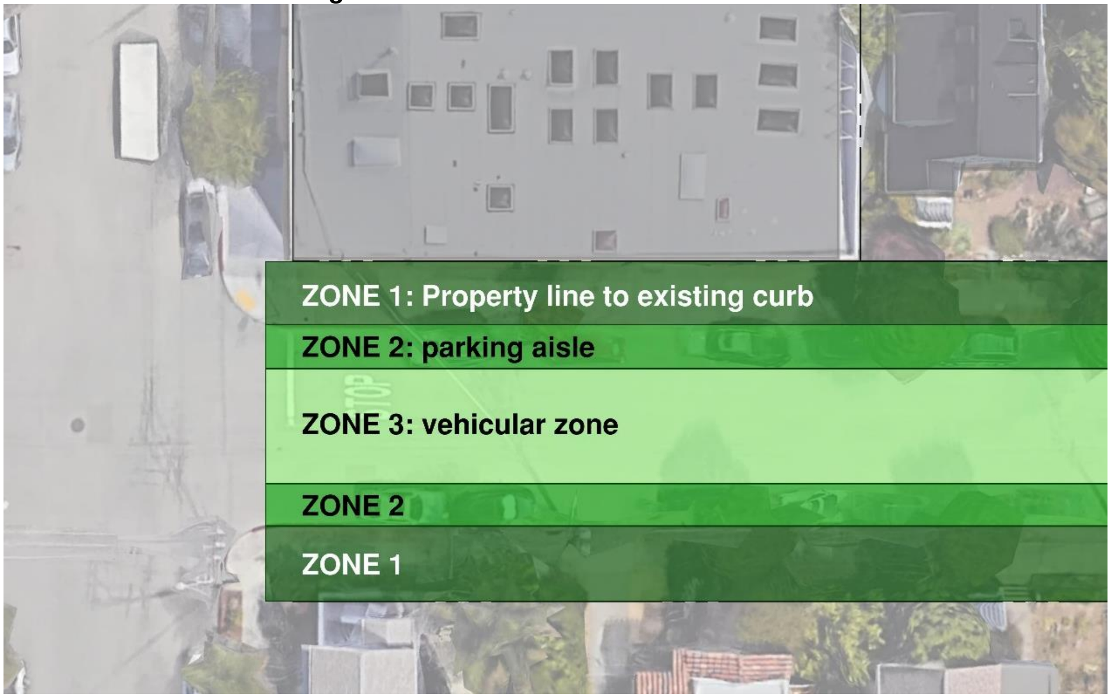
Bolt-on D: Green Infrastructure in a ROW at Neighborhood Scale.
Source: Skidmore, Owings & Merrill, LLP

Green Infrastructure Components

Green stormwater best management practices (BMPs) can be implemented at the individual house scale, at the block scale on private property, or in the public right-of-way.

Figure 4-27 illustrates the three zones where green infrastructure can be implemented.

Figure 4-27: Green Infrastructure Zones



Zones are delineated by the existing dimensions from property line to the curbline, parking aisle, and vehicular zone of the street. Zone 1 assumes no disruption beyond the existing curb line. Improvements include reducing imperviousness by replacing sidewalks and driveways with porous paving and increasing landscaping and street trees. Zone 2 includes bioretention curb bulb-outs and parking aisle replacement with pervious pavement. Zone 3 assumes the full street redesign.

Source: Sherwood Design Engineers

The team considered the following strategies (figures 4-28 through 4-31) for the Oakland EcoBlock:

Figure 4-28: Permeable Sidewalks and Planting Strips

Site design measures to reduce stormwater runoff include replacement of impervious surfaces with landscaping and permeable pavements. The photo above shows permeable sidewalks and a bioretention planting strip in Milwaukie, Oregon.

Photo: Milwaukie Green Streets

Figure 4-29: Residential Rain Gardens

Rain gardens (bioretention) can be created on private property to collect, cleanse, and infiltrate both stormwater runoff and rainwater (including excess from rainwater harvesting systems). Rain gardens can be coordinated with native planting improvements. The photo above shows a small residential rain garden in the City of Portland, Oregon (left), and Berkeley, California (right).

Photo: Portland Sustainable Stormwater Division

Figure 4-30: Bioretention Curb Bulb-out

Rain gardens (bioretention) in the public right-of-way of residential neighborhoods typically take the form of curb bulb-outs at street corners and mid-block within the parking aisle. Curb-cuts allow water from the street to enter the bioretention areas and promote cleansing and infiltration of stormwater runoff from roadways. The photo above shows bioretention in a curb bulb-out designed to collect stormwater from the street in San Bruno, California.

Photo: San Francisco Estuary Partnership

Figure 4-31: Permeable Streets

Permeable streets and/or parking lanes in the public right-of-way replacing typical asphalt or concrete street paving with permeable pavements (permeable concrete, asphalt, or pavers) filters pollutants and promotes infiltration into the subsurface. These strategies are best suited for areas with infiltrative underlying soils. The photo above shows pervious concrete roadways adjacent to a bioretention swale in the High Point neighborhood of Seattle, Washington.

Photo: Mithun

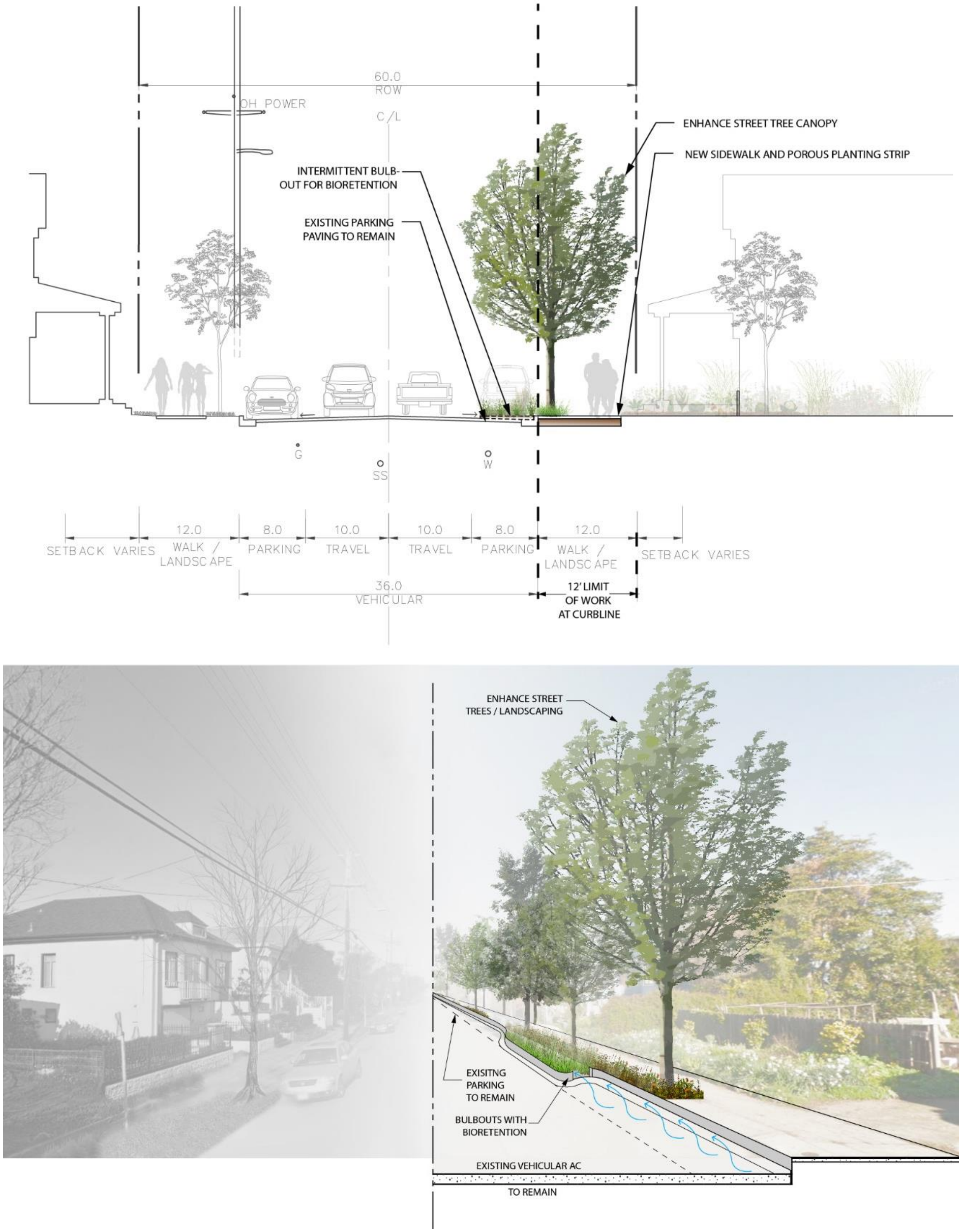
Figures 4-32 through 4-35 illustrate typical street sections with green infrastructure improvements in each of the three zones.

Figure 4-32: Existing Conditions at the Oakland EcoBlock

The streets surrounding the Oakland EcoBlock consist of an approximately 60-foot right-of-way (ROW) with a 20-foot wide drive aisle in the center and approximately 8-ft wide parking aisles on either side of the vehicular zone.

Source: Sherwood Design Engineers (Section); Photo: Google Earth

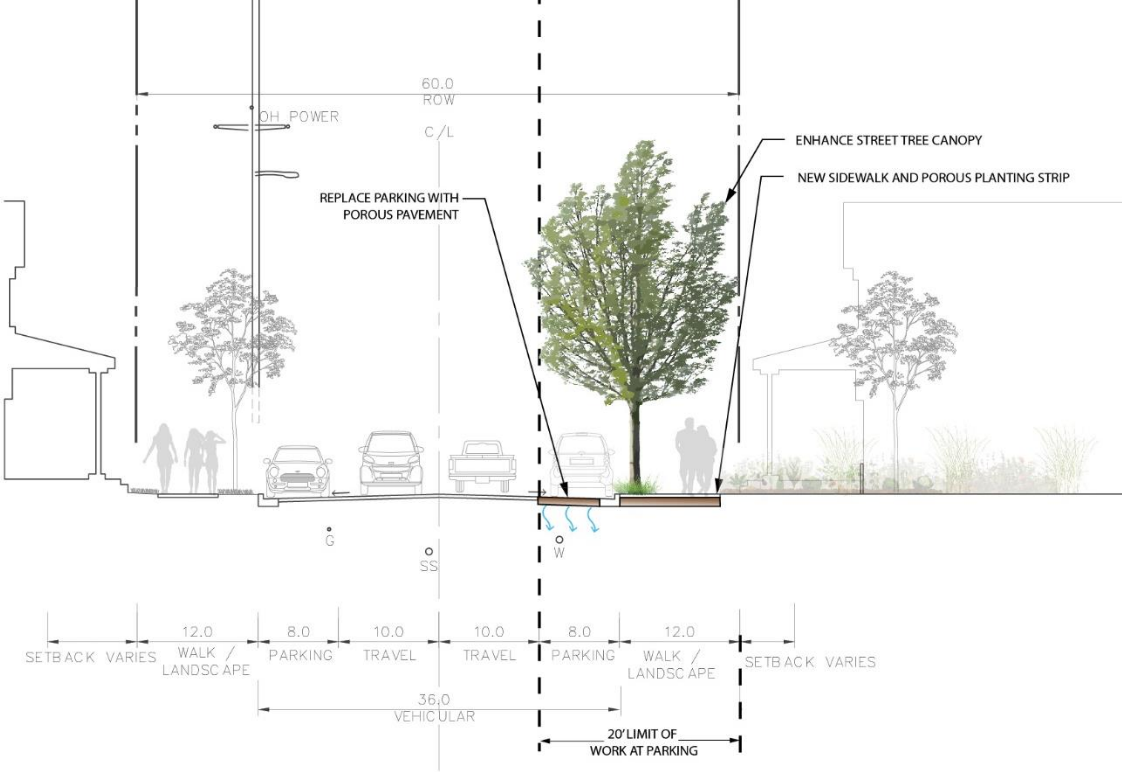
Figure 4-33: Zone 1 and 2 (partial) – Maintain Existing Vehicular Zone

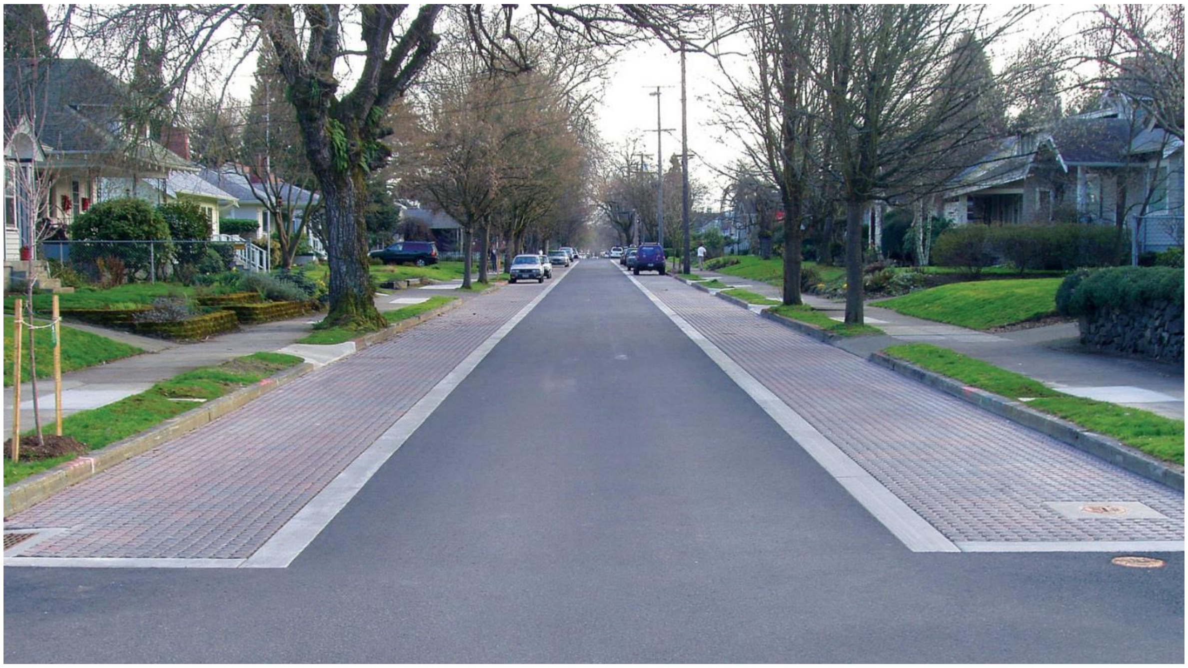


Zone 1 improvements include reducing imperviousness on private property, addition of street trees, permeable sidewalks. Partial encroachment into Zone 2 is shown for intermittent bioretention curb bulb-outs.

Source: Sherwood Design Engineers

Figure 4-34: Zone 1 and 2 – Replace Parking Aisle, Maintain Existing Vehicular Zone

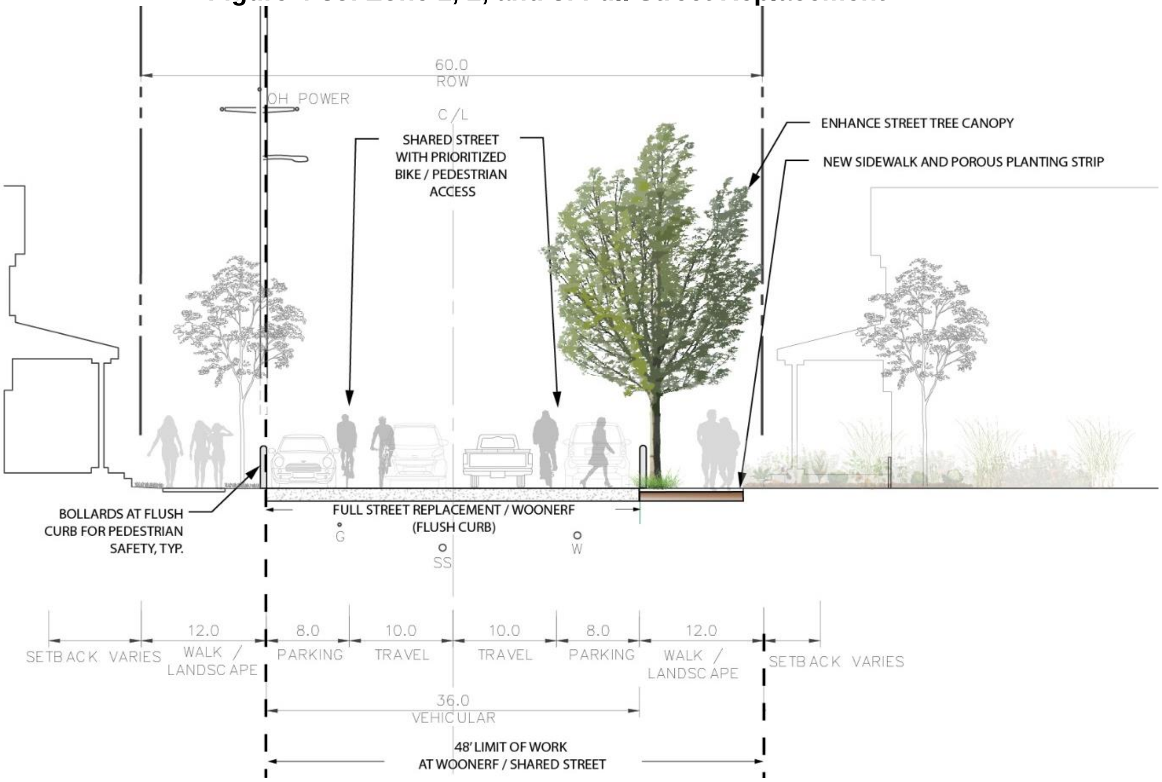


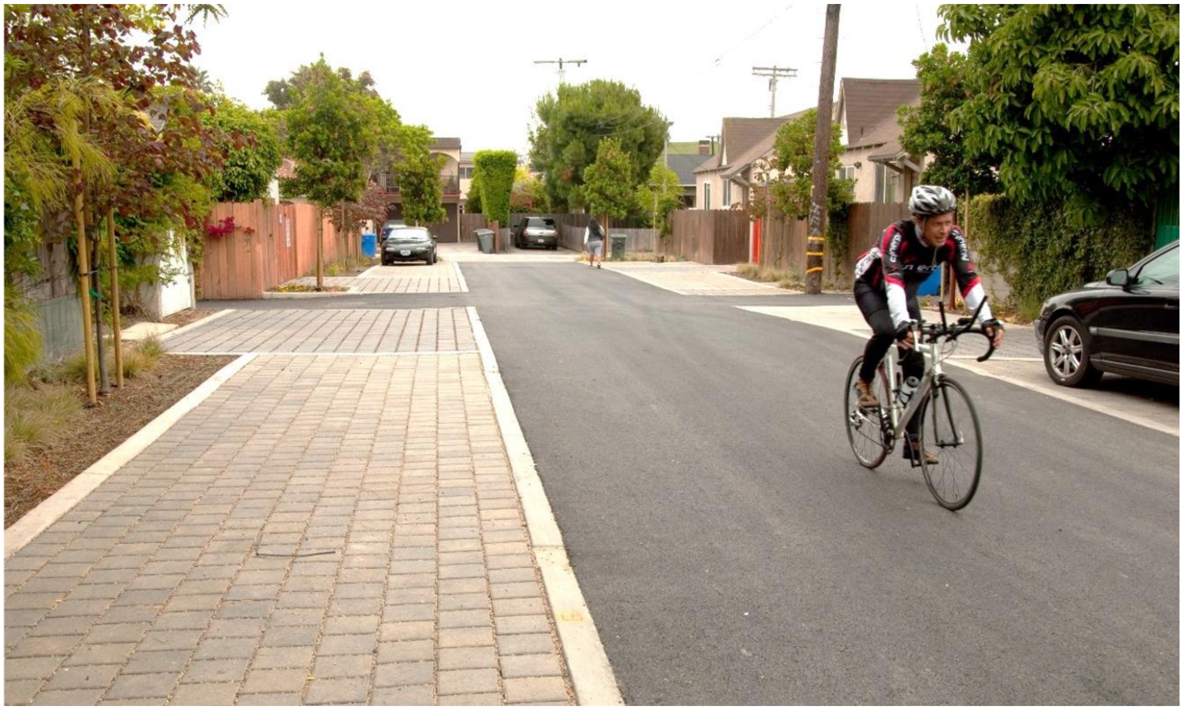


Zone 2 improvements include replacement of the parking aisle with permeable pavement. For the Oakland EcoBlock the 20-ft wide two-way vehicular travel lanes would be maintained, as shown in the section above. Improvements within the ROW would be in partnership with the city, as described above.

Source: Sherwood Design Engineers (Section); Photo: Mutual Materials (www.mutualmaterials.com/projects/westmoreland-permeable-pavement-pilot-project/)

Figure 4-35: Zone 1, 2, and 3: Full Street Replacement





Zone 3 improvements include full "complete street" redesign (also known as a "woonerf" or "shared street"), incorporating elements such as permeable pavements, flush curbs, and prioritized bike and pedestrian travel. Vehicular travel lanes are maintained. Improvements within the ROW would be in partnership with the city, as further described above. The photo above shows a complete street in the Borderline neighborhood of Santa Monica.

Source: Sherwood Design Engineers (Section and Photo)

Summary

This chapter summarized components of, and issues related to, urban water systems in general and the Oakland EcoBlock in particular. It described and analyzed a suite of possible interventions that could lessen, even possibly end, the EcoBlock's dependence on the current, centralized water and wastewater systems (EBMUD).

Upgrading to more-efficient appliances appears to be cost-effective and could lower dependence on EBMUD water by 30 to 40 percent. Some of the systems considered do not appear to be cost-effective for the EcoBlock but could be suitable in different climates, at a larger scale, or in a utility system with higher costs. High O&M costs, regulatory issues, and/or public acceptance are barriers for some of the systems discussed. Finally some systems could provide substantial, difficult-to-quantify indirect benefits, such as stormwater management benefits of rainwater harvesting systems.

If approved, Phase 2 will explore more technical detail, partnerships, and funding sources for potential implementation of the Core Project and bolt-ons.

CHAPTER 5: Recommendations for Planning and Building Departments

Abstract

This section provides a detailed analysis of the regulatory and governance issues with reviewing, approving, and permitting the EcoBlock model in cities. It details several iterations of the project to demonstrate the ways in which common or available planning, building, and public works tools and strategies can be applied to facilitate the consideration of EcoBlock projects. Recommendations are structured by department type, allowing the consolidation and focus on tools and codes specific to each municipal function. The section is written specific to the laws and standards used in California, but the principles can be applied outside of California as well.

Planning Department Issues and Guide

This section identifies, analyzes, and recommends solutions to overcome barriers to designing and implementing the EcoBlock retrofit concept in California cities. The analysis contained in this section aggregates the various components into three alternative design scenarios, and seeks to assess the ability of cities to accommodate similar retrofits. These scenarios reflect likely possible applications of the principles and components contained in this report, and are aggregated to provide cities and regulatory agencies with examples of how the EcoBlock model could be reviewed, permitted, and approved under some of its iterations. The structure and analysis are based on typical departmental structures in California city governments, and generally follow traditional applications of federal, state, and common local regulations of buildings, energy, water, and transportation systems. Information for analysis was collected through discussions with local government employees, scientists, and engineers.

This section identifies and recommends changes in state law necessary to enable the alternative business model/legal frameworks explored by the Integrated Electricity and Integrated Water System Design teams, as well as adjustments based on which of the innovative business models and legal frameworks prove most favorable. This information can be used by both the California Energy Commission and interested cities as a primer for preparing codes, regulations, and processes to allow for the efficient, scaled retrofit of existing neighborhoods to a low-carbon, resource-efficient model.

The three energy system scenarios, one core water scenario and bolt-on options A, B, C, and D reflect the common project approach of determining which measures are easier to accommodate with existing regulatory and permitting processes in cities.

Scenario 1e: AC Solar/Storage Microgrid with EE Retrofits and Exist AC Houses reflects those elements of the energy, transportation, food, and social systems that are generally feasible and permittable under existing planning and building codes in California. The AC Microgrid would be owned and operated by PG&E with separate regulatory review. Scenario 2e: DC Solar/Storage/EV Microgrid w EE Retrofits and Exist AC Houses adds in design components that may require additional levels of review, additional permits, or nontraditional approaches to establish regulatory compliance. Scenario 3e: DC Solar/Storage/EV Microgrid with EE retrofits and AC/DC houses is similar to Scenario 2e and may require additional levels of review, permits and regulatory compliance. It includes components that may require substantial revisions or changes to local, regional, state, or national codes and legislation, or which require the establishment of alternative governance models, to implement at scale. Scenario 1w: Core Project: Water Efficiency and Rainwater Capture and Use at the House Scale (and Water Bolt-on A) involve elements that are generally permittable under existing planning and building codes in California. Water bolt-ons B, C, and D add in design components that may require additional levels of review, additional permits, or nontraditional approaches to establish regulatory compliance. Specific components are called out in the analysis of scenarios to clarify applicability of analysis, and to relate back to technical elements as described earlier.

Each subsection below begins with the particular element of city practice or permit process, with specific recommendations and analysis for each of the three scenarios identified in the project description. Recommendations from each section are additive, meaning that the recommendations for Scenario 1 also apply to Scenario 2, and recommendations from Scenarios 1 and 2 apply to Scenario 3.

General Plans and Specific Plans

This section identifies recommendations for how planning departments may need to revise General Plans and Specific Plans to facilitate the approvals and entitlement process for the various land use, transportation, and infrastructure elements of the EcoBlock model. General Plans serve as the primary regulatory document to designate allowable land uses within a city, as well as establish the generally desired goals, objectives, and policies for developing buildings, infrastructure, and transportation systems. Specific Plans serve to add greater specificity to General Plans by providing a greater local context to an area with a distinct set of geographic, political, social, or cultural needs. General Plans are required by law for all cities in California, while Specific Plans may be adopted by cities as needed and desired.

Scenario 1e: AC Solar/Storage Microgrid with EE Retrofits and Exist AC Houses

This scenario contains primarily measures that do not require changes to general or specific plans. Energy improvements such as efficiency upgrades to appliances, installation of insulation and efficient lighting, installation of rooftop photovoltaic systems, and replacement of some gas appliances with electric alternatives are similarly allowable under usual general and specific plan standards. This scenario does not pose significant needs for changes to general and specific plans to accommodate at scale.

Scenario 2e: DC Solar/Storage/EV Microgrid with EE Retrofits and Exist AC Houses

Incorporating the block effect improvements identified in Scenario 2e creates the potential for a variety of challenges in municipal general and specific plans.

Additionally, statements of intent regarding housing and neighborhoods may also reflect similar characterization concerns. These sections of applicable plans will require revision to ensure that these block-scale improvements will be consistent with the intent of land use designations for properties being considered as an EcoBlock. Energy improvements identified in this scenario, including the shared microgrid, will also likely require a similar consistency analysis with general and specific plan statements regarding residential character and aesthetics. Window revisions and other elements affecting the exterior of buildings may conflict with historic preservation requirements or guidance if the neighborhood is registered as a historic district (or individual homes are on the National Register of Historic Places).

While these aspects of the EcoBlock may prove inconsistent with these descriptive elements of general and specific plans (particularly if the plans are older), it is likely that these inconsistencies arise from a lack of consideration for nontraditional design features rather than from inherent or applied incompatibilities with the land use and transportation network. General plans in California may be amended up to four times per year, and specific plans have no limitation on the frequency of updates. Such actions in this context will allow for cities to provide clarification of intent and need.

Scenario 3e: DC Solar/Storage/EV Microgrid with EE retrofits and AC/DC Houses

Adding the full net-zero district-level improvements to an existing residential neighborhood involves substantial changes to a broad array of physical and regulatory systems. However, the challenges associated with these improvements do not appear to be significantly impacted by the types of regulations set forth in general and specific plans. Beyond the issues identified in the earlier two scenarios, the addition of enhanced energy systems, the incorporation of connected technologies, and scaled additions of electric vehicle charging infrastructure are generally not items likely to appear in this level of planning documents. Depending on the placement of the electric vehicle charging systems, there may be a need to ensure consistency in the allowance of curbside charging in the land use and transportation elements. If water bolt-ons are added, there may also be locational concerns with the shared infrastructure from water and wastewater treatment, as well as water storage. Solutions to these could take the form of revised statements of intent or other descriptions in the affected elements, or the establishment of new land use designations to allow for the discrepancies. Revisions to existing land use designations and conceptual descriptions will appear to be the simplest form of solution and preferable to the establishment of new designations.

As of 2017, most California cities do not appear to have adopted a standard for permitting street side electric vehicle charging stations. To broaden the scale of the EcoBlock, a standard must be created and incorporated into regulatory frameworks, potentially including cities' General Plans. Models of such standards do appear to be present in leading communities such as Berkeley and Los Angeles.

Scenario 1w: Core Project: Water Efficiency and Rainwater Capture and Use at House Scale and Bolt-on A

This scenario contains primarily measures that do not require changes to general or specific plans. Water system improvements such as drought-tolerant landscaping, low-flow appliances, purple pipe (recycled water) installations, and on-site rainwater collection are all permissible in traditional residential zones.

Water Bolt-ons B, C, and D

Water system improvements such as a shared rain garden and a block-serving wastewater treatment system may run counter to some of the descriptive aspects of elements associated with buildings and infrastructure (land use element, housing element, optional elements for infrastructure or community design). General and specific plans often contain descriptions of the character of residential areas that may define an aesthetic contrary to inclusion of water treatment infrastructure or water storage. Transportation and community infrastructure improvements in this scenario, particularly the use of permeable pavers and nontraditional sidewalk/parking treatments, may also be inconsistent with general descriptions for transportation systems and their components.

Zoning Requirements and Entitlement Processes

This section identifies recommendations for how planning departments may have to modify zoning codes, subdivision ordinances, and procedures to facilitate the approvals and entitlement process for the widescale deployment of the EcoBlock model. Zoning requirements set rules for whether a zone may be used for residential or commercial purposes, as well as size, density, height, and placement of structures in those zones. The entitlement process establishes the steps that one must take to ensure a proposed project meets existing zoning requirements. The project must be approved before moving forward.

Scenario 1e: AC Solar/Storage Microgrid with EE Retrofits and Exist AC Houses

This scenario primarily contains measures that do not require changes to existing zoning requirements. In-home and on-site energy efficiency modifications are allowable under most residential zoning ordinances. Exterior cisterns are generally allowable in residential zones if they do not extend into setbacks or obstruct areas with easements.

Many of the Scenario 1e improvements will require entitlements in the form of use permits or ministerial approvals, but can be accommodated within the traditional zoning structures of California cities.

Scenario 2e: DC Solar/Storage/EV Microgrid with EE Retrofits and Exist AC Houses

While individual home measures for energy remain largely the same in terms of zoning requirements, several of the block-scale measures raise the potential for discrepancies with zoning codes and entitlements. With energy systems, similar benefits will accrue to block-scale applications, allowing cities to analyze benefits and issues across a broader area. While state and local codes regarding electrical and energy systems do not appear to pose insurmountable challenges to Scenario 2 improvements, careful consideration will be given to the placement and design of the energy systems. Of particular concern will be issues of easements and rights-of-way, where utility wiring may vary from that traditionally distributed via utilities, for which well understood and agreed-upon easements are usually in place.

Microgrids, while a technology growing in popularity and frequency in California, are typically located in commercial, institutional, or industrial areas. The placement and design of microgrids in a residential setting create several challenges for cities. The placement of block-serving infrastructure such as controllers and energy storage may prove problematic for cities. In the Oakland EcoBlock project, these concerns were assuaged by placing the block-serving infrastructure on an adjacent industrial lot, thus removing the potential incompatibilities in the residential zone. The Oakland project team concluded that microgrid infrastructure is not among the defined allowable uses in residential zones. Because of the scale of the proposed flywheel energy storage, controllers, and interconnected electric support lines across property lines and rights-of-way, this system will likely be classified as an “Extensive Impact Civic Activity” in the City of Oakland, and will require a Major Conditional Use Permit.

It is expected that most cities will need to make a similar determination. To reduce the administrative burden on future EcoBlock efforts, cities may wish to add microgrid components to the list of allowable uses in relevant planning documents, as well as make statements of intent to support local clean energy technologies in residential zones.

Scenario 3e: DC Solar/Storage/EV Microgrid with EE retrofits and AC/DC Houses

The technologies presented in this scenario will likely require substantial changes to existing zoning requirements, in addition to the changes recommended in the first two scenarios. The energy systems will also require substantial revisions to zoning codes. As indicated in Scenario 2, the energy storage system will likely be subject to a major conditional use permit in most cities. The addition of the advanced microgrid elements, including the direct current backbone and secondary wiring system into homes, will be similarly subject to advanced review by cities. While these issues will be similar in nature to those in Scenario 2, there is potential for impacts to be greater with the addition of a secondary electric system.

Scenario 1w: Core Project: Water Efficiency and Rainwater Capture and Use at House Scale and Bolt-on A

Within the water systems, the use of treated rainwater for piping into homes and its corresponding use as greywater will be unusual for cities to evaluate in traditional permit processes. If proposed as part of a block-wide project, planning tools such as conditional use permits will allow for consideration of such elements in a coordinated fashion by planning departments. On an individual level, however, cities may lack sufficient knowledge or creative interpretation of applicable plumbing code standards to successfully grant necessary permits for these systems.

Water Bolt-ons B, C, and D

Research and development infrastructure such as the water storage system and rainwater capture system will likely present challenges for current zoning ordinances. Rainwater capture that is distributed at a block scale will require a right-of-way or easement. Rainwater storage at the block scale will also require some form of use permit, depending on its location in a neighborhood and the physical design of the storage system. However, if the rainwater storage system were owned by the city, it is possible that a right-of-way or easement will not be necessary. In addition, shared infrastructure for water and wastewater is not permissible within current zoning rules. The addition of such infrastructure will need to be added to the list of allowable uses for residential zones being considered for an EcoBlock, in addition to the creation of relevant design standards for such systems to avoid adverse impacts to residents of the block. If the treatment of wastewater to potable standards was pursued as part of an EcoBlock, it is likely that the Uniform Plumbing Code and local codes will require amendment to specifically allow for the use of such water resources in homes.

Discretionary Approvals / Conditional Use Permits

This section details recommendations for how planning departments may have to utilize discretionary approvals and conditional use permits to facilitate the approvals and entitlement process for the widescale deployment of the EcoBlock model. Discretionary approvals allow city planning departments to review suggested changes to legislation and planning ordinances using their own personal judgment. A conditional use permit (CUP) is needed to move forward with a project that does not follow existing zoning code. One must go through the process of discretionary review to acquire a CUP.

Scenario 1e: AC Solar/Storage Microgrid with EE Retrofits and Exist AC Houses

Except for the AC microgrid, the changes proposed in the scenario will be implemented independently at every residence. Homeowners will need to sign off on any permits applying to their own home, but no further obstacles are expected. Water storage systems adjacent to existing homes have the potential to require additional review if placed in setbacks or they are above a size threshold established by a city, but water efficiency measures are permittable under traditional regulations.

Scenario 2e: DC Solar/Storage/EV Microgrid with EE Retrofits and Exist AC Houses

Incorporating the improvements suggested in this scenario could present new challenges, in addition to those presented in the first scenario. The flywheel storage system could be considered by a city as a land use not permitted in the zoning code. These typically require application for a conditional use permit, requiring approval from the city's Planning Commission. If no CEQA problems arise, the permit could be acquired in five to six months. If many community meetings occur during the CEQA process, the major conditional use permit may be delayed. When applying for a conditional use permit, it is important to focus on potential odors, noise, and other nuisances that may come from the proposed project. Finally, alternative utility pole or street lighting strategies sought at this level could also be addressed in this process, although standards for such infrastructure are typically maintained by electric utilities and public works departments.

Scenario 3e: DC Solar/Storage/EV Microgrid with EE retrofits and AC/DC Houses

All the suggestions in the previous Scenario 2E will also be included in this scenario.

Scenario 1w: Core Project: Water Efficiency and Rainwater Capture and Use at House Scale and Bolt-on A

Water storage systems adjacent to existing homes have the potential to require additional review if placed in setbacks or they are above a size threshold established by a city, but water efficiency measures are permittable under traditional regulations.

Water Bolt-ons B, C, and D

The right-of-way issues created by the suggested water storage systems may be solved using an overlay. While creating an overlay may facilitate getting a California Environmental Quality Act (CEQA) exemption for the EcoBlock, it may also create delays and require a larger geographic area to effectively implement in cities. The bolt-ons with water storage infrastructure at the block scale will likely also have issues with regard to use compatibility, as water will flow across property lines and potentially have issues with in-building modifications.

Additional Permitting Considerations

This section of the report provides recommendations for how planning departments can address any remaining planning or design issues to allow for design and construction of the EcoBlock model.

Scenario 1e: AC Solar/Storage Microgrid with EE Retrofits and Exist AC Houses

To complete the permitting process, it is necessary to know the location of all the physical improvements. Individual home improvements, as delineated in Scenario 1, will not require any additional unique consideration. Energy efficiency improvements, along with in-home electric vehicles, are within acceptable uses in residential zones. Some limited compliance documentation may be required for any improvements (such as solar photovoltaic panels) that encroach upon setbacks or other site restrictions. These permits will likely include over-the-counter compliance permits for local standards, as well as planning approvals of building permits for home measures.

Scenario 2e: DC Solar/Storage/EV Microgrid with EE Retrofits and Exist AC Houses

Some of the retrofits in this Scenario will likely require changes to current code. Planning permit procedures will generally be sufficient to accommodate consideration of the proposed improvements. Planning departments typically house one or more use permits that allow for the consideration of site-specific designs to improve a site. However, these use permits are typically used for review of commercial or industrial areas, rather than residential. Cities may need to consider whether to utilize the use permit process to review features of block-scale improvements that cross property lines and challenge traditional use definitions in residential zones. These will particularly apply for private electrical distribution lines and ancillary infrastructure to support the concept.

Changes to a city’s regulatory codes will require a proposal to the relevant department, and likely approval by the city council. Various improvements in the EcoBlock model could necessitate changes to the methods of consideration of right-of-way issues for infrastructure, including sewers, street lighting, street trees, roads, and electricity. These issues will require not only regulatory solutions for the city, but also some form of agreement regarding the responsibility for operations and maintenance. If the city is responsible for maintaining infrastructure or improvements, then an easement is typically needed, along with an analysis of funding availability and structure. For privately maintained infrastructure, cities will also require verification of how the operations and maintenance will be funded and delivered, and assurances of how unforeseen issues and emergency needs will be addressed.

When scaling the EcoBlock up to several blocks, it will likely be necessary to obtain a franchise fee to fund operations and maintenance, and acquire an encroachment permit to place shared infrastructure across public rights-of-way between private properties. Encroachment permits may require city council approval, following analysis and recommendation from relevant departments.

Scenario 3e: DC Solar/Storage/EV Microgrid with EE retrofits and AC/DC Houses

This scenario includes full electrification, infrastructure crossing multiple private property lines, and additional transportation components. While the depth of these systems will likely include additional review, it is anticipated that cities will generally be able to address these concerns through the processes already established or those discussed under Scenario 2e above. The advanced nature of these infrastructure systems will present challenges for cities to find ways to allow for creativity in residential zones. Some cities have done this in architectural considerations, to allow for nontraditional designs of facades. The principles of residential design review may be applied to non-design considerations as a method of creating a review procedures for deep energy and deep water reduction retrofit projects. This will require the city to create a standard incorporating the principles of the EcoBlock, and developing the list of considerations that the city will use in reviewing the application of the principles to a particular block or neighborhood.

Scenario 1w: Core Project: Water Efficiency and Rainwater Capture and Use at House Scale and Bolt-on A

Water storage systems adjacent to existing homes have the potential to require additional review if placed in setbacks or they are above a size threshold established by a city, but water efficiency measures are permittable under traditional regulations.

Water Bolt-ons B, C, and D

Cities may need to consider whether to utilize the use permit process to review features of block-scale improvements that cross property lines and challenge traditional use definitions in residential zones. These will particularly apply to larger water storage facilities (either adjacent to homes or in a central location), easement issues for private water distribution lines, and ancillary infrastructure to support the concept.

Various improvements in the EcoBlock model could necessitate changes to the methods of consideration of right-of-way issues for infrastructure, including sewers, street lighting, street trees, roads, and electricity. These issues will require not only regulatory solutions for the city, but also some form of agreement regarding the responsibility for operations and maintenance. If the city is responsible for maintaining infrastructure or improvements, then an easement is typically needed, along with an analysis of funding availability and structure. For privately maintained infrastructure, cities will also require verification of how the operations and maintenance will be funded and delivered, and assurances of how unforeseen issues and emergency needs will be addressed.

Overall Assessment

This section describes recommendations on potential incentives that local governments may consider to further support projects pursuing the EcoBlock model, including financial, administrative, procedural, or other mechanisms which the local government may apply to make projects more feasible or cost-effective. It also provides explanation and detail to document the extent to which the proposed changes can accomplish a variety of environmental and social goals, including GHG reduction, enhanced social equity, improved indoor and outdoor air quality, and reduced resource demands.

Scenario 1e: AC Solar/Storage Microgrid with EE Retrofits and Exist AC Houses

This scenario appears to be consistent with the traditional planning procedures, and will be implementable by most cities without significant difficulty. Conventional permitting processes are adequate to provide the city with appropriate standards of review for home improvements on the electricity elements of the project, as well as the limited proposed transportation infrastructure. All procedures for the AC microgrid would be handled by PG&E.

Scenario 2e: DC Solar/Storage/EV Microgrid with EE Retrofits and Exist AC Houses

This scenario presents challenges for cities in the attempted construction of improvements which may create incompatible land uses, include private infrastructure that crosses property lines, and involve infrastructure and equipment that may not be considered allowable in residential zones. Cities may seek to apply permitting procedures that are traditionally used for commercial or industrial projects, including conditional use permits, to review these improvement types. Additional revisions also may be necessary to zoning and land use plans, to ensure that the principles of EcoBlocks are reflected in the land use desires of the community. The scale of consideration of the infrastructure and improvements in this scenario will likely vary by city, with the need to adapt standards and permitting processes to deploy at scale.

Scenario 3e: DC Solar/Storage/EV Microgrid with EE retrofits and AC/DC Houses

This scenario is likely to pose significant difficulties for cities in reviewing the appropriateness and adequacy of proposed block-scale improvements. Planning documents, processes, and permitting procedures will all require substantial review and potential modification to accommodate some of the advanced research and development ideas in this scenario. Examples include the consideration of utility-level infrastructure deployed at the block scale (such as potable water from on-site treatment by a party other than the water utility or a secondary electric microgrid), design standards for operations and maintenance agreements of community-held infrastructure, and the placement of nontraditional systems like energy storage adjacent to homes. As in Scenario 2e, the interpretation of the value and issues of this approach will vary by city, and it is expected that cities will utilize different solutions to adapt their processes, plans, and procedures to allow for this type of redevelopment.

Scenario 1w: Core Project: Water Efficiency and Rainwater Capture and Use at House Scale and Bolt-on A

This scenario appears to be consistent with the traditional planning procedures, and will be implementable by most cities without significant difficulty. Conventional permitting processes are adequate to provide the city with appropriate standards of review for home improvements.

Water Bolt-ons B, C, and D

These bolt-ons are likely to pose significant difficulties for cities in reviewing the appropriateness and adequacy of proposed block-scale improvements. Planning documents, processes, and permitting procedures will all require substantial review and potential modification to accommodate some of the advanced research and development ideas in this scenario. Examples include the consideration of utility-level infrastructure deployed at the block scale (such as potable water from on-site treatment by a party other than the water utility), design standards for operations and maintenance agreements of community-held infrastructure, and the placement of nontraditional systems like energy storage adjacent to homes. As in Scenario 2e, the interpretation of the value and issues of this approach will vary by city, and it is expected that cities will utilize different solutions to adapt their processes, plans, and procedures to allow for this type of redevelopment.

State Building Code

California Code of Regulations, Title 24, provides the state requirements for the construction of buildings in California. Cities adopt these requirements, along with variations or additional sections, via the Ordinance process. Cities have limited flexibility to vary from state standards, but may do so when additional requirements are deemed cost-effective and do not compromise the health and safety of building occupants. This section is written from the perspective of a city that has adopted all mandatory provisions of Title 24, but without additional amendments (such as a Green Building Ordinance, CALGreen tier levels, or similar changes). All sections of Title 24 applicable to the redevelopment of residential neighborhoods are listed in this section of the report.

Part II: California Building Code Volumes I and II

In review of the EcoBlock, the range of measures and improvements do not appear to require changes to California Building Code Volumes I and II (California Code of Regulations, Title 24, Part 2).

Part III: California Electrical Code

Scenario 1e: AC Solar/Storage Microgrid with EE Retrofits and Exist AC Houses

The measures included in the first scenario do not appear to require changes to the California Electrical Code.

Scenario 2e: DC Solar/Storage/EV Microgrid with EE Retrofits and Exist AC Houses

The measures included in this scenario do not appear to require changes to the California Electrical Code.

Scenario 3e: DC Solar/Storage/EV Microgrid with EE retrofits and AC/DC Houses

Two issues of concern were identified in the evaluation of Scenario 3e of the EcoBlock. The proposed integration of the fully enabled smart poles and lights on the block will replace the city's existing LED street lighting system in the neighborhood. There will likely be right-of-way challenges for the street lights in this scenario if they are connected to the DC microgrid within the EcoBlock instead of the utility's grid. Disconnecting the street lights from a utility grid and operating them on a private power supply will create the need for a new design standard in most applications, as no such standard exists in most cities. There will also be questions of integration of the street lighting system into adjacent blocks with the proposed improvements.

Beyond street lighting, Scenario 3e introduces a DC microgrid connected to solar panels and solar energy storage. There is uncertainty as to whether the meters connecting the DC microgrid to the homes will be allowable with exceptions under the California Electrical Code. It appears likely that cities could conclude that a secondary electrical system with meters could be placed alongside existing utility meters in homes, provided other minimum safety considerations can be met regarding spacing and placement in the structures. Dual conduit will likely be required for compliance (California Code of Regulations, Title 24, Part 3).

Part IV: California Mechanical Code

The measures included in each of the three EcoBlock scenarios do not appear to require changes to the California Mechanical Code (California Code of Regulations, Title 24, Part 4).

Part V: California Plumbing Code

Scenario 1w: Core Project: Water Efficiency and Rainwater Capture and Use at House Scale and Bolt-on A

The measures included in this scenario do not appear to require changes to the California Plumbing Code, except for the rainwater capture and use for potable as discussed above

Water Bolt-ons B, C, and D

The measures included in the water bolt-ons introduce several challenges with regard to California Plumbing Code. The rainwater capture system creates potential complications because, per current plumbing code, a city cannot permit a system to distribute water from rainwater capture as potable water. However, individuals may choose to drink rainwater caught on their own property. Water from rainwater capture systems can be used as non-potable water, and has been allowable by code since 2012. Another proposed technology, an on-site wastewater treatment system, appears to be prohibited under Title 12; if the water supply comes from an approved source, legal complications will be minimized. Cities will also seek to verify the applicable Health and Safety Code requirements within plumbing codes for nontraditional systems such as this. While the California Plumbing Code is updated every three years, state variances can occur on an ongoing basis if they follow established rules and guidelines. Appendix K of the California Plumbing Code provides additional authority relative to the design and use of on-site wastewater treatment systems, which will expand the flexibility of cities to accommodate such systems. Ultimately, solutions to allow for the use of either rainwater or wastewater for potable water use in the homes will most likely need to be specifically allowed under the California Code of Regulations, with training to local jurisdictions to understand the relevant associated health and safety issues to be reviewed in plan drawings and field inspections.

The Plumbing Code challenges for the Bolt-ons included all the challenges already discussed above. If a city has not yet adopted the portion of the model plumbing code that allows for use of potable rainwater catchment systems, the system will not be permittable. Permission may be acquired by obtaining a variance through the Building Department. It may also be necessary to form an entity that purveys water. Scenario 3 also includes the mining of waste material from existing regional wastewater collection lines. This concept will be new to all cities, and it is unlikely that any design standards for the review and approval of such systems will be in place. If sufficient operations and maintenance provisions were provided to the reviewing city and utility, it is expected that the concept will be viewed positively. Removal of flows will generally lower costs of wastewater conveyance and treatment, and improve the overall system efficacy. Backflow prevention will be an issue in need of resolution if treated wastewater is to be used on site (California Code of Regulations, Title 24, Part 5).

Part VI: California Energy Code

Scenario 1e: AC Solar/Storage Microgrid with EE Retrofits and Exist AC Houses

The measures proposed in this scenario do not appear to present major challenges to the California Energy Code.

Scenario 2e: DC Solar/Storage/EV Microgrid with EE Retrofits and Exist AC Houses

Scenario 2e does not create significant issues of compliance with the California Energy Code. Minor issues may be present due to the placement and integration of the flywheel energy storage system. The location and integration of flywheel systems will likely trigger specific interpretation needs, especially as systems are directly connected to microgrid systems. No additional Energy Code concerns appear to be present for this scenario.

Scenario 3e: DC Solar/Storage/EV Microgrid with EE retrofits and AC/DC Houses

Like Scenario 2e, the only California Energy Code issues of note will likely result from the connections of specific electric systems to the microgrid. Specifically, the street lighting system and DC appliances in homes will require supportive interpretation of the Energy Code to accommodate permitting. No additional Energy Code concerns appear to be present for this scenario (California Code of Regulations, Title 24, Part 6).

Part VIII: California Historical Building Code

The measures included in each of the three EcoBlock scenarios do not appear to require changes to California Historical Building Code. If the EcoBlock model was proposed for structures or neighborhoods carrying a historic preservation designation, additional design limitations may be present for exterior improvements to buildings or placement of supporting infrastructure (California Code of Regulations, Title 24, Part 8).

Part VIII: California Fire Code

The measures included in each of the three EcoBlock scenarios do not appear to require changes to California Fire Code (California Code of Regulations, Title 24, Part 9).

Part X: California Existing Building Code

To make permitted changes to residential homes, the existing infrastructure in the homes must already be code compliant. If a building within the proposed EcoBlock area is not compliant to code, home-wide upgrades may need to be implemented to meet building codes before making any further changes. In residential buildings, a non-wooden building frame may need to be seismically retrofitted, depending on the local code requirements. If the roofing material on a building is not compliant, it is possible to ask for an exception with an explanation, which is typically referred to as an *alternative materials request.* Additional similar issues may be present with other code violations that exist prior to the retrofit. The solutions to these situations will likely be specific to the jurisdiction and issue (California Code of Regulations, Title 24, Part 10).

Part XI: California Green Building Standards Code

The measures included in each of the three EcoBlock scenarios do not appear to require changes to California Green Building Standards Code (often referred to as *CALGreen*) (California Code of Regulations, Title 24, Part 11).

Local Processes

This section provides recommendations for how building departments may modify their building code permitting and inspection processes to facilitate the integrated systems approach of the EcoBlock model and its widescale application.

Plan Check Processes

Existing plan-checking processes and procedures will likely be adequate to allow for the consideration of the EcoBlock model in most cities. The unique nature of the retrofits, with infrastructure crossing easements and property lines and nontraditional energy, water, and transportation elements, provides a range of new elements for building departments to consider. However, analysis of this project suggests that the consideration of these elements could be undertaken with existing processes.

Inspection Processes

Like the plan check process described above, it is concluded that the inspection processes of most cities will be sufficient to accommodate consideration of the EcoBlock model. One area of note is whether inspection procedures will allow for the placement of an EcoBlock in areas with existing non-permitted accessory dwelling units. One noted alternative to this challenge is to consider the use of video inspections. Several electronic permit systems such as Accela have modules which allow for video systems to be used that ensure the inspector only views the relevant areas of the building, eliminating the potential for the visual identification of additional non-compliant building features. Each city will consider the value proposition of using such a system for this purpose, and any decisions regarding its applicability and appropriateness will be within the discretion of the jurisdiction.

Overall Assessment

Based on this report’s review, the EcoBlock model appears to have multiple options for the successful design, installation, and permitting of most improvements described in Scenarios 1e and 2e and 1w. Scenario 3e and the water bolt-ons contain additional elements that may require changes to state law, as well as the adoption of additional local laws. Several design elements may require training of Building Department staff to ensure that they are understood relative to their interpretations in code, and the ability of the EcoBlock model to receive permits may be limited to those areas in which these issues can be successfully addressed.

Legal Statutory Report

This section provides recommendations on potential incentives that local governments may consider to further support projects pursuing the EcoBlock model, including financial, administrative, procedural, or other mechanisms that the local government may apply to make such projects more feasible or cost-effective. It includes recommendations on ownership, management, and operational components of nontraditional infrastructure systems contained in the model, including recommendations for how municipal governments and utility providers, both public and private, can more effectively enable block-scenario or neighborhood-scenario water and sewer systems to be developed and implemented. Additionally, it provides recommendations for non-municipal operators of infrastructure, including public and private utilities, to revise standards, conditions, and approval processes to facilitate EcoBlock model solutions to infrastructure issues. Information for analysis was collected through discussions with local government employees, scientists, and engineers.

This section supplements the analysis contained in Chapter 7: Business and Financing Models, detailing the governance/business and finance structures that are most feasible and cost-effective for the development of the EcoBlock model. Following the analysis and conclusions of that analysis, this section provides supplementary recommendations relative to local governments considering how to incentivize or otherwise increase rates of adoption of this model in their community.

Scenario 1e: AC Solar/Storage Microgrid with EE Retrofits and Exist AC Houses

The measures proposed in Scenario 1e mostly include technologies that traditionally have been used in residential areas. The report concludes that the preferred solution for this scenario is a traditional homeowners association (HOA), with financing provided by Property Assessed Clean Energy (PACE). Cities have no need to take action to support HOAs, which are formed independent of local governance. PACE providers do require local government authorization in California, and increasing the number of PACE providers who offer financing in the residential sector will increase the viability of this financing tool for use in cities. Cities may elect to provide incentives or other regulatory relief (such as permit streamlining) for EcoBlock projects, but such incentives will likely not be a primary driver of homeowners and residents seeking to implement these efforts.

Scenario 2e: DC Solar/Storage/EV Microgrid with EE Retrofits and Exist AC Houses

The measures proposed in Scenario 2e include more nontraditional infrastructure than those in Scenario1e. The complexity of the proposed improvements and infrastructure, particularly the block-level additions energy systems, create both a challenge and an opportunity for local governments. The report concludes that the preferred solution for this Scenario is an EcoBlock Trust governing model, utilizing a Community Facilities District (CFD) and PACE to finance improvements. The challenging portions of this approach include the need to organize a vote among the residents to form the CFD, along with the detailed cost projections and establishment of sufficient operations and maintenance agreements to properly assure the city of the long-term risk management and viability of block improvements.

These challenges are balanced by the opportunities presented in the solutions to this scenario. The EcoBlock model has the potential to develop consistent and common metrics, technologies, and processes that, when scaled, will significantly reduce the financial and regulatory challenges to this type of project. The property taxation authority of the CFD, along with the homeowner-financed measures utilizing PACE, offer a layering of tools that can provide flexibility and contingencies. Finally, the flexibility in ownership of the communal infrastructure has benefits for the city as they consider the appropriate level of risk tolerance in the deployment of this model.

The ownership considerations of this approach are of particular importance to cities. While this report concludes that the most viable option available to govern this strategy is a CFD with city ownership, this strategy carries significant risk for cities. Operations and maintenance agreements will need to provide a level of certainty in how they provide for the adequate upkeep of such systems, particularly those with which the city may not have expertise (such as the energy storage system or water treatment system). Engagement of multiple departments, including planning, public works, and relevant utility management will be critical to the successful design and implementation of these agreements.

Incentive options will likely be similar between Scenario 1e and 2e. Cities may wish to provide additional incentives to block-scale developments that accomplish a variety of local goals, such as carbon reduction, increased resilience, and infrastructure financing. One additional option available to cities to incentivize this scenario is the development of a Demonstration Ordinance. A Demonstration Ordinance provides for the expedited and customized review of innovative ideas, creating an avenue for cities to more creatively review special projects and providing a pathway to working out the various issues associated with the new technologies and practices. The cities of San Jose and Sacramento have both adopted such ordinances, and any consideration of the use of this approach will be done in consultation with the city attorney’s office.

Scenario 3e: DC Solar/Storage/EV Microgrid with EE retrofits and AC/DC Houses

As with Scenario 2e, the preferred solution for this Scenario is an EcoBlock Trust governing model, utilizing a Community Facilities District (CFD) and PACE to finance improvements. The nature of the improvements in Scenario 3 include additional features to be included in potential city ownership, exacerbating the issues identified above. Otherwise, the Scenario 3e incentive and regulatory recommendations remain the same as with Scenario 2e.

CHAPTER 6: Innovative Financial and Business Models

Abstract

This section addresses the various business and financing models that could support and accelerate the adoption of the EcoBlock model. In addition to the technological and environmental developments that EcoBlock residents will implement, a suite of financing, governance, and ownership structures will be needed to facilitate and manage these investments. The EcoBlock will not only realize environmental benefits but also reduce energy, water, and other costs for residents over the long term, so the business and financing models that support it 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 the Oakland 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 and maintenance costs, nor do they address questions surrounding liability.

First, this section identifies the various financing options that could be adopted to support the EcoBlock. Second, it analyzes the models based on legal requirements, organizational and practical challenges, and actual savings and revenue streams available through EcoBlock improvements. It then breaks down the various ownership and governance models that could apply to the EcoBlock. It is important to emphasize that the "best" business and/or financing model for a given project will depend on its specific circumstances and context, and will likely be a composite of several different tools that could be developed into a single model with the potential for market transformation.

Summary of Models

This section discusses a range of public, private, and utility-based financing and governance models for the EcoBlock. Public financing models generally rely on state laws enabling residents to agree collectively to direct property tax funds to the acquisition of communal EcoBlock assets and infrastructure, subject to local government-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. One or more of the models may require a governance structure to coordinate resident actions and financing instruments.

The team concluded that the most appropriate business and financing model for the creation and eventual scaling of the EcoBlock is a combination of public and private financing—namely, Community Facilities Districts (CFDs) and Property Assessed Clean Energy (PACE)—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. While this arrangement entails certain legal and coordination-related challenges, it represents the best set of options to finance and manage both the in-home and block-scale energy and water infrastructure of the EcoBlock. Alternatively, a third-party ownership and management structure could play a similar role, if a private third-party partner can be identified.

Layering of Models

There is no single existing “model” for either the financing or the governance of the EcoBlock. This is because the EcoBlock will likely:

- contain a mix of traditionally public assets (such as streetlights) and traditionally private ones (such as home appliances),
- cover residents who own homes and those who rent their homes,
- require funding for initial installations and purchases as well as ongoing maintenance, and
- upgrade both energy and water infrastructure.

Thus, the financing and governance models that are ultimately selected to support it will need to be flexible and multifaceted. Appendix J lists some of the various costs and revenues that these financing and governance models will need to account for.

As a result, models will need to be layered to address these diverse issues. Several financing tools stand out as potentially useful for specific aspects of the EcoBlock:

1. The CFD could provide a way to finance many of the project’s higher-cost, community-wide installations, such as the proposed energy storage plant, right-of-way improvements, and the water treatment facilities.
2. A public-private partnership could provide support for ongoing operations and maintenance.
3. PACE financing may allow homeowners to finance improvements on their private property that may not be financed through other means.
4. A homeowners association or nonprofit ownership entity might be necessary to properly implement and manage the three financing programs. This example, neither conclusive nor offered as a preferred model, is intended merely to highlight the extent to which the models described below will need to be combined or integrated to fully finance and operate the EcoBlock.

These financing tools are discussed in greater detail below. In addition, Appendix K includes brief descriptions of other models that are not discussed in full in the report but could potentially be applicable to the EcoBlock.

Business and Financing Models

Business models and financing models each play a separate role. For the purposes discussed in this report, *business models* are legal and organizational structures designed to govern and convey improved value to EcoBlock residents, and references to "business" mechanisms and "organizational" mechanisms are interchangeable. In contrast, *financing models* provide channels for funding various costs, including EcoBlock improvements, operations, and maintenance. It is important to note that certain financing models may include governance-related components such as voting structures, or may dictate what form ownership must take.

Currently, there is no single model that could effectively finance all aspects of the EcoBlock. However, there are multiple financing tools that may work in concert to create a comprehensive financing strategy. Which tools are used, and how, will depend on legal constraints, resident preferences regarding ownership and asset management, and the cost of financing, as well as the infrastructure and technology components that are ultimately selected to transform the pilot block into an EcoBlock. The following sections examine the different business and financing models and their potential benefits and pitfalls.

This section groups business and financing models into four general categories:

1. Public financing models
2. Private financing models
3. Business (organizational and governance) models that support financing
4. Utility business models

Within these overarching categories, each subsection describes the following:

1. The function, mechanism, and key issues of the model
2. The general benefits and Oakland EcoBlock-specific benefits of the model
3. The general and specific challenges of the model
4. Brief suggestions of policy reforms that could promote EcoBlock development
5. Discussion of how the business model could be used to scale up the EcoBlock or replicate the EcoBlock in a new location

Public Financing Models

Several public tools allow homeowners to finance private and community improvements through property tax assessments. In general, public financing tools have lower interest rates than traditional bank loans. Lenders benefit from the security of a property tax lien, a municipal partner collecting payments and issuing bonds, and frequently, from tax-exempt bond status.

Community Facilities District (CFD or Mello-Roos)

Function and Legal Background

Community Facilities Districts are property tax-based finance tools that cover district-level public improvements (Cal. Gov. Code § 53311 et seq.). Under the Mello-Roos Community Facilities Act of 1982, any county, city, special district, school district, or joint powers authority may form a CFD, which allows for financing of public improvements and services. Public improvements that a district may finance include "energy efficiency, water conservation, and renewable energy improvements that are affixed…to real property and in buildings, whether the real property or buildings are privately or publicly owned" (Cal. Gov. Code § 53313.5(l)).

Function

CFD bonds can be used for a variety of improvements and services, including the purchase of property, such as parks and open space; the construction of water transmission and distribution facilities; and servicing debt. Furthermore, CFDs can finance a broad swath of services, including the maintenance and operation of public facilities, and facilities for the transmission or distribution of electrical energy (Cal Gov. Code § 53313).

Mechanism

A CFD is created by a two-thirds majority vote of "qualified electors" in the district. If the district contains 12 or more registered voters, the qualified electors are the registered voters; however, if there are fewer than 12 registered voters, the qualified electors are the landowners in the district, with each such owner entitled to one vote for each acre or portion of acre owned (Cal. Gov. Code §§ 53326, 53328). After adoption of a resolution outlining the purpose and boundaries of the district, the municipality conducts public hearings. Once public hearings conclude, the municipality holds an election to approve the district. The district is a public, governmental or quasi-governmental entity that is responsible for constructing and maintaining the improvements on behalf of residents.

Once a CFD is approved, the municipality sells bonds on behalf of the CFD to private investors who purchase them, typically at tax-free interest rates. The CFDs is enforced as a property tax lien and paid for as a tax line item (Cal. Gov. Code § 53340). As with other tax liens, the legislative body can foreclose on the property if there is outstanding debt (Cal. Gov. Code § 53356.1). The arrangement provides simplicity for homeowners and security for lenders.

Key Issues

"Public" facilities versus private property improvements. Any facilities financed through the CFD are "public facilities," owned and maintained by the public authority (there are limited exceptions for seismic and flood retrofits, and CFD-financed public energy assets may be installed on private property with consent) (Cal. Gov. Code § 53313.5). While the act expressly permits financing of energy- and water-efficiency improvements on private property, any improvement on private property financed by the CFD would necessarily be considered a "public facility" and a "public improvement," and is owned by the district (or, as discussed below, a joint powers authority). As a result, the public agency overseeing the district may be responsible for ongoing maintenance and liabilities for the improvement. While there is no express restriction against using CFD funds to finance improvements within individual homes, such as energy-efficient appliances, it is unclear whether residents (or public authorities) would accept a "public" designation of such improvements, and whether their financing via publicly administered assessment would be an appropriate use of the statutory authority.

Joint powers authority. To manage the financing, construction, and ownership of public infrastructure, local governments and/or government agencies often form a JPA. A JPA is a public entity created to exercise the powers of multiple independent jurisdictions in a coordinated manner, while sharing costs, risks, and liabilities among the constituent governments or agencies.[22] For example, the Western Riverside Council of Governments (WRCOG), a JPA that was created to provide a group of cities in Riverside County with unified transportation, energy, water, waste, education, and economic development planning, has become the largest PACE program administrator in California (see the PACE section for further discussion). Other notable JPAs include the California Statewide Communities Development Authority (CSCDA), which was created by the League of California Cities and the California State Association of Counties to increase the accessibility of public financing options to its 389 member cities across 56 counties, and the Association of Bay Area Governments (ABAG), which facilitates regional planning for its 101 member cities covering nine counties. According to the California Grand Jurors' Association, as of February 2016, there are over 1,250 JPAs operating in California. JPAs can be particularly useful for the coordinated installation of energy infrastructure, and could be necessary to provide a platform for local governments to initiate CFD financing for EcoBlock projects while helping to insulate them from the liabilities of owning the public assets (through contractual risk allocation mechanisms, guarantees, insurance, or outright ownership by the JPA).

Potential layering of property tax assessments. It is possible to layer different types of public assessments to achieve different goals. For instance, an enhanced infrastructure financing district (EIFD), assessment district or PACE financing (discussed later in this report), and a CFD may be layered on the same parcels to finance different improvements. Both may be used to support financing for public-private partnerships.

Which public authority implements the CFD. Arguably the most important aspect of the CFD is whether the legislative body has determined that the improvement provides a public benefit and agrees to take ownership of it. The legislative body creating the CFD makes its determination via a resolution.

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[22] For more information on the structure and purpose of JPAs, see WRCOG, 2017.

Whether public approval allows for tax-exempt bond status. The CFD authorizes local governments to sell tax-exempt bonds, which are attractive to investors for their tax benefits (by comparison, interest payments from bonds issued by private organizations for private activities are generally taxable [Novogradac & Co. 2017]). Tax-exempt status for public bonds, however, is not a given, as it must ultimately receive the approval of bond counsel. A legislative determination that the improvements provide public benefit or public ownership greatly increases the odds of tax-exempt status and attractiveness to investors. In addition, to support a successful bond issuance, it is essential that the public authority administering the CFD can demonstrate the capacity to properly evaluate both the technical aspects of new installations and retrofits and the financial benefits that will accrue.

Benefits

General Benefits

Established finance tool. CFDs are an extremely common finance tool in California, with deep investor awareness and existing market buy-in.[23] As mentioned, CFDs can be used to secure tax-exempt bonds, making them more attractive to investors. CFDs also potentially can qualify for green bond financing, which could open additional avenues for investment (more on green bonds below).

Simplicity of tax payments. For residents, the CFD has benefits of simplicity and transparency. As a property tax line item, residents pay through their taxes, similar to PACE and assessment district financing. The transaction provides a single payment for the value of the improvement or service funded through the CFD. Any such combination would be subject to the general industry practice of limiting total property taxes to no more than 2 percent of a home's total value (of which 1 percent is occupied by the statewide *ad valorem* property tax under Proposition 13) (Bort 2015).

Annexation. A CFD can also expand and annex new and noncontiguous territory (provided that the CFD is properly designated when initially formed) (Cal. Gov. Code § 53339). The CFD can also be layered with other types of property tax assessments, such as PACE financing and EIFDs.

Binding mechanism. As a public financing mechanism, the CFD has the power to enact a binding property tax assessment for all properties located within the district. While this binding aspect involves complex considerations of community buy-in and landlord-tenant concerns (see discussion below), it has the benefit of ensuring against withdrawal from EcoBlock participation, since district residents are legally bound to pay special tax amounts.

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[23] Between 1992 and 2015, there were 2,269 CFD issuances, for a total of $26,068,509,846. *California Mello-Roos Community Facilities District Yearly Fiscal Status Report* (2014–2015), California Debt and Investment Advisory Commission | CDIAC No. 16.16.

Benefits to the Oakland EcoBlock

Potential to finance improvements**.** CFDs may play an integral role in the financing and business model of the EcoBlock project. Several of the technical improvements involve public or communal infrastructure of the sort CFDs were designed to finance, such as the improvements to the streetscape, the energy distribution backbone, and the energy storage flywheel. Other proposed features could potentially be treated as public or communal property, such as rooftop solar and rainwater collection pipes, depending on whether residents and the City of Oakland would accept them as public (Cal. Gov. Code § 533113.5(m)).

Potential to finance maintenance. CFDs also are able to finance service and maintenance of public improvements, which would help with the long-term viability of the EcoBlock (Cal. Gov. Code § 53313).

Potential to layer with PACE. As noted above, facilities and assets financed by a CFD are "public" assets owned by the public agency with authority over the CFD, which could be problematic for either residents or public authorities with regard to assets such as home appliances that are located on or within individual homes. However, the Mello-Roos legislation would permit the EcoBlock to create a CFD to fund communal infrastructure such as the electric microgrid, while also employing PACE financing at the individual household level to fund appliances and other household-level assets. A separate governance structure would be necessary to coordinate the PACE activities and ensure participation, and to ensure that payment of the obligations of both the PACE assessment and the CFD tax lien do not conflict. The Home Energy Renovation Opportunity (HERO) PACE program, which operates nearly statewide in California, is a potential model for such a coordinating structure (Renovate America 2017).

Potential to establish a citywide district. A CFD may be established for an area larger than the particular neighborhood or district seeking financing. For example, the City of Oakland could enact a citywide, annexable (or "opt-in") CFD, which would enable any district or neighborhood within the city—including the EcoBlock—to then petition the city council to create an improvement district within the citywide CFD, financing improvements as described above, while only binding those residents who live in the annexed block or neighborhood. Other similar districts could later follow suit with their own financing plans under this umbrella authorization, facilitating streamlined expansion of the EcoBlock model (while still allowing the Oakland EcoBlock to pursue its own project-specific goals) and also encouraging outside investment due to increased replicability. It is important to note that unlike a standard CFD, an annexable CFD requires unanimous approval.

Challenges and Potential Trade-offs

General Challenges

Public improvements and liability. The local agency in charge of the CFD may be unwilling to accept certain EcoBlock facilities as "public" due to the possible risk of legal liability. Any assets financed by the CFD are necessarily "public" and thus within the legal control and responsibility of the district, and ultimately of the local government body that administers it (with the exception of certain types of facilities that may be later owned and operated by private utilities). Local governments may not be willing to accept all improvements as public, particularly those that are relatively unproven or could even potentially present public risks (such as the energy storage flywheel), since they could be responsible for replacing them if they fail, or compensating individuals who are somehow injured by them. One potential solution to this problem is the creation of a JPA between a group of local, state, or even federal energy- and water-management agencies, which could assume direct control of the district and/or partially insulate the local government from liability by providing insurance, guarantees, or legal risk allocation (Cal. Gov. Code § 53316.2). JPAs often contract with private parties for administration (such as in the PACE financing context); such an arrangement could be implemented to further spread liability. Another possible solution is for residents to simply redirect a portion of their funds to the municipality directly, for deposit into a liability reserve fund specifically intended to protect against unforeseen costs that could arise as a result of declaring a particular improvement "public."

Two-thirds vote. A CFD requires a two-thirds supermajority vote for approval. A two-thirds vote could successfully bind "no"-voting residents into the CFD, which could present challenges in terms of resident participation and coordination. Extensive polling and outreach to determine willing participants and properly determine the boundaries of the district may be necessary to address these concerns.

Tax-exempt bond status. One benefit of CFD bonds is that they are attractive to investors because of their tax-exempt status. Tax-exempt status, however, is not automatic, and ultimately will rely on bond counsel to render a legal opinion regarding the tax status of interest payments. Bond counsel will also issue a legal opinion as to the authority of the issuer to sell the bond. Although Section 53313.5(m) grants the local authority the right to finance certain private improvements through the CFD, it does not circumvent the requirements for federal tax status and the authority to issue the bond.

Challenges to the Oakland EcoBlock

Acceptance of public improvements. The EcoBlock plan proposes appliance retrofits and home improvements that could arguably fit within the definition of "public facilities" under the CFD legislation (Bort 2015). As discussed above, the City of Oakland may not be willing to accept ownership, liability, and responsibility for ongoing operations and maintenance, but the creation of an structured JPA and the institution of proper governance mechanisms for residents would likely address this concern.

Landlord-tenant issues. CFDs historically have been used to finance new facilities and community improvements in suburban areas and neighborhoods primarily occupied by homeowners. The Oakland EcoBlock, however, includes a number of multi-unit rental dwellings. This presents an issue in the context of the two-thirds vote to create the CFD, which due to the number of residents of the EcoBlock would be held among all registered voters in the district, not just property owners. As a result, landlords could find themselves bound to a property tax assessment on which they had no vote, or on which they disagreed with tenants' votes. As with any assessment-based model, landlords may also elect to pass some or all of the CFD-related property tax expenses through to tenants via increased rents, which raises equity concerns for tenants who did not vote in favor of the tax.

Potential Policy Reforms

Since the use of CFDs requires the creation of "public" facilities, they have rarely, if ever, been applied to the financing of efficiency-related appliances or retrofits within individual homes, which are essential components of the EcoBlock. While these items can also be financed by other mechanisms such as PACE, socializing the cost of liability for the public benefits of the EcoBlock would be a step forward in expanding a tax-exempt bond market for EcoBlock improvements.

Scalability and Replicability

Scaling to Adjacent Blocks

The CFD enabling statute has a provision for the annexation of new territory (Cal. Gov. Code § 53339). This territory need not be adjacent to the existing CFD, but it must be within the jurisdiction of the government agency in charge of the CFD. As such, the Oakland EcoBlock CFD could annex additional territory within Oakland (or within Alameda County, if a county-level agency administers the CFD) if its residents voted unanimously in favor of joining the district. Alternatively, a citywide annexable CFD could allow for rapid expansion of the EcoBlock model within Oakland while still permitting each additional block or neighborhood to tailor its own program to its own needs.

Replicating the EcoBlock in New Locations

The CFD is a well-established, statewide mechanism, and municipalities are familiar with the CFD as a method for financing public improvements and services. And while CFDs are unique to California, other states have analogous community facilities district laws.[24] As a result, the CFD could play an important part in replicating the EcoBlock business model in other locations. However, as discussed above, it is uncertain whether local governments would be willing to accept all EcoBlock facilities as "public." Each jurisdiction has discretion in its determination of the public benefit of the EcoBlock improvements. The creation of a well-structured JPA would assist with replication within California.

Assessment District

Function and Legal Background

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[24] Arizona, Florida, New Mexico, and Texas, among other states, have similar laws.

Assessment districts are commonly used public financing tools. A special assessment is a charge on real property imposed by a local agency to finance the cost of providing public improvements or services. The assessment district allows a local government to raise money for public improvements that provide local special benefits to assessed property.

Function

Assessment districts are tools to finance limited public infrastructure enforced as a property tax assessment and recovered as a property tax line item. Unlike a CFD, which has a two-thirds majority voter approval process, an assessment district requires only a majority vote, with ballots weighed according to the proportional financial obligation of the affected property. After the final actions of the legislative body, bonds are issued by the local agency to fund project costs.

Under Proposition 218, property assessments cannot be directly based on the value of property; instead, they must be based on how much the property will benefit from the assessment (Cal. Const. Art. XIII D, § 4).[25] Proposition 218 only permits property assessments for "special benefits," which confer "a particular and distinct benefit over and above general benefits conferred on real property located in the district or to the public at large" (Cal. Const. Art. XIII D, § 2, subd. (i)).[26] By contrast, a "general benefit" goes to the community at large. Thus any assessment district must finance infrastructure whose benefits accrue to district properties in specific and unique ways.

To be assessed on individual properties, special benefits must be demonstrated through a reliable methodology, typically developed by an assessment engineer. Examples of special benefits include flood protection provided by storm drain improvements, proximity to public parks, safety resulting from street lighting, and sanitation benefits from sewer improvements.

Mechanism

California statutes and the state constitution enable assessment districts (Cal. Const. Art. XIII D; Municipal Improvement Act of 1913; Improvement Bond Act of 1915; Cal. Gov. Code § 53753). As with other tax-assessment finance tools, the assessment district is established by the local government and the local residents via a vote. Typically, a public agency will engage the support of assessment engineers to identify the improvements or services and their respective costs. The engineers then determine the specific benefits to each parcel and provide an analysis of why the improvements should be recovered through the assessment.

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[25] Propositions 13, 218, and 26 (often referred to collectively as *Proposition 13* or *Proposition 218*) effectively create a presumption that any revenue-generating measure imposed by the state or local government is a tax, subject to a two-thirds vote of the legislature or two-thirds vote of qualified electors of a city, county, or special district.

[26] See also *Silicon Valley Taxpayers Ass'n, Inc. v. Santa Clara County Open Space Authority,* 44 Cal.4th 431 (July 14, 2008).

Key Issues

Valuing Improvements. To properly assess the tax increment, the agency must be able to determine the value of the improvement. This calculation is a technical process.

Calculating the special benefit of the improvement to each parcel. Once the value of the improvement has been determined, the benefits of the improvement are then assessed to each specific parcel. Although each district may use its own methodology, typical apportionment for assessment is based on Equivalent Benefit Units (EBUs), which measure the benefits conferred by an improvement relative to the uses permitted under zoning or land use rules.

Benefits

General Benefits

Public financing and securitization. Similar to other public finance tools; assessment district instruments can be used to secure tax-exempt bonds, making them more attractive to investors.

Borrower benefits. Assessment districts have benefits to the borrower, including statutory options to prepay assessments and level debt service (which can be of particular benefit to residents). Borrowers also incur a direct special benefit to their own property, as well as an enhanced degree of control over what would otherwise be tax payments.

Majority vote. Creating an assessment district requires only a majority vote, unlike a CFD, which requires a two-thirds majority vote.

Benefits to the Oakland EcoBlock

Project-appropriate scale and purpose. Assessment districts are appropriate for projects similar to the EcoBlock, such as small, local infrastructure projects, projects with multiple property owners, and maintenance programs and services.

Challenges and Potential Trade-offs

General Challenges

Benefit assessment debt expense. Bonds that are backed by benefit assessments can be more expensive than other types of bonds because property owners may fail to pay their taxes. Assessment bonds may be unrated and uninsured, which may also increase costs (Lui 2011).

Types of improvements financed. Assessment districts are available to finance only limited public infrastructure. Section 5101 of the Improvement Act enables a legislative body to order improvements on lands or rights-of-way owned by the city, county, or state, or lands open or dedicated to public use (Cal St. & High. Code § 5101). As such, the assessment district may not reach all of the proposed EcoBlock improvements, as many are on and inside of private property. By contrast, a public agency administering a CFD has the authority to declare improvements "public."

Categories of improvements. A different special district must be created for public infrastructure and for public services. The EcoBlock proposal includes both infrastructure and ongoing service components, meaning multiple districts would be necessary.

Assessing the benefits. The value of the EcoBlock assessment may prove difficult. As stated above, only special benefits may be assessed on the resident's property tax bill. When assessing a special benefit, local agencies and assessment engineers must follow a formulaic approach to determining the benefit. Multiple assessments could prove complicated with the already complex ownership and design of the EcoBlock project and could also present challenges to the scalability of the EcoBlock.

Policy Reforms

The assessment district is a relatively old tool for public finance in California. There are no suggestions for reform at this time, as newer instruments such as the CFD, EIFD, and PACE have built upon the principle of tax-assessed financing.

Scalability and Replicability

Scaling to Adjacent Blocks

Assessment districts are rigid instruments that typically do not allow the district to expand into adjacent properties. As such, the assessment district would not be the most useful tool to help the EcoBlock expand into the surrounding neighborhood.

Replicating the EcoBlock in New Locations

Property tax assessment districts are established and widespread tools for financing public improvements in California, so it would be possible to use assessment districts to set up EcoBlocks throughout the state. However, because each block would be a unique transaction and would require a similar formation process, it is not an optimal tool for replicating the EcoBlock throughout the state.

Enhanced Infrastructure Financing District (EIFD)

Function and Legal Background

Function

SB 628 (Beall, Chapter 785, Statutes of 2014) created the Enhanced Infrastructure Financing District (EIFD) as a successor to the state's now-defunct redevelopment program (Cal. Gov. Code § 53398.50 et seq.). An EIFD allows a local agency to leverage and borrow money to finance the construction or rehabilitation of a range of infrastructure, based on the "tax increment" that is generated by increased property values in the district that result from the introduction of the new infrastructure. An EIFD can theoretically be used for all public projects that can demonstrate a community-wide benefit (Cal. Gov. Code § 53398.52). The EIFD is a public entity separate and distinct from the city or county that established it. As a result, the EIFD enables the city to issue bonds for which only the district is liable.

An EIFD can serve as an umbrella organization for other permitted funding sources, including other types of special districts such as a CFD. Since the tax increment is not generated until after the infrastructure is at least partially built, EIFD funding is often used to reimburse a private developer or take over the obligations of a CFD. The EIFD is authorized to combine tax increment funding with other permitted funding sources in order to issue bonds for the authorized purpose. An EIFD agency can also form a joint powers agreement with the city or county in which the EcoBlock resides to further enhance financing and ownership (Cal. Gov. Code § 6500). A city, county, or special district that contains territory within the district may loan moneys to the district to fund the activities authorized by the Infrastructure Financing Plan. Because an EIFD does not have the power to levy taxes on its own, it is not subject to Proposition 218 voting requirements (CES 2015).

Mechanism

To initiate an EIFD, the city or county must first pass a resolution to establish a public financing authority (PFA). The PFA is composed of three members of the legislative body of the participating affected taxing entity and two members of the public.

The city or county must also adopt a resolution of intention to establish an EIFD and infrastructure financing plan. The Infrastructure Financing Plan describes the type of public facilities and development that will be financed by the EIFD. The city or county must hold a public hearing before approving the adoption of the plan and formation of EIFD. While direct voter approval is not required to create the organizational structure behind the EIFD, the city or county must get voter approval for the issuance of a bond.

The bond measure must pass with approval of 55 percent of eligible voters within the district. Following voter approval of the bond, the PFA and EIFD implement the infrastructure financing plan, previously adopted by the city or county (CES 2015).

Key Issues

<u>Organizing the PFA</u>. The PFA is the legislative body that governs the EIFD. The body must include three members of the legislative body and two members of the public. If there is more than one taxable entity involved in the EIFD, there must be representatives from each jurisdiction.

<u>Infrastructure Financing Plan</u>. The infrastructure financing plan specifies the types of public facilities and developments that will be implemented by the EIFD. The city or county must adopt the Infrastructure Financing Plan.

Benefits

General Benefits

<u>Access to capital</u>. As a form of tax-assessed public funding, the EIFD’s principal benefit is to provide access to bonds at a lower cost of amortization. Lower-cost funding pools may make the long payback periods of a project more attractive.

Governance structure. In addition to serving as a financing vehicle, EIFDs also provide an organizational and governance structure via the creation of the PFA and the ability to form joint powers authorities with existing districts. Since the PFA includes both legislators and members of the public, it can facilitate a measure of community involvement in the planning process even beyond the initial design and enactment of the Infrastructure Financing Plan (however, as noted below, the EIFD cannot be used to finance ongoing operations and maintenance).

Flexible and tax-exempt. A secondary benefit of the EIFD is that policy makers and voters can tailor the use and amount of funding to a specific purpose. EIFD bonds may be tax exempt, which could make them more attractive to investors. Furthermore, the EIFD can be layered with other types of tax-assessed public financing to cover other types of assets and services. For instance, EIFD revenues can offset a portion of CFD special taxes, and EIFD revenues could also be used on a pay-as-you-go basis.

Benefits to the Oakland EcoBlock

Coverage of different assets. Within the Oakland EcoBlock project, several proposed improvements to the public right-of-way and other improvements could be financed through an EIFD mechanism, and an EIFD could be layered with a CFD to finance a wider range of EcoBlock improvements (CES 2015). Table 6-1 provides a demonstration of how an EIFD, CFD, and PACE can all be layered together on a sample property tax bill.

Table 6-1: Hypothetical EIFD + CFD + PACE Layering

Demonstration of EIFD + CFD + PACE Layering for an Oakland EcoBlock Single Family Residential Home		
Estimated Assessed Valuation and Property Taxes		**Amount ($)**
Estimated Sales Price/Assessed Value		**$604,698**
AD VALOREM PROPERTY TAXES		
Base Property Tax Rate	**1.0000%**	**$6,047**
County General	***0.1584***	
Peralta Community College	0.0264	
Oakland USD	0.1867	
County Supt. Education Instit. Pupils	0.0015	
County Supt. Juvenile Hall Education	0.0003	
County Supt. Service	0.0009	
County Supt. Capital	0.0007	
Alameda Co. F.C. & W.C.	***0.0011***	
Flood Zone 12	***0.0176***	
Bay Area Air Quality Management	0.0019	
Alameda Co. Mosquito Abatement	***0.0008***	
AC Transit Special SVC. #1	0.0463	
SF-BART	0.0054	
East Bay Regional Park	0.0242	
E.B.M.U.D.	0.0145	
E.B.M.U.D. Special Dist. #1	0.0052	
City of Oakland	***0.2825***	
Oakland Zoo	0.0018	
Proposed Ad-Valorem Tax Increment		
EIFD No. X	*0.2239*	*$1,354*
OTHER AD VALOREM TAXES		
City of Oakland	0.2045%	$1,236.61
School Unified	0.1015%	$613.77
School Comm Coll	0.0310%	$187.46
Bay Area Rapid Transit	0.0084%	$50.79
East Bay Regional Park	0.0021%	$12.70
EBMUD Spec Dist 1	0.0011%	$6.65
Total General Property Taxes	**1.3486%**	**$8,155**
PROPOSED SPECIAL ASSESSMENTS		
CFD No. 20XX-01 - Oakland EcoBlock (Public Facilities)		***$1,000***
CFD No. 20XX-02 - Oakland EcoBlock (Public Services)		***$500***
Residential PACE Program Assessment No. XXXX		***$1,316***
OTHER SPECIAL ASSESSMENTS (ESTIMATES, SUBJECT TO CHANGE)		
Mosquito Abatement		$1.74
CSA Paramedic		$31.72
CSA Vector Control		$7.20
City Emerg Medical		$14.40
City Paramedic Srv		$11.46
School Measure G		$195.00
Peralta CCD Meas B		$48.00
OUSD Measure N		$120.00
OUSD Measure G1		$120.00
Violence Prev Tax		$105.42
SFBRA Measure AA		$12.00
Flood Benefit 12		$16.00
Haz Waste Program		$8.46
CSA Vector Cntrl B		$4.08
Mosquito Assess 2		$2.50
AC Transit Meas VV		$96.00
City Library Serv		$101.62
EBMUD Wetweather		$98.80
Easy Bay Trail LLD		$5.44
EBRP Park Safety/M		$12.00
City Landscp/Light		$111.54
Total Assessments, Special Taxes, and Parcel Charges		**$1,123**
TOTAL PROPERTY TAXES BEFORE CFD(s) AND PACE		**$9,278**
PROJECTED TOTAL PROPERTY TAXES INCLUDING PROPOSED CFD(s) AND PACE		**$12,094**
Projected Total Effective Tax Rate (as % of Assessed Value)		**2.0000%**

**** Numbers may not sum due to rounding. Many figures are FY 17-18 estimates and are subject to change.***

DTA DAVID TAUSSIG
& ASSOCIATES

Source: David Taussig & Associates

Challenges and Potential Trade-offs

General Challenges

Projecting tax increment. The principal issue with an EIFD is projecting the tax increment. Because the EIFD borrows against future tax increments, it may be a challenge to accurately project the increase in property value.

No operations and maintenance funding. Unlike CFDs, EIFDs are only authorized to pay for initial capital costs. The EIFD statute explicitly bars the use of funds to pay for operations and maintenance costs (Cal. Gov. Code § 53398.52(a)(3).

Cutting into future tax revenue. A municipality may be hesitant to create an EIFD because, as the EIFD allots future tax revenue to finance a current project, it limits the potential of the city to use that tax revenue for other purposes in the future.

Challenges to the Oakland EcoBlock

Size of tax increment. Since the EIFD relies on the tax increment generated by increased property values for the source of its funding, its effectiveness as a financing tool is generally proportional to the size of the proposed district. The Oakland EcoBlock, which includes fewer than 100 total residential units, provides a limited total assessed property value from which to generate a tax increment sufficient to fund the necessary infrastructure. This limited increment could restrict the usefulness of the EIFD to support the Oakland EcoBlock.

Identifying tax increment for the variety of improvements. Identifying the future tax increment for a multi-element demonstration project such as the Oakland EcoBlock could prove to be more complicated than for a more traditional public improvement. It is unclear what elements of the design homeowners might select, and even more uncertain how the novel improvements could affect long-term property values and corresponding tax revenue.

Services. Because the EIFD is not authorized to finance long-term service costs, it would have little to offer the first EcoBlock demonstration project if all capital costs are already covered through grants.

Potential Policy Reforms

To better support the Oakland EcoBlock, the legislature could amend the EIFD to finance long-term service costs to support the EcoBlock's operation and maintenance.

Scalability and Replicability

Scaling to Adjacent Blocks

An EIFD must follow the Infrastructure Financing Plan, which is passed by resolution. Unlike the CFD statute, the text of the EIFD statute does not permit the addition or annexation of new parcels to a district after it is formed (Cal. Gov. Code § 53398.50-.74). However, the statute does allow a city or county to designate multiple EIFDs at any time, and expansion could be achieved by replicating the terms of an existing EIFD in a neighboring area or block or by creating multiple EIFDs specifically tailored to the needs of different neighborhoods (Cal. Gov. Code § 53398.59).

Replicating the EcoBlock in New Locations

The EIFD is available statewide (and similar tax increment-based financing mechanisms exist nationwide). As such, any California city, county, district or neighborhood could go through the process to create an EIFD to fund an EcoBlock.

Private Financing Models

Property Assessed Clean Energy (PACE)

Function and Legal Background

Function

Property Assessed Clean Energy (PACE) allows homeowners to finance improvements as a line item assessment on their property tax bill (Cal. St. & High. Code § 5895.10 et seq.). California first enabled PACE in 2008 by amending existing law to expand local government financing to include renewables and energy efficiency improvements.[27] Currently, there are 12 active PACE programs in California, with multiple programs serving municipalities in Alameda County (PACENation 2017).[28]

Under PACE, individual homeowners obtain loans to install renewable energy and energy and water efficiency-related improvements, and repay the loans via property tax assessment (rather than stand-alone interest payments). PACE financing is a voluntary, contract-based assessment on the property, which is levied pursuant to the local government's taxing authorities (Cal. Gov. Code § 26054). Borrowing via a tax assessment is attractive to property owners because they can finance projects without paying any up-front costs. PACE financing applications were historically assessed based solely on the value of the property, but new state legislation (AB 1284) (Dabaneh, Chapter 475, Statutes of 2017) will require financing providers to consider applicant income beginning in early 2018 (Khouri 2017). PACE programs offer competitive interest rates with lengthy payback periods but do not encumber personal credit.

PACE financing enjoys tax lien priority, which provides security to lenders and thus helps to decrease the cost of capital for PACE loans. Generally, the delinquent portion of a property tax assessment has priority over private debt in the event of a foreclosure, regardless of the date the prior liens were recorded or when the tax assessments

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[27] The Improvement Act of 1911 allowed municipalities to issue bonds, repaid via property taxes, for a wide variety of infrastructure improvements. AB 811 (Levine, Chapter 159, Statutes of 2008) amended the Improvement Act of 1911 to allow municipalities to issue PACE bonds to finance for renewable energy and energy efficiency improvements.

[28] Alameda County has 59 municipal programs run by various providers, including CaliforniaFIRST, PACE Funding, HERO Program California, Samas PACE, Ygrene Works California, Figtree PACE, and Alliance NRG California.

became delinquent (Kelly 2008). This priority can ensure recovery of amounts owed, reducing the need for assurances regarding repayment and increasing lender security, thus lowering borrowing costs.

PACE relies on program administrators to evaluate borrowing property owners, help find appropriate contractors for the work, and implement the tax assessments that facilitate payment. Programs may be administered by public agencies or private parties on behalf of public agencies (Cal. Gov. Code § 26052). Several city and county governments operate their own PACE programs and arrange with private contractors to manage financial and installation mechanics.[29] Even in publicly administered programs, funding for PACE programs comes entirely from the private sector, although municipal bonds may provide underlying funds for some PACE programs.

Local governments often create a JPA to work together across jurisdictional lines to administer a single PACE program; this helps to limit risk and administrative costs to any individual governmental body by spreading them among the participating entities. As a result, most PACE programs in California operate through JPAs.[30] Private financial firms that administer PACE programs may contract with JPAs or directly with local governments. The Association of Bay Area Governments JPA, which was formed in the 1960s to manage regional-scale projects such as bridges and mass transit, administers PACE programs in the Bay Area through the Bay Area Regional Energy Network. The WRCOG JPA administers three separate PACE programs in collaboration with private partners—CaliforniaFirst, which covers residential and commercial PACE through Renew Financial; HERO, which covers commercial PACE through Renovate America; and SAMAS, which covers commercial PACE through SAMAS Capital. It has developed the largest PACE program in the nation, with tens of thousands of property owners accessing hundreds of millions of dollars for energy and water efficiency upgrades (NARC 2017). PACE financing at the EcoBlock could be administered through an existing PACE program under an existing JPA, or as discussed above, could be managed under a new JPA that supports both PACE and CFD activities.[31]

Mechanism

Local governments must create and approve a PACE program, either through public administration or as part of a JPA, and collect payments via tax assessment. Aside from

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[29] For examples of such programs, see GreenFinanceSF, available at https://sfenvironment.org/article/financing/greenfinancesf-commercial-pace-program; and Los Angeles County PACE, available at http://pace.lacounty.gov/commercial.html.

[30] For examples of such programs, see California Statewide Communities Development Authority, Open PACE Program; available at http://cscda.org/getdoc/205a5831-d67d-40e8-b726-086edfae2358/Open-PACE-Property-Assessed-Clean-Energy-Program; and Western Riverside Council of Governments, WRCOG PACE Programs, available at http://www.wrcog.cog.ca.us/230/PACE-Programs.

[31] In December 2017 the Federal Housing Authority announced that it would no longer insure new mortgages for homes with PACE financing. See U.S. Department of Housing and Urban Development, “Mortgagee Letter 2017–18” (December 7, 2017), available at https://www.hud.gov/sites/dfiles/OCHCO/documents/17-18ml.pdf. The team has conferred with PACE program managers who have indicated that this change is unlikely to have a significant impact on PACE loan origination in California.

local government approval and oversight (as well as administration, if applicable), PACE programs are operated by private lending companies under contract with local governments and/or JPAs.[32]

Key Issues

Identifying assets to be financed through PACE. PACE financing is available for the installation of distributed generation renewable energy sources or energy or water efficiency improvements that are permanently fixed to the property owner's real property, such as rooftop solar panels (Cal. St. & High. Code § 5898.21).

Interest rates. Interest rate is market-based and determined at the time of financing. Rates are typically between 3.99 percent and 8.50 percent, depending on the size and term of the loan, as well as other factors (ABAG 2015).

Lien Priority. As a tax lien, PACE loans have priority over other types of loans, including mortgages. Under SB 77 (Pavley, Chapter 15, Statutes of 2010) California created the Loan Loss Reserve in response to a Federal Housing Finance Agency directive that Fannie Mae and Freddie Mac not buy mortgages on PACE-encumbered properties until states developed standards to protect consumers and mortgage lenders. The PACE Loan Loss Reserve Program supports PACE financing by reimbursing first mortgage lenders on direct losses resulting from the seniority of a PACE lien in foreclosure or forced sale (CAEATFA 2017).

PACE versus traditional bank loans. In general, PACE is more favorable to borrowers. PACE does not require business credit review, tax returns, financial history, or down payment during the application process. PACE offers fixed-interest, long-term ownership financing. In addition, unlike a traditional non-mortgage bank loan, PACE loans attach to the property if it is sold (HERO 2017).

Benefits

General Benefits

Financing for private property improvements. PACE financing allows property owners to lower their utility bills and increase the value of their buildings with no out-of-pocket costs or down payments. Unlike the other tax-assessed financing or public financing tools discussed below, which are structured to fund community improvements, PACE financing is designed for financing improvements to individual private properties.

Streamlined approval process. PACE financing also benefits from its approval process. Homeowners apply directly to PACE financing programs, which review applications based on home equity (instead of credit scores). Unlike other mechanisms, PACE agreements are formed by individual landowners, not community votes or a regulatory

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[32] For an example of a private PACE lender, see HERO PACE, available at https://www.renovateamerica.com/financing/hero.

approval processes. As such, a dissenting neighbor or group within the district cannot stop others from financing infrastructure through PACE.

Securitization. PACE is an established financing mechanism that is familiar to investors. Bonds associated with PACE can be packaged and securitized. There have been over a dozen investment-grade rated securitizations of PACE assets. For example, in 2017, Renew Financial securitized PACE bonds for $223 million, funding more than 7,000 projects (Renew Financial 2017). That securitization received the highest “green” rating available from Moody’s Investors Services.

Green bond certification. Green bonds are a burgeoning financial market in which bonds are certified based on the environmental benefits of an investment (CBI 2017). Central institutions maintain databases of certified green bonds, which offer the same rates of return and levels of security as other investments but appeal to certain investors due to the environmentally beneficial projects they finance. Many PACE bonds may already qualify for green bond certification, which could expand the pool of interested investors. In fact, some PACE programs, such as the HERO program, which provides PACE financing to hundreds of thousands of customers based on statewide minimum eligibility criteria, already package and market their bond issuances as green bonds. This level of market maturity could be a significant benefit with regard to financing the EcoBlock.

Appendix L includes a detailed discussion of the role of green bonds to finance climate-friendly urban infrastructure, the market practice of green bonds in the municipal space in the United States, and potential EcoBlock criteria and issuance options for a green bond to finance the EcoBlock developments. While the green bond market is relatively young, the process for certification, issuance, and reporting is well established. As the EcoBlock model proliferates, issuers could develop an EcoBlock-specific standard for green bond certification, drawing on established benefits from low-carbon buildings, water efficiency, solar energy, and low-carbon transportation to facilitate widespread investment in the EcoBlock model.

Benefits to the Oakland EcoBlock

Existing programs in Alameda. PACE financing is already available in Oakland and the rest of Alameda County, with companies already financing in the area of the EcoBlock. In fact, the first PACE program was implemented in nearby Berkeley, California.

Financing for private improvements. PACE financing may be the only financing available to cover aspects of the EcoBlock that consist of improvements to private property or fixtures within the residents’ homes. PACE financing is a well-established tool for financing sustainability improvements to private property, which should ease some of the transactional issues in other financing models.

Challenges and Potential Trade-offs

General Challenges

Funding for individual versus community property improvements. Since PACE is intended to allow homeowners to finance private improvements through their property tax assessment, it is generally limited to improvements located on the property that is being assessed. As such, PACE financing would likely be unavailable for communal improvements, such as an electricity distribution system backbone or microgrid, energy storage installation, or community water improvements. These types of improvements would require other financing vehicles such as a CFD.

Property burden and lender resistance. Like other tax liens and assessments, PACE liens run with the property and thus become a point of negotiation during the sale of the home, and can result in foreclosure if unpaid. Mortgage lenders also have concerns regarding PACE lien priority, which California has attempted to address through the creation of the Loan Loss Reserve Program.

Challenges to the Oakland EcoBlock

Coordination and enforcement. PACE is an individual program, lacking a block-scale coordination or enforcement mechanism. Each homeowner would have to enter into a separate PACE agreement for the suite of improvements proposed as part of the design. It would be challenging to ensure adoption of all EcoBlock retrofits with each homeowner entering into a separate PACE agreement—or potentially not entering into a PACE agreement at all—unless PACE were paired with an adequate governance mechanism.

Landlord-tenant split incentives. The Oakland EcoBlock includes a variety of single- and multi-family homes, with both owned and leased units. The attractiveness of PACE will vary depending upon who receives the benefit and cost of the property improvements; owners may be unwilling to take on financing obligations for efficiency retrofits and upgrades that will reduce tenants' utility bills. Only property owners may undertake PACE financing obligations.

Potential Policy Reforms

It might be possible to reform PACE financing so that homeowners negotiate as a group before taking on their individual assessment liens. This might reduce transaction costs and benefit both parties by creating new markets, enlisting neighbors as recruiters, and decreasing overall costs.

Scalability and Replicability

As an established financial tool used to contract with private parties, PACE could expand to homeowners on adjacent blocks. Since PACE financing is widely available nationwide, it will likely play a role in exporting the EcoBlock model to new areas.

Public-Private Partnership (P3)

Function and Legal Background

A public-private partnership (P3) is a contractual arrangement between a public agency and a private-sector entity (Rizzo and Cruz 2017). In the case of the EcoBlock, a number of ownership arrangements might lead to a P3. The open questions involve the identities of the different parties and their willingness to participate in the partnership.

P3s typically involve a long-term partnership agreement between a public entity and a private developer. Under the agreement, the private developer usually designs, builds, finances, operates, and maintains a fee-generating public improvement. P3s are frequently (but not always) built on public land and focus on public infrastructure that has a revenue stream to help secure and repay project costs. The goal of California P3s is to grant local governments the authority to mobilize private investment capital for fee-producing infrastructure (Cal. Gov. Code § 5956.1).

There are two fundamental differences between a P3 and privatization:

1. In a P3, the government remains an active participant through the deal, rather than simply granting concessions to a private party.
2. The government is a party to the P3 transaction and is ultimately expected to provide the service since it is a public good, even in default (Travelers 2017).

P3 projects require specific enabling legislation that defines the public agencies and types of projects. California has enacted four statutes giving state and local government agencies the authority to enter into P3s.[33] Enabling statutes define the private partner (concessionaire), selection methodology, and term of the operations and maintenance agreement, and they often expressly mandate that the public improvement remain in the ownership of the government at the end of the term. Ultimately, the terms of the enabling statute will define the scope of a local agency's ability to create a P3 as a vehicle for the EcoBlock.

Function

P3s are a form of project financing and management. Based on the local government P3 statute, the concessionaire typically obtains most or all of the funding for the project. The concessionaire is then repaid through the project's revenue stream or by the public. Arrangements vary from project to project, using different financing tools that may include private equity investment by the concessionaire and/or investors, loans from

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[33] The four P3 enabling statutes cover public transportation projects, court facilities, high-speed rail, and local agency projects for "fee producing infrastructure." See Cal. St. & High. Code § 143; Cal. Gov. Code §§ 5956; Cal. Gov. Code §§ 70391-94; Cal. Pub. Cont. Code §§ 10187–96, 22160–69.

private commercial lenders, government grants, federal government loan and guarantee assistance programs, and private activity bonds or other corporate bond financing.

Mechanism

Each type of P3 requires an enabling statute. While California has narrow P3 statutes for transportation, courthouses, and the high-speed rail project, it has a broad P3 enabling statute available to "local government agencies" for the development of a variety of types of public infrastructure projects using a P3 approach (Cal. Gov. Code § 5956.3(a)). The local government enabling statute has been used to pursue "fee-producing" infrastructure for irrigation; drainage; energy or power production; water supply treatment, and distribution; flood control; inland waterways; harbors; municipal improvements; commuter and light rail; highways or bridges; tunnel; airports and runways; purification of water; sewage treatment, disposal, and water recycling; refuse disposal; and structures or buildings, except those that are to be used primarily for sporting or entertainment events (Douglass 2013).

Key Issues

Design-Build-Finance-Operate-Maintain (DBFOM) projects. Certain P3s award the private party with a contract to design, build, finance, operate, and maintain infrastructure. There are benefits and detriments to the approach, which may be amplified depending on the EcoBlock components that are ultimately financed.

Concession term. A P3 agreement typically grants the private third party a concession to operate (and, in some cases, to own) the infrastructure for a limited period of time, up to 35 years (Cal. Gov. Code § 5956.6(a)). The length of the term is a key design point for any P3.

Requisite operations and maintenance standards. The agreement should contain some standards for operations and maintenance on the project. Poor operations and maintenance may eventually become a public expense. The terms of the agreement must have sufficient assurances for operations and maintenance over both the term of the concession and the lifetime of the assets.

Supervening events and risk allocation. The P3 should include sufficient guards against supervening events or catastrophic risk. Assignment of risk, duties to carry insurance, and indemnification should all be included in the P3 agreement.

Defaults and early termination of the contract. The local agency should make clear and enforceable agreements covering default or termination of the P3 contract.

Public financing/private operation model. Some P3 arrangements may involve initial public financing for a project, followed by private maintenance and operation. Such a model could potentially be used for the EcoBlock, as long as the public and private parties are able to properly allocate the "revenue" generated by EcoBlock energy and water savings to both pay for private maintenance and recoup initial costs.

Benefits

General Benefits

Private sector finance and expertise. The main benefit of a P3 is access to private finance and expertise. P3s are a common model for local governments building and operating complex infrastructure, such as water, energy, and sewer treatment projects. Furthermore, incentivizing a private party to own and operate a public facility can increase project efficiency. "Build-own-operate-maintain" (BOOM) P3 districts that build, own, operate, and maintain public facilities can solve many issues with financing, liability, and long-term operations and maintenance.

Benefits to the Oakland EcoBlock

Long-term service provider for operations and maintenance**.** EcoBlock is both a policy and technology demonstration that could benefit from a hybrid business model. One of the major issues for the Oakland EcoBlock is how to assign ownership of certain assets, as well as how to assign liability and responsibility for long-term operations and maintenance (O&M). A P3 model would expressly define the terms of liability and long-term operations and maintenance in the concession agreement, which might ease costs and concerns with communal assets.

Simplicity. The concession agreement could also simplify issues regarding communally operated property such as the flywheel, energy distribution backbone, and sewer scalping facility. Homeowners would pay a fee and the private concessionaire would provide the EcoBlock as a service, avoiding complicated ownership, operation, and liability issues for the homeowners.

Challenges and Potential Trade-offs

General Challenges

Enabling statute. The first major challenge in the P3 model is whether the enabling statute permits the project. The project proposal must fit within the authority of one of the California P3 statutes. Although the enabling statute for P3s for local governments has a broad scope, there are still limits on the projects a local government can undertake through a partnership. Specifically, such agreements may include:

> "provisions for the lease of rights-of-way in, and airspace over, property owned by a governmental agency, for the granting of necessary easements, and for the issuance of permits or other authorizations to enable the private entity to construct infrastructure facilities supplemental to existing government-owned facilities." (Cal. Gov. Code § 5956.6)

As such, the public actor may enter into P3 agreements for its own land, but the enabling statute does not grant the authority to the government to contract on behalf of private property owners. A P3 is an agreement between a public department and a private concessionaire. It is unclear how a P3 would be constructed to include facilities or improvements on private property. An EcoBlock P3 would likely be limited to financing the construction of public elements located on public land such as the shared electric microgrid and wastewater treatment components, and it would need to be coupled with another financing mechanism for elements on private property.

Political will. Even if the type of project is covered under the enabling statute, the local government must be willing to undertake the project and surrender control of the public infrastructure to a private actor. Depending on the type of project and the enabling statute, a local government may have to contribute some financing and resources. A government department must be a party to the partnership, and terms regarding liability, operations and maintenance, eventual ownership, or performance at default might attach to the local government.

Design responsibility and risk. P3s are frequently design-build arrangements that can maximize the project efficiency. However, this efficiency comes at a cost: a design-build contractor is legally responsible for non-delegable duties that arise when both designing and constructing a project. Unlike more traditional public projects, in which a contractor who has followed plans and specifications warranted by an owner cannot be held legally liable for alleged construction defects or insufficiencies attributable to the plans, a design-build contractor assumes all responsibilities necessary to deliver a completed project. Design-build operations cannot delegate duties in the same way traditional construction arrangements could, since the builder is also the designer. As such, while there might be efficiencies in a design-build P3, there may be heightened liabilities for the concessionaire in comparison to other bid projects with no private design component (Castro 2009).

Compensation. P3 projects typically repay private developers through either "toll/revenue concession" or "availability payment" approaches. If there is not a clear "fee" or revenue stream for the use of the asset (e.g., entry fee to a public ice skating rink or a toll on a road), it may be difficult to structure a long-term concession agreement that a private party could use to finance the project.

Benefit-sharing. P3s can run a risk of windfall profits for the private developer. As such, the public partner must construct the concession agreement to share gross financial benefits, should they arise. Benefit-sharing agreements should reflect the relative risk-adjusted return on the project, while still incentivizing the developer to engage with the project (USDOT 2014). The project must also be large enough in scale to justify P3 transaction costs.

Public Utility Commission jurisdiction. 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 California Public Utilities Commission (CPUC) (Cal. Pub. Util. Code § 216). CPUC regulations can be stringent and reduce the potential profitability and commercial appeal of a project, as the CPUC has long accepted the proposition that its jurisdiction does not extend to a homeowner's self-supply of these utilities. For example, this exception traditionally covers the use of a back-up generator, rooftop solar, or a potable water well at an individual property, which is not subject to CPUC regulation. However, a P3 distributing water and electricity, and providing sewer services, to private residents could potentially be treated as a utility, rather than an entity engaged in a form of self-supply. If this were the case, the P3 would be subject to additional regulation under the Public Utilities Act, as well as oversight by CPUC.

Challenges to the Oakland EcoBlock

Private property. The major issue with creating a P3 for the EcoBlock is that the block consists of a group of private property owners, and the EcoBlock is a unique proposal that cuts across public, communal, and private property ownership. While the technical proposals specify several improvements to the right-of-way and include a suite of community improvements (such as the flywheel and microgrid), much of the project occurs on private property. These private-improvement elements of the proposal (such as home appliance upgrades) would likely fall outside of the authority of the P3 financing statute and would require separate arrangements.

Risk allocation. The P3 model does not clearly allocate project risk and liability. Each P3 is a unique agreement between the government actor and the concessionaire, with terms unique to the project. As such, liability and responsibility for long-term operations and maintenance would need to be negotiated between the parties. As discussed above, a design-build arrangement may allocate all legal liability for the project to the private contractor, a responsibility that contractors may be unwilling to shoulder if a project is not sufficiently profitable. EcoBlock retrofits with leading-edge technologies and advanced performance could also add an additional layer of maintenance requirements.

Compensation. Another major challenge to an EcoBlock P3 is how to structure the block as a fee-generating asset. While residents could pay a monthly or yearly fee to a concessionaire that would own, operate, and maintain the public portion of the EcoBlock infrastructure to make it function as a fee-generating asset, this could open the block model to new challenges, such as being considered a utility that requires state regulation (see discussion of CPUC jurisdiction above). In addition, the Oakland EcoBlock is relatively small in terms of potential revenue generation, compared to traditional P3 assets (e.g., major toll roads).

Policy Reforms

P3s are inherently statutory creations. While the “local governments” P3 enabling statute provides broad authority for local governments to form partnerships, there might be a benefit to greater specificity. In particular, § 5956.1 gives local authorities flexibility in forming P3s for “fee-producing” infrastructure facilities. An enabling statute for EcoBlock P3s could modify language to allow local agencies the authority and flexibility to utilize private investment capital to finance, for example, “fee-producing activities or activities that result in a net-decrease in residential water use, energy use, or carbon dioxide production.” Such language might enable local authorities and private developers to more easily initiate EcoBlock projects.

It is unclear whether this reform for a "fee-producing activity" that involved the provision of water and/or electricity would trigger CPUC jurisdiction over EcoBlock as a regulated utility.

Scalability and Replicability

Scaling to Adjacent Blocks

As a discrete agreement between the local government and concessionaire, a P3 might include language that would allow the concessionaire to annex adjacent territory into the project, but it is any such annexation would require a second, separate negotiation and could essentially function as a separate P3. It is also unclear whether terms for annexation would be able to carve out specific time periods for the partnership and the concession.

Replicating the EcoBlock in New Locations

If the P3 model could overcome the other challenges, creating new EcoBlock projects would be a matter of finding willing partners in new locations. Assuming the terms could be made replicable and the P3 model could interface with private property rights, then public-private partnerships could help establish new EcoBlock projects in separate locations. As initial EcoBlock projects demonstrate consistent revenue streams, more concessionaires will be willing to partner with local governments. In addition, to the extent terms are replicable, subsequent projects may be able to minimize legal and transaction costs.

Project-Level Non-Recourse Financing

Project financing is a form of financing common in renewable energy development. Project-level loans are "non-recourse," which means they are secured only by the project assets and paid off entirely by the cash flow from the project—the lender cannot recover from the project sponsor if revenues are insufficient to repay the loan. Project loans are often used to finance projects valued at hundreds of millions or billions of dollars, and are characterized by high capital expenditures, long repayment periods, and projections of consistent cash flows. In a project financing, the project sponsor raises capital through an independent entity, the Special Purpose Vehicle (SPV), which is essentially a holding company with no assets but the project. (In this respect, project financing resembles a private form of the CFD financing structure). The project sponsor and other investors own the SPV, and the SPV in turn owns the project (Feldman 2016).

Project financing could potentially be used to implement the EcoBlock, but residents would face a number of significant questions and barriers. It is unclear whether the EcoBlock could produce sufficient "revenue" from savings to attract any investors willing to take a security interest in the EcoBlock assets alone; and the legal complexity of creating an SPV and arranging for project-level financing would produce significant transaction costs. In addition, creating an SPV that deals in the EcoBlock assets might create conflict with CPUC jurisdiction (see analysis above with regard to P3s).

Business (Organizational and Governance) Models

Certain organizational and governance structures are available to allocate ownership and decision-making responsibility for EcoBlock assets and to assist residents and property owners with initial and ongoing management of new infrastructure items. In addition, some may create new business opportunities and venues for financing. For instance, a homeowner's organization allows the community to create an entity that can borrow for projects and raise money through dues to cover ongoing maintenance costs. Similarly, a community choice aggregation program opens up new avenues to enhance potentially enhance the EcoBlock value proposition and facilitate investment. This section explores these ownership and organizational structures.

Homeowners Association (HOA)

Function and Legal Background

A homeowners association (HOA) is a governing body of a development or community, comprised of members of the community. The HOA has a governing board of elected volunteers that manage the community. HOAs must adhere to the state's corporate code and the Davis-Stirling Common Interest Development Act (Cal. Gov. Code § 4000 et seq.). Within the HOA, rules are enforced through covenants, conditions, and restrictions (CC&Rs), which are contractually binding agreements among residents.

Function

In addition to its traditional role of enforcing community rules (which is not centrally relevant to the EcoBlock business model), the HOA has the power to take out loans and make investments in the infrastructure (Cal. Corp. Code § 7140(d)). HOAs borrow from private financial firms, some of which are specialized in financing HOAs and neighborhood associations, and repay loans through member dues.

Mechanism

Under California law, an HOA is treated as a nonprofit mutual benefit corporation (Cal. Corp. Code §§ 7110-8910). As a result, HOAs are required to meet certain duties of the corporate form including regular meetings of the members, notice requirements, development of bylaws, bookkeeping requirements, and more. Although lawyers may support the formation of an HOA, most of the day-to-day duties fall to the residents, who must be willing to volunteer their time and effort.

Key Issues

<u>Designing necessary covenants to bind current homeowners</u>. There are several covenants that homeowners would need to agree to in order to bind an EcoBlock HOA. Depending on the final design proposals, this might include requiring homeowners to give permission to the HOA to maintain solar panels on their roofs and install water distribution and irrigation equipment, and subscribe to local microgrid service over their incumbent utilities.

Qualifying for financing. As a private organization of homeowners, the HOA would need to seek its own financing for EcoBlock improvements. These loans would likely come from private financing sources, unless coupled with another public financing tool. HOA creditworthiness and community dues could affect the cost of capital and the overall cost-effectiveness of the EcoBlock.

Balancing existing property rights with the community needs of the EcoBlock. HOAs serve as a form of governance for a shared community, which often include restrictions on how homeowners can use their property. An EcoBlock HOA would not fill the typical role of an HOA, and instead would be limited to energy- and water-efficiency related infrastructure and use measures. The CC&Rs would need to be carefully written to balance existing property rights with operating and maintaining EcoBlock improvements.

Rights of a property owner to enter an HOA with current tenants. Landlords could be barred from entering into HOA-related covenants for units under existing leases. While it does not appear that any state statutory or common law rule limits a property owner's ability to enter a new covenant under an existing lease, rent control laws and the terms of individual leases will restrict a landlord's ability to increase rents or require a tenant to undertake new responsibilities. Any landlord seeking to enter into the HOA would need to ensure that its terms do not conflict with existing leases or limits on rent increases (an issue that is common to any new financing).

Benefits

General Benefits

Familiarity. HOAs are common instruments for community governance and development. Policy makers, financiers, and property owners understand and in many cases have interacted with HOAs. An HOA is a relatively straightforward legal instrument that could result in lower setup and transaction costs/efforts. The HOA would be able to encompass various types of assets, potentially negating the need for composite public/private financing methods (Cal. Corp. Code § 7140(d)).

Private arrangement. HOAs are private arrangements with few statutory limits on their scope, instead relying on the homeowners voluntarily agreeing to undertake certain mutually enforceable responsibilities and restrictions pursuant to the CC&Rs. These covenants enable the neighborhood or community to enforce rules against individual homeowners regarding the use of property and common spaces and infrastructure. State-imposed requirements mainly dictate the form and procedure of the HOA but do not shape the powers of the entity.

Community. An HOA necessitates community involvement. Depending on the community and its goals, increased involvement could deepen the sense of stewardship and membership to the common endeavor.

Financing and ownership. An HOA operates as a separate entity that can borrow and lend to finance projects and could own and operate assets. In addition, the HOA would have the ability to take ownership of certain community facilities, which would ease insurance, financing, and operations burdens that might otherwise be difficult to assign. This layer of separation could shield the individual homeowners and the local government from potential liabilities arising from community assets.

Benefits to the Oakland EcoBlock

Financing and ownership. One of the main challenges for the EcoBlock is creating an entity that could finance, own, and operate both public and private property. An HOA, supported by the proper CC&Rs, could potentially manage all of the EcoBlock assets. This could include financing the retrofit improvements, retaining consultants for long-term maintenance, and recovering costs through community dues.

Community vision. An engaged and visionary community could push the EcoBlock idea after the initial project to incorporate further sustainability measures. An HOA might facilitate long-term, community-governed administration of the locally sustainable and community-based EcoBlock model.

Challenges and Potential Trade-offs

General Challenges

Weak enforcement of dues and CC&Rs. HOAs have a weaker enforcement mechanism than other types of organization and governance that can lead to challenges in repayment. Delinquent HOA dues are often only recovered at the time of sale, and the only mechanisms to enforce CC&Rs are financial (also only recoverable, ultimately, at time of sale) and restricted access to common areas. By comparison, tax liens can lead to foreclosure.

Community fatigue and management. HOA participation can feel onerous and owners may be unwilling to create an organization that requires them to pay dues and submit to the rules of the organization. Elected or even volunteer organizations in charge of community resources can cause tension in the neighborhood.

Liability. One potential benefit of an HOA is that it could not only be used to obtain financing and organize residents, but also to own common infrastructure outright. While this would provide simplicity and protect individual homeowners and entities providing financing (whether government or private), the HOA would become liable for the assets both legally and financially. Since the HOA would be supported solely by residents' dues, this liability could pose a point of resistance for residents.

Challenges to the Oakland EcoBlock

Withdrawal from EcoBlock design. As a community governed by its members, an HOA board can decide to change or cancel certain plans. In short, HOA would have the freedom to withdraw from aspects of the EcoBlock project portfolio (e.g., shutting down and removing the energy storage flywheel), with no limitation other than the terms of any existing financing. This could jeopardize project energy, water, and carbon savings, as the technical elements and business model that are designed to work as a whole.

Creation of an HOA from existing properties. HOAs are typically created when a larger property is subdivided, or at the creation of a new property interest, such as the construction of a condominium. By comparison, the Oakland EcoBlock is a community of existing property owners and tenants. Creating an HOA in this context would require the homeowners to submit voluntarily to new limitations on their property rights. Although not impossible, it is an uncommon legal arrangement that might bring unique legal and community issues. Deciding the extent of new CC&Rs would require significant input from owners.

Policy Reforms

HOAs are common community governance tools. As a result, changing the existing laws may not be a useful approach. Instead a more useful approach might be to craft a specific HOA-like entity that could only be formed by existing property owners for the purpose of energy and water sustainability retrofits. Creating a standard format for block-level retrofits that involve owners and tenants, a "Green Retrofit Organization," might ease some of transaction cost, while putting lenders, cities, and counties at ease.

A Green Retrofit Organization would be different from a third-party nonprofit because it would be tied to the land through covenants (recorded in each property's chain of title) rather than a contractual agreement, providing greater certainty for potential financing options. The benefit would be that, unlike an HOA, a set of standard terms would limit the reach of the Green Retrofit Organization to energy and water improvements, versus the broad reach of a typical HOA, which can require certain homeowners to follow community aesthetic and property use standards. A standard model could dispel some of the perceived negativity toward HOAs by creating a recognizably different organization for block-level retrofits, tailored to the specific EcoBlock goals.

Scalability and Replicability

As a note, the HOA is an organizational model that could support the EcoBlock business model and potentially create an avenue for financing. The HOA alone does not create a business case for the EcoBlock. Scalability and replicability based on the HOA model will still have to contend with financing initial and ongoing costs.

Scaling to Adjacent Blocks

The declaration of restrictions used to bind the properties to the CC&Rs as part of the HOA may provide criteria and procedures for annexation of adjacent property into the existing association (Geier 2017). Annexation terms are common provisions for phased developments, and the HOA could provide a vehicle for the Oakland EcoBlock to expand into adjacent properties to form an "EcoNeighborhood."

Replicating the EcoBlock in New Locations

HOAs are common organizations throughout California and the United States. If an HOA or "Green Retrofit Organization" proved a functional business model for the EcoBlock, and terms were developed to address the existing property and tenancy issues, it would be a straightforward exercise to use the HOA as a tool for organizing new EcoBlocks elsewhere.

Community Choice Aggregation (CCA)

Function and Legal Background

AB 117 (Migden, Chapter 838, Statutes of 2002) enabled local governments to participate in the electricity market as Community Choice Aggregators (CCA). The law enables a local government agency to form a CCA to procure electricity for local ratepayers by aggregating demand (Cal. Pub. Util. Code § 331.1). To create a CCA, a local government must pass an ordinance that forms the entity and enrolls the citizens, typically on an opt-out basis (DeShazo 2017; Cal. Pub. Util. Code § 366.2(3)). While the CCA procures energy sources, it does not replace the existing utility, which it uses for billing, transmission, and distribution (ACCDA 2017).

In addition to energy procurement packages, CCAs can offer locally tailored energy programs and attractive financial tools that support energy efficiency programs, ownership of rooftop solar, and other renewable technologies and strategies. Some CCAs are expanding into roles where they own and operate generation as part of procurement for their constituents.

Function

CCAs are an alternative to incumbent utility or energy service company models. They are managed by a board of elected officials and operated as a nonprofit, and make collective procurement of electricity on behalf of residents (Cal. Pub. Util. Code § 331.1).

CCAs can influence clean energy investments in several ways. First, they can administer energy-efficiency programs with ratepayer funds as though they were a utility or public authority. Second, some CCAs create favorable rate structures for their constituents, such as net metering and feed-in tariffs. Beyond rate structures and program administration, CCAs can also finance and own generation assets. As mentioned above, some CCAs have started partnering to build generation to aid in procurement of clean energy for their customers, such as the Marin Clean Energy Solar One Project in Richmond, California.

CCAs provide different services, depending on the financing model. In large-scale generation procurement, the CCA functions as a project partner. As a program administrator, the CCA is a conduit for statewide grant funding or program funding raised through ratepayer charges. In addition, depending on the enabling agreement, a CCA has rights and powers to set rates and charges for electricity and services, incur indebtedness, and issue bonds or other obligations. As such, the CCA can issue a bond to finance a program for its constituents, which would then be recovered through rates or surcharges.

Mechanism

Pursuant to the enabling statute, a local government must create the CCA as an authority and enact a joint powers agreement to grant the CCA jurisdiction over ratepayers (Cal. Pub. Util. Code § 366.2). Once established, a CCA meets and make decisions as a public agency, including meetings of the board of directors, public hearings, drafting and voting on resolutions for the CCA, and transparent accounting.

Key Issues

Opt-in or opt-out. Different CCA statutes and ordinances may include opt-in or opt-out provisions. Opt-in provisions require customers to sign up with the CCA to be part of the aggregated customer base. Opt-out provisions automatically enroll customers in the territory and require them to affirmatively opt-out of the CCA procurement.

Financing and owning assets. In California, CCAs can participate in a wide scope of potential activities. A CCA's lightest role is as a pure procurement entity that aggregates demand and enters power purchase agreements accordingly. On the other end of the spectrum, the CCA could potentially own and operate generation.

Tariff structure. CCAs are responsible for their own energy tariff structure, which governs the rates charged to customers (distribution tariffs are still set by the utility). CCA tariff structures inform the value and payback on different clean technology assets. A CCA could even include its own tariff structure for a one-off demonstration project, such as the EcoBlock.

Territory of a CCA. CCAs are regional. Whether or not the CCA can participate in or facilitate the project will depend on whether the customers can participate in the CCA.

Exit fees. Incumbent utilities have started imposing "exit fees" on CCA customers to make up for the departing load the utility had previously factored into its own long-term power purchase agreements. Exit fees could impact the economics of an EcoBlock project by effectively increasing the cost of entering a CCA.

Benefits

General Benefits

Cost-effective renewables and incentives. CCAs offer a larger share of renewable energy compared to investor-owned utilities; a recent University of California, Los Angeles, study found that CCA efforts reduced emissions by approximately 600,000 metric tons in twelve months compared with incumbent utilities (DeShazo 2017). CCAs also have the ability to control their own procurement portfolios and enter into power purchase agreements based on their own goals. As a result, CCAs can create other incentive programs, such as energy-efficiency and local generation tariffs, which help diversify energy resources and increase community engagement.

Powers to potentially own and operate generation. Depending on the enabling instrument, a CCA's powers range from simple energy procurement to financing, owning, and operating facilities. A CCA may be willing to step in and act as an external project backer with interest in both the provision of electricity and the policy goals of its resident constituents.

Local influence over energy programs. CCAs across California have provided renewable energy at competitive prices. The relationship between ratepayers and the elected board also increases the opportunity to tailor programs to the needs of the local community. For instance, Marin Clean Energy offers on-bill repayment loans for energy efficiency retrofits for multifamily properties and small businesses.

Benefits to the Oakland EcoBlock

Favorable rates and incentive programs. A CCA could promote programs that would favor EcoBlock development. For instance, a CCA could work with the EcoBlock to create a favorable rate for distributed generation and energy storage; or create a program that incentivizes deep energy efficiency retrofits. CCA programs could also incentivize electric vehicle usage and off-peak charging. The CCA creates an opportunity to tailor local policy to the EcoBlock technical proposal.

Ownership, operations, and maintenance. CCAs can finance, operate, and own energy projects. One of the recurring questions with the Oakland EcoBlock is how to assign ownership responsibility for the various improvements. If a CCA was involved in ownership and operation, it could potentially alleviate some concerns about liability and the long-term maintenance of the block.

Forthcoming Alameda CCA. The Oakland EcoBlock will be within the jurisdiction of a new CCA in 2018, which will help inform tariffs and the long-term revenue stream for the block.[34] Details will emerge as East Bay Community Energy implements new programs.

Sustainability policy focus. CCAs are models of local governance with a voter-accountable board that might be interested in expanding the EcoBlock as a policy position. Frequently, CCAs offer renewable energy purchase options and present themselves as a local, more environmentally friendly option. EcoBlock could become a standard for this kind of policy-driven, local vision for energy. A CCA might also be able to develop programs for advertising EcoBlock programs, although they may be subject to marketing rules from the CPUC.

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[34] The CCA will be known as *East Bay Community Energy* (http://ebce.org).

Challenges and Potential Trade-offs

General Challenges

Ownership of distribution infrastructure. A CCA could own and operate the electrical generation and distribution infrastructure of the EcoBlock, or it could just serve as a procurement entity or a sponsor in project finance. CCA ownership could thus help to provide residents with a streamlined structure by eliminating an additional layer of governance, but it is unclear whether ownership of EcoBlock assets could be monetized in a way that would offset potential liabilities, and whether CCA ownership could function without 100 percent participation of residents. In addition, CCA ownership of the EcoBlock's local distribution infrastructure, the block-scale microgrid, may present a regulatory issue in conflict with utility/CPUC jurisdiction, or lead to CPUC regulation, due to the CCA's delivery of electrical service to members of the public (Cal. Pub. Util. Code § 216(a)). Further, it is unclear whether the Alameda CCA would be interested in owning or operating such infrastructure.

Water service. CCAs do not serve water customers. Therefore, while the CCA might have a role in the energy demonstration projects, there must be a separate entity for water infrastructure issues.

Cost of resource procurement. The CCA's primary role in energy procurement for a wide group of customers may create obstacles to supporting distributed energy projects, because there are currently cheaper energy sources. For instance, a CCA may find other energy procurement options, such as offshore wind, more economically feasible. Non-distributed energy CCA customers also may not support participation, as it could be viewed as cross-subsidization, and such customers could opt-out of the CCA to return to utility service. If this occurs, remaining customers could bear increased costs for their service.

Difficulty qualifying for financing. CCAs are a relatively new business model. As such, when they issue bonds and seek financing for projects, some investors may express concerns with CCA creditworthiness, opt-out risks, and exit fees (Barrow 2017). All CCAs have some kind of opt-out protection for customers who may return to the incumbent utility, which fuels concerns about the long-term viability of financing the CCA model. Exit fees are becoming an increasingly common tool for utilities to compensate for departing customers. Both opt-outs and exit fees are negatively influencing investors' confidence in the CCA model.

Challenges to the Oakland EcoBlock

Depth of CCA involvement. The Oakland EcoBlock would fall under the jurisdiction of a new CCA, East Bay Community Energy (EBCE), which is currently being established. At this point, it is unclear whether EBCE would want to be involved, and if so, how deep its involvement would be, ranging from procurement contracts to actual ownership of assets. Beyond EBCE's interest, customers also have the choice to opt out and remain with PG&E, which could effectively remove them from the CCA portion of the EcoBlock.

Types of improvements covered by CCA. The Oakland EcoBlock proposal includes numerous water-efficiency retrofits, landscape and streetscape upgrades, and other improvements that would fall outside the purview of a CCA. Even if involvement in different types of resources were permitted, it could fundamentally change the business model and affect the CCA's balance sheet.

Policy Reform

First, EcoBlock would benefit from an amendment to the enabling legislation that explicitly expands the powers of a CCA to own/develop microgrid distribution infrastructure. There are certain carve-outs to the statutory definition of a utility, and it might be possible to create one for small-scale CCA-owned infrastructure.

Second, an amendment to the enabling legislation might enable a CCA to serve water customers to procure/develop alternative water sources. Creating a unified local public service aggregator would enhance the prospects of EcoBlock scaling.

Scalability and Replicability

Scaling to Adjacent Blocks

EBCE could play a significant role in expanding or incentivizing the expansion of the EcoBlock to adjacent neighborhoods. Because CCAs have territorial jurisdiction with opt-out enrollment, they potentially could orchestrate a regional plan to expand to the surrounding neighborhood.

Replicating the EcoBlock in New Locations

Establishing new EcoBlocks in different jurisdictions using a CCA ownership and business model would depend on whether the local government had created or joined a CCA. If the proposed EcoBlock-type project was within a CCA's jurisdiction, and if the CCA wanted to finance it, the next issue would be how much of an EcoBlock the CCA might be willing to own and manage. Given that California already has created the legislative framework for new CCAs and the model is rapidly growing, CCAs have the potential to help proliferate the EcoBlock model throughout California. In addition, Illinois, Massachusetts, New Jersey, New York, and Ohio have enacted CCA-enabling statutes.

In every instance, the CCA will be limited in scalability and replicability because it cannot currently influence water procurement or infrastructure.

Third-Party Ownership

Private Party

The EcoBlock could be wholly owned and operated by a private third party. Private third-party ownership of the EcoBlock could include having a vendor own, operate, and maintain some or all EcoBlock infrastructure. In exchange for a monthly fee that would replace their utility bills, residents would grant a private entity the authority to purchase and install the EcoBlock improvements, and then maintain those improvements and provide energy and water services on an ongoing basis. After the initial contract arrangements, residents would have no day-to-day involvement in the management of the EcoBlock. Pure private party ownership would thus provide both a governance structure (entirely managed by a third party) and a financing structure (entirely paid for by a third party, using residents' monthly fees).

This arrangement would still raise questions of ownership of in-home assets such as efficient appliances, but it would resolve issues around public ownership and liability for these assets, while also protecting government bodies from responsibility for new block-scale installations. The model would also require the third party to lease land and/or use of the public right-of-way, which residents and/or the city would have to permit. Finally, a wholly private third-party ownership structure would likely be deemed to be serving the role of a utility and trigger CPUC jurisdiction (or require a special exception).

Nonprofit "EcoBlock Trust"

The EcoBlock could also be formed as a wholly separate, nonprofit corporation or trust, which would finance, own, and maintain the infrastructure. While the model would impose a legal burden to initially form, an established EcoBlock nonprofit—an "EcoBlock Trust"—could aid in the expansion and scalability of future EcoBlock projects. The EcoBlock Trust would serve as an ownership and management structure that would need to obtain financing for capital costs and contract out for ongoing maintenance and service needs, and charge residents periodic fees to fund these services and administrative costs.

An EcoBlock Trust could serve a role similar to that of an HOA, providing residents a platform from which to obtain and implement financing, but without requiring residents to record any CC&Rs or enter into other agreements that bind their properties indefinitely. Residents would either serve on or appoint members of the trust's board, and finance the trust's activities via the payment of dues or fees. An EcoBlock Trust could support a CFD and/or PACE financing structure, by providing a governance mechanism and an ownership entity for any assets not owned or deemed "public" by the local governing body.

As a legal entity, the defining feature of a trust is that it holds title to property or assets for the benefit of group of beneficiaries. A trustee, who controls the trust, has a legal duty to manage the property in the best interest of the beneficiaries, subject to any limitations or rules set out in the trust documents. For the EcoBlock, which will include a combination of communal and private assets, the trust model would provide a common ownership entity for a subset of assets that are not owned publicly by a JPA (or the city), while providing assurances to residents that those assets are being properly managed. For example, to ensure that the EcoBlock achieves maximum efficiency performance (and thus cost savings), it may be necessary to perform regular inspection and maintenance of a number of the improvements, including new appliances installed within individual homes. An EcoBlock Trust could hold title to these appliances and take responsibility for maintenance, without giving residents pause about how their in-home assets are being handled. Alternatively, the trust's ownership could be limited to the communal assets, with individual residents retaining ownership of PACE-financed assets.

Unlike an HOA, an EcoBlock Trust would not include CC&Rs that permanently bind owners of the property, and thus while it might be difficult for all residents to agree to enter the trust on the same terms, one significant barrier would be removed. However, an EcoBlock Trust might lack a strong enforcement mechanism to prevent resident withdrawals, and would not bind subsequent property owners (except to the extent they are otherwise bound by existing PACE or CFD obligations). The EcoBlock Trust would need to incorporate contractual or other similar mechanisms to solidify residents' commitment to the project and to one another. One essential aspect of an EcoBlock Trust governance model would be a requirement (stated in the organizing documents) that the trust undertake regular assessments of community assets to determine their remaining useful life and replacement cost. Such a requirement, similar to the "reserve study requirement" of California's Davis-Stirling Act governing condominiums and other planned developments, would provide key assurance to entities that might offer investment opportunities (Cal. Civ. Code § 5550).

One potential model for an EcoBlock Trust is the community land trust (CLT), a mechanism by which community residents form a nonprofit entity that takes title to multiple parcels of real property, and then grants long-term leases back to residents who construct and own homes and businesses on the trust-owned land (Davis 2010). (In the EcoBlock context, trust ownership would extend only to energy and water infrastructure, not to land or houses). Residents constitute the leadership of the CLT and manage ongoing financing and operations, often leveraging an initial investment for the trust's purchase of the land, resulting in community ownership and management of land and individual ownership of homes and structures. CLTs currently exist nationwide, including in Oakland and throughout California.[35] An EcoBlock trust could use the CLT model as a basis for the hybrid community-scale and private-scale ownership of and responsibility for the different EcoBlock assets. This nonprofit trust would own and finance communal assets in trust for all residents (for example, by initiating a CFD), while also providing a community management structure to oversee private installations (such as by coordinating a group PACE program). Unlike the CFD, EIFD, and other public models, there is no specific legislation enabling the CLT, which means that residents could face significant hurdles in properly fitting the model to this unique use—but also means that the flexibility exists to create an EcoBlock-tailored solution.

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[35] For an example of a CLT, see Oakland Community Land Trust, available at https://oakclt.org/.

Utility Models

Utility On-Bill Financing

Function and Legal Background

On-bill financing refers to a loan made to a customer by his or her utility to pay for renewable energy or energy- and water-efficiency improvements (Henderson 2013). The utility then collects monthly loan payments as part of the customer's energy bill. Incumbent utilities could fund part or all of or the total project cost and recover payments through on-bill financing.

Function

On-bill financing can occur for loans created through either utility lending or private lending. The loan is made to a utility customer for energy- or water-efficiency improvements and the loan payments are recovered via the customer's recurring utility bill. Typically, on-bill financing follows the meter, meaning that payments stay with the property regardless of a change in tenant.

Mechanism

On-bill financing is administered through utilities but initiated through a variety of processes. For instance, the CalConserve Water Use Efficiency Revolving Loan Program enables the State Treasury to make loans for a variety of water conservation and efficiency projects (Cal. Water Code § 81023). These loans are repaid through customer's utility bills.

Key Issues

Loan production and securitization. Utilities may be hesitant to carry additional debt for customer benefit. There may also be issues with securitizing on-bill programs as bonds.

Managing a contractor network. In addition to the financial aspect of an on-bill financing program, utilities may want to manage a network of certified contractors outside of their own employees. This could generate additional administrative costs.

Legal compliance with lending laws. Utilities may be reluctant to take on a loan program, as it may subject them to banking regulations. Turning the utility into a quasi-financial institution may be outside the utilities' statutory mandates or against the interest of utility investors.

Benefits

General Benefits

Loans with no upfront cost. On-bill financing has many benefits. The greatest benefit is that on-bill financing, like PACE financing, provides customers with a financial tool to upgrade their property at no upfront cost to them. Absent an on-bill financing program, customers might otherwise need to search out and qualify for financing that might require a down payment.

Straightforward payments and recourse. On-bill financing also benefits from straightforward billing. Customers already pay a regular utility bill, so a bill line item is does not add complexity to their budgeting and records. Loan payments are also tied to the customer's utility service, giving the utility the option to suspend service until payments are made (Henderson 2013). Unlike other creditors, the utility has immediate recourse against its customers.

Split benefit remedy. Beyond billing, on-bill financing helps alleviate the "split benefit" problem between landlords and tenants. *Split benefit* refers to the imbalance that occurs when costs of retrofits accrue to landlords while efficiency savings accrue to tenants. With on-bill financing, the financing typically attaches to the meter so payments remain with the beneficiary of the improvement.[36]

Private lender options. On-bill financing can also be structured between a utility customer and a private lender, with the utility company acting only as a debt collector. This arrangement benefits from the security of the on-bill payment format without adding additional debt to the utilities' books.

Reduced system load and environmental benefits. On-bill financing provides a utility program to reduce overall system load. Creating pathways for customers to reduce their own demand has numerous benefits, including alleviating base load and peak demand, and contributing to reductions in carbon emissions.

Benefits to the Oakland EcoBlock

The benefits of on-bill financing at-large and for the Oakland EcoBlock are the same: customers get loans with low upfront costs to reduce their utility usage, while utilities create a pathway for reduced consumption. As on-bill financing is of particular use in addressing the landlord-tenant split benefit problem, it may be especially useful for the Oakland EcoBlock, which includes multiple rented units.

Challenges and Potential Trade-offs

General Challenges

Utility debt. On-bill financing affects utility creditworthiness, which is in part due to the amount of debt carried on its books. If a utility lends money to customers for improvements, it carries that money as part of its debt. However, the utility can avoid this situation by serving as an administrator for third-party lenders or as the debt collector on a public revolving fund.

Financial regulation. Another challenge that could emerge with an extensive on-bill financing program is that the utility could reach a level where it could be regulated as a bank, if it is determined to be "engaged in the business of making consumer loans" (Cal. Fin. Code § 22009). If the utility were regulated as a financial institution, it could be

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[36] One example of such an arrangement is The Power NY Act of 2011 (A. 8510/S. 5844).

subject to myriad state and federal laws. In general, utilities would likely want to avoid this additional regulatory burden.

Cost. The combination of utility debt and additional regulation, combined with difficulties securitizing on-bill financing, may result in a higher cost relative to other methods of financing. Some states have started introducing bond structures for on-bill financing programs, which may help bring down costs (for example, the New York State Energy Research and Development Authority administers and provides capital for on-bill financing, while utilities collect the payments through their existing billing structures).

Challenges to the Oakland EcoBlock

Water and energy utilities. The design proposes retrofits and new installations for both energy and water, which are serviced by separate utilities—PG&E (energy) and East Bay Municipal Utility District (water). Using on-bill financing to finance improvements in both areas would require organizing two different on-bill financing programs and loan pools from the two utilities.

Communal assets and billing. Another issue is how on-bill financing could be applied to communal assets, such as the distribution grid or the flywheel. Accurately apportioning savings among users of different types could be challenging, as savings would be calculated based in part on hypothetical usage rates.

Master-metering and billing. Some EcoBlock design proposals specify a single master meter for the distribution backbone, which would be the outward-facing link to the utility. If this were the case, some kind of internal billing structure would need to be installed to allocate the on-bill finance payments among the residents.

Policy Reforms

On-bill financing could be improved to support the EcoBlock. Regulatory modifications might shield utilities administering on-bill finance programs from banking regulations, so long as the loans were related to the provision of utility service. For instance, Section 819 of the California Financial Code could be amended to adjust the standards for bonds and indentures so that on-bill financing was discounted or used more utility-friendly accounting than the standard measure of the utility's funded debt (Cal. Fin. Code § 819).

In addition, the state could create an on-bill financing EcoBlock revolving fund for EcoBlock-style projects to catalyze future development.

Scalability and Replicability

Scaling to Adjacent Blocks

If on-bill finance could overcome the issues described above, it could be a viable tool to expand the EcoBlock into the neighborhood. Adjacent neighbors are PG&E customers, which may facilitate an EcoBlock package that would be repaid on-bill (although integration with the newly created local CCA could interfere with this). Questions would likely focus on whether the utility was the lender or whether there was a third-party lender. In both cases, the primary issue is expanding the funding pool to finance improvements on the adjacent properties.

Replicating the EcoBlock in New Locations

Replicating an on-bill financing program in other jurisdictions would require asking different utilities to administer the program, with varying levels of utility interest in doing so. New jurisdictions would face questions regarding the ultimate source of the funding and whether it triggers additional regulation. Finally, no matter where an EcoBlock is proposed, there will still need to be significant resident buy-in to make the goals of the project a reality (an issue common to every EcoBlock business model).

Utility Ownership

Function and Legal Background

A utility could finance, develop, own, and operate the EcoBlock infrastructure outright.

Function

Under a utility ownership model, incumbent utilities would simply construct and own the new EcoBlock infrastructure in the same manner they own existing infrastructure. Utility ownership of a demonstration project requires public hearings and approval of the CPUC. The process would be subject to the requirements of the Public Utilities Act and regulations of the CPUC. In addition, there may be interactions between different water and electricity utilities, depending on the nature of the design proposals.

Mechanism

Prior to a utility building new infrastructure, the CPUC must hold a hearing and make a finding that the improvement or demonstration project should be built (Cal. Pub. Util. Code § 762). In the finding, the CPUC can order the new structure and fix its site. The process would also require consent of the homeowners to install improvements inside their homes. In normal utility ratemaking practice, the construction-related portion of a demonstration project would be treated as a capital investment, financed out of a utility's capital budget and included in the utility's rate base.

Key Issues

Commission approval. If the EcoBlock were going to be directly owned by public utilities, the Public Utilities Commission would likely need to approve the project. If this were the case, the project would have to follow Commission process.

Ownership arrangement between the utility and the property owner. The EcoBlock proposal includes different public, private, and right-of-way improvements. A utility-ownership model would need to delineate ownership and responsibilities for each class of improvements.

Benefits

General Benefits

Self-financing and ratepayer proceeds. An incumbent utility has access to financing and ratepayer-backed cost recovery. While the utility might need to develop a specific tariff for EcoBlocks to prevent cross-subsidization, it would be a relatively simple process for an entity that already frequently deals with the CPUC.

Operation and maintenance programs. The incumbent utilities already have technical teams and budgets to support the ongoing operations and maintenance of demonstration projects. While they may be reluctant to take on additional responsibilities, utilities might be in a better position than any other party to maintain improvements.

System access. The incumbent utility has access to system-level information that could theoretically allow for improved integration and deployment of distributed resource assets. This could include long-term plans, system needs (such as peak usage and time-of-use data), and interconnection processes. Integration benefits are discussed in greater detail in the Scalability and Replicability section below.

Easing liability concerns. Incumbent utility ownership may ease local government concerns about liability and insurance. City and county officials may be concerned about liability and indemnification of the local government. Even with a third-party private operator, concerns could remain regarding its creditworthiness and whether the company would persist through the life of the project. An incumbent utility has the means and permanence to carry liability for the block throughout its lifespan.

Benefits to the Oakland EcoBlock

Utility ownership of some of the common assets proposed as part of the EcoBlock could help address some of the ownership issues and concerns surrounding long-term maintenance and liability. Both Pacific Gas and Electric and East Bay Municipal Utility District could take ownership of certain water and energy improvements on the block. If the utilities took ownership, it would resolve questions as to what party is responsible for the improvements, but it could also create a secondary issue of whether the EcoBlock residents may have to pay a separate tariff for their advanced infrastructure.

Challenges and Potential Trade-offs

General Challenges

Utility resistance. The utility may not want to participate. Some incumbent utilities may be reluctant to encourage or accelerate alternative business models. Incumbent utilities' motivations—the provision of safe, reliable service; compliance with CPUC regulations and generation of profit and shareholder returns (in the case of investor-owned utilities)—may not align with the policy goals of a demonstration project.

Third-party resistance. In other proceedings, third parties have expressed their opposition to utility ownership of distributed resource projects. The distributed resource market has been cited as a growth market, and private companies frequently oppose regulatory intervention that cedes the potential market to the incumbent utility.

Multiple utility involvement. The demonstration project includes a hybrid of energy, water, and land use improvements, and it is unlikely that a single utility could take complete ownership of all of the assets. As a result, utility ownership might also create a patchwork business model.

Long-term liability, operations, and maintenance. The incumbent utilities may not want to accept the liability, operations, and maintenance requirements of a demonstration project. Aspects of the demonstration project, such as the energy storage flywheel, are in early stage deployment, with some risk attached to their long-term performance. New technologies may require contractors or necessitate training current employees with new skills, which may require union approval. A utility may not want to take on the project due to complications in long-term responsibilities.

Contract between the utility and property owners. Homeowners still have to enter into some kind of voluntary agreement with the utility, and the private ownership/retrofit aspects of the project are not amenable to utility ownership. The long-term nature of the project may require certain agreements that could attach to the land and encumber it for future owners, or the utility investment may create incentives for owners to sell or drive out tenants. There would have to be careful contracting to ensure both parties were protected in the agreement.

Challenges to the Oakland EcoBlock

The Oakland EcoBlock falls within Pacific Gas and Electric and East Bay Municipal Utility District service territories. Both PG&E and EBMUD have their own needs and planning processes, and would assess the EcoBlock accordingly.

Policy Reforms

There is an outstanding question of whether the EcoBlock could be treated as a public utility (Cal. Pub. Util. Code § 216(a). Aspects of the EcoBlock will deliver electricity and water to the local residents, and thus potentially could fall under the jurisdiction of the CPUC as electric corporations and water systems. While there are detriments to treating the EcoBlock as a utility, including an onerous regulatory burden and opposition from the incumbent utility, an EcoBlock Utility may have benefits as a scalable business model.

A legislative amendment to the Public Utilities Code could create an "EcoBlock corporation" or "distributed resource corporation." For instance, Section 218 of the Public Utilities Code defines "electric corporation" and its exceptions. Adding language that exempted local energy and water distribution from utility regulation could enhance the EcoBlock model and further enhance competition in the sustainable provision of public goods.[37] The key element of any potential amendment would be keeping the exception broad enough to allow flexibility for EcoBlocks, without subsuming the definition of public utilities.

Scalability and Replicability

Scaling to Adjacent Blocks

Utility ownership could potentially be one of the most effective tools for expanding into adjacent neighborhoods. The utilities have access to capital, trenches and poles, and planning data to site projects. Utilities could also streamline their own interconnection process for distributed resources. If the challenges to utilities could be overcome, the model has the potential to be an effective tool for expanding the block to an "EcoNeighborhood."

Replicating the EcoBlock in New Locations

California electric utilities have large service territories, which could help establish new EcoBlock projects in separate locations. A variety of different water utilities exist, however, and setting up EcoBlocks through the multitude of smaller water utilities might prove challenging and transaction-heavy.

Scaling through Annexation

Another possible arrangement is utility annexation. The Public Utility Code allows utilities to annex districts or property into their service territory (Cal. Pub. Util. Code § 17362). Under utility annexation, a party would develop the EcoBlock with the intent of eventually ceding ownership to the utility. After annexing the property, the utility would assume responsibilities for the project's debts and liabilities, and for its operations and maintenance.

Utility annexation shares many of the long-term benefits of a utility ownership business model, with a few crucial differences. Under the annexation model, there would still need to be an initial entity that seeks financing for the various EcoBlock assets, and there would still need to be some legal entity behind the initial application and permitting.

As an overall business model, utility annexation might function where a third-party developer uses non-recourse financing to retrofit the block, and then the utility annexes the block(s) once built. It might also be a third-party nonprofit retrofit developer that initiates and develops the project, leaving the utility with long-term O&M and the return on investment.

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[37] For example, a potential amendment could include language that specifies an EcoBlock corporation must provide water and electric service, and must serve blocks of less than 100 parcel units in an aggregated grid.

Conclusion: Preferred Solutions for the EcoBlock Business and Financing Model

The technical scenarios identified in this report as potential combinations of energy- and water-related improvements for the EcoBlock all involve both block-wide and communal installations, at increasing scale and increasing costs. As a result, a suite of financing and governance solutions will likely be necessary to support these improvements. Below is a brief analysis of the preferred solutions that the team has identified.

The preferred solutions described below represent the team's analysis of the most feasible, yet innovative, methods to support the technical developments of the EcoBlock under current California law in a scalable form; however, a different financing and governance model may ultimately be more appropriate for the Oakland EcoBlock, given the level of technological demonstration proposed and the level of grant funding.

Preferred Model: Combined CFD and PACE

Each possible combination of EcoBlock energy and water technical scenarios includes both home-scale installations (such as water-efficient appliances and fixtures, energy-efficient building envelope and appliance upgrades, and rooftop solar panel installations) and block-scale communal installations (such as shared water wells, rainwater harvesting tanks and "purple pipe" irrigation, flywheel energy storage, neighbor-to-neighbor redistribution of solar-generated energy, and shared electric vehicle charging stations).

Financing Model: Community Facilities District Layered with PACE Financing

A public, community-scale financing model is needed to pool community funds and share the capital and maintenance costs for shared assets. The CFD provides the best comprehensive financing solution in this context, as it is able to finance both up-front costs and ongoing operational expenses, and also is able to finance both energy and water infrastructure. While the CFD could potentially be used to finance the private house-level improvements by deeming them "public," the EcoBlock could more easily utilize PACE financing to finance those improvements. While the CFD may face some tensions between landlord and tenant preferences, these issues are ultimately common among all financing options for community improvements.

If the city or other public authority that administers the CFD does not agree to include traditionally "private" assets (e.g., appliances, home envelope upgrades, water and lighting fixtures) in the bond financing such that they are converted to public ownership and responsibility, the EcoBlock would finance these items via PACE, while financing communal items via the CFD. This would appear to be a first-of-its-kind innovative arrangement, but there is no indication that the state's PACE or CFD statutes would bar it. Rather, an innovative, well-structured governance model would be needed to manage the simultaneous CFD and PACE financing obligations. Importantly, the balance of financing obtained through CFD and PACE may be flexible to accommodate resident preferences, local government needs or limitations, and variable costs of financing. This potential for flexibility increases the appeal of the model to all EcoBlock parties, and facilitates the future development of a single streamlined EcoBlock business model.

Governance Model: EcoBlock Trust

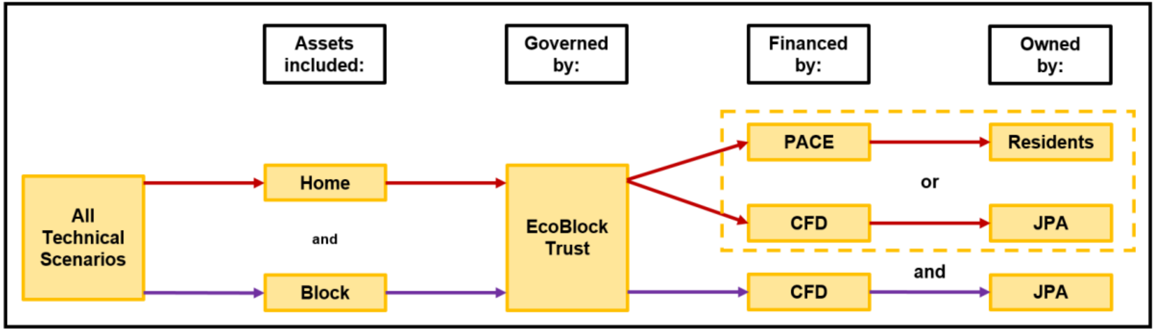
The combination of both CFD and PACE financing sources necessitates the introduction of a governance mechanism. An EcoBlock Trust could facilitate the ownership, management, and financing of these community facilities, while also providing oversight and coordination for individual residents to finance and manage house-scale upgrades. The EcoBlock Trust could serve as a platform from which to design and secure agreement to the terms of the CFD, and potentially to obtain preferential terms for PACE financing via aggregation of individual projects. As described above, an EcoBlock Trust would rely in part on combining useful mechanisms from other existing state law models, including the Community Land Trust and the Davis-Stirling Act.

Ownership

Block-scale assets, financed via the CFD, will be owned by a JPA formed to manage the CFD and potentially to administer PACE (or owned by the City of Oakland or a subsidiary agency, with insurance and/or indemnification provided by the JPA). Individual home-scale assets will be owned by the JPA (or the city), if also financed via the CFD; or by individual homeowners, if financed via PACE.

Figure 6-1 illustrates the structure of the preferred EcoBlock business and financing model.

Figure 6-1: Preferred EcoBlock Business and Financing Model



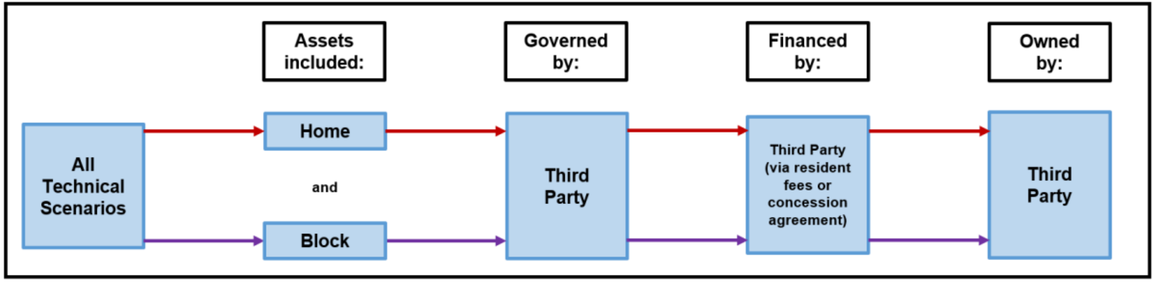
Source: UC Berkeley

Alternative Model: Third-Party Financing, Ownership, and Management

Alternatively, the third-party model discussed above may be a viable option to finance and operate those aspects of the Oakland EcoBlock that are not grant-funded; the team has had preliminary discussions with third parties that have indicated interested in such an arrangement. Such an arrangement could support the Oakland EcoBlock and, when the technologies under demonstration have reached full commercial viability, could support EcoBlocks at scale. However, as discussed above and in other report sections, complete third-party ownership could raise significant Public Utilities Commission-related regulatory issues that might only be resolved through significant legislative exceptions.

In this scenario, a private third party would finance, own, and manage the EcoBlock independently (Figure 6-2). Resident fees or a concession agreement would provide the third party with the necessary funds. No additional financing or governance mechanisms would be necessary, since the third party would handle management and resident interactions and service.

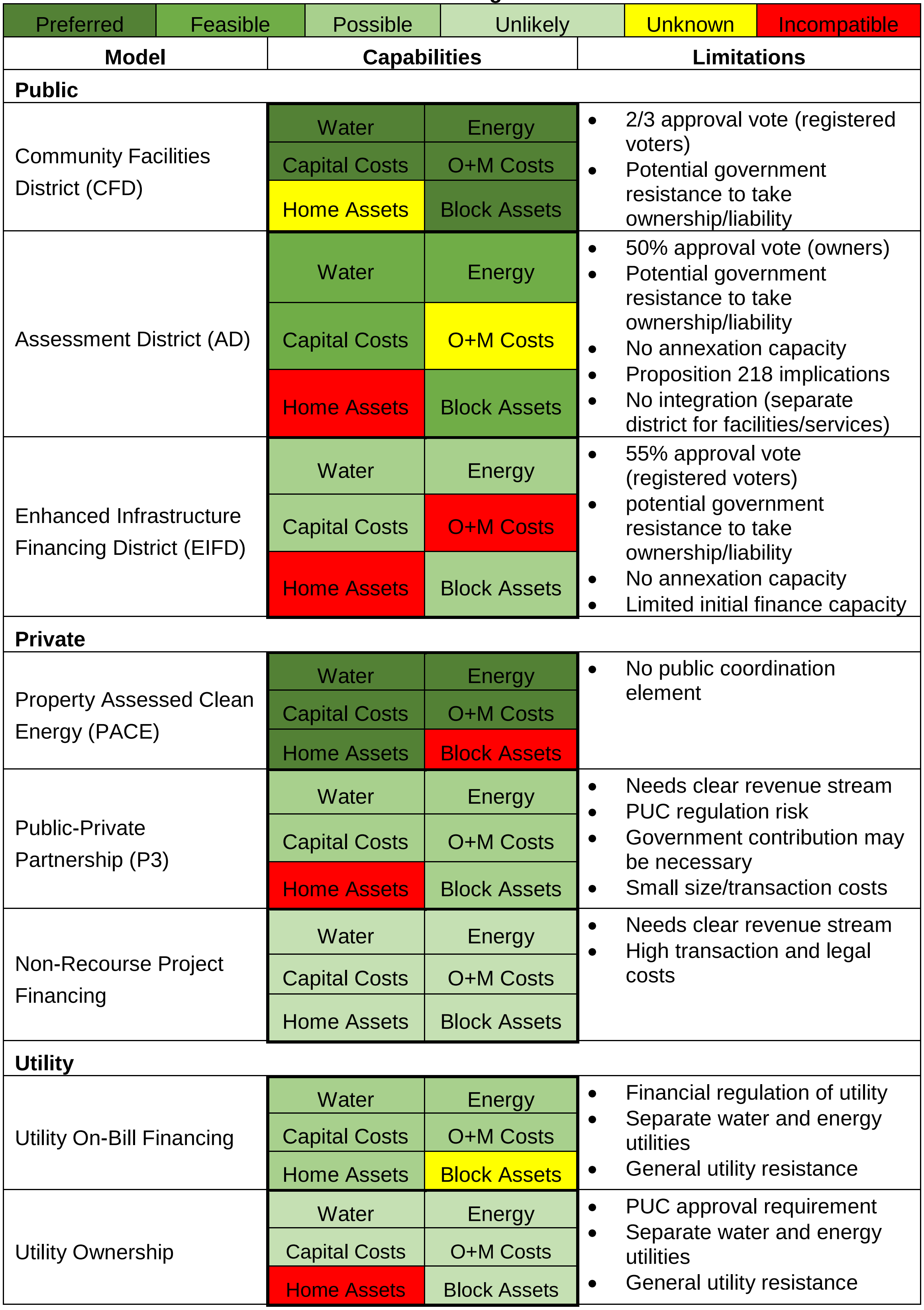
Figure 6-2: Third-Party EcoBlock Business and Financing Model



Source: UC Berkeley

Table 6-2 identifies the characteristics of the EcoBlock financing models, and Table 6-3 provides a comparison and analysis of the selected financing models.

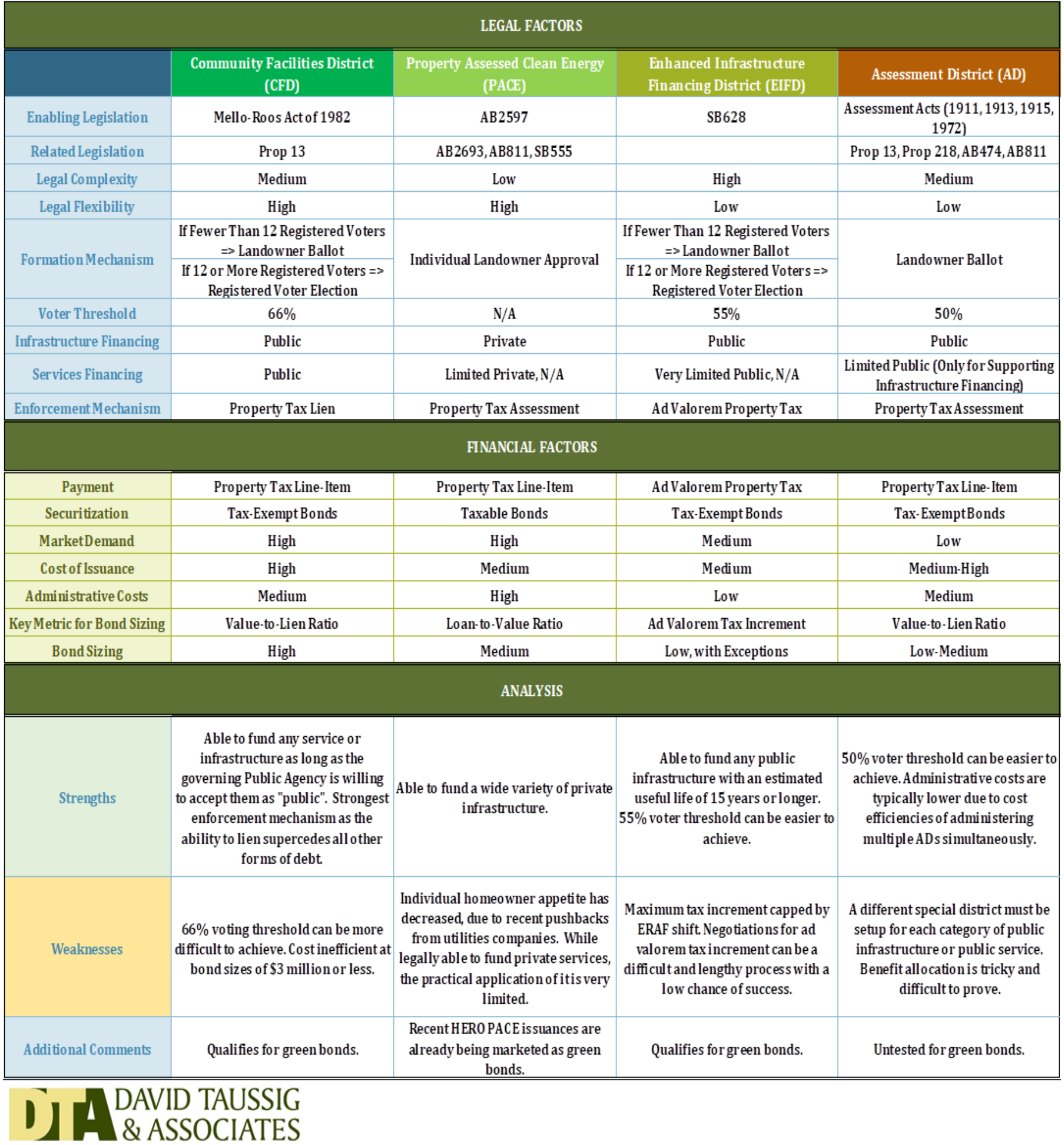
Table 6-2: EcoBlock Financing Model Characteristics



Preferred	Feasible	Possible	Unlikely	Unknown	Incompatible

Model	Capabilities	Limitations
Public		
Community Facilities District (CFD)	Water Energy Capital Costs O+M Costs Home Assets Block Assets	• 2/3 approval vote (registered voters) • Potential government resistance to take ownership/liability
Assessment District (AD)	Water Energy Capital Costs O+M Costs Home Assets Block Assets	• 50% approval vote (owners) • Potential government resistance to take ownership/liability • No annexation capacity • Proposition 218 implications • No integration (separate district for facilities/services)
Enhanced Infrastructure Financing District (EIFD)	Water Energy Capital Costs O+M Costs Home Assets Block Assets	• 55% approval vote (registered voters) • potential government resistance to take ownership/liability • No annexation capacity • Limited initial finance capacity
Private		
Property Assessed Clean Energy (PACE)	Water Energy Capital Costs O+M Costs Home Assets Block Assets	• No public coordination element
Public-Private Partnership (P3)	Water Energy Capital Costs O+M Costs Home Assets Block Assets	• Needs clear revenue stream • PUC regulation risk • Government contribution may be necessary • Small size/transaction costs
Non-Recourse Project Financing	Water Energy Capital Costs O+M Costs Home Assets Block Assets	• Needs clear revenue stream • High transaction and legal costs
Utility		
Utility On-Bill Financing	Water Energy Capital Costs O+M Costs Home Assets Block Assets	• Financial regulation of utility • Separate water and energy utilities • General utility resistance
Utility Ownership	Water Energy Capital Costs O+M Costs Home Assets Block Assets	• PUC approval requirement • Separate water and energy utilities • General utility resistance

Table 6-3: Selected Financing Models Comparison and Analysis



LEGAL FACTORS				
	Community Facilities District (CFD)	Property Assessed Clean Energy (PACE)	Enhanced Infrastructure Financing District (EIFD)	Assessment District (AD)
Enabling Legislation	Mello-Roos Act of 1982	AB2597	SB628	Assessment Acts (1911, 1913, 1915, 1972)
Related Legislation	Prop 13	AB2693, AB811, SB555		Prop 13, Prop 218, AB474, AB811
Legal Complexity	Medium	Low	High	Medium
Legal Flexibility	High	High	Low	Low
Formation Mechanism	If Fewer Than 12 Registered Voters => Landowner Ballot If 12 or More Registered Voters => Registered Voter Election	Individual Landowner Approval	If Fewer Than 12 Registered Voters => Landowner Ballot If 12 or More Registered Voters => Registered Voter Election	Landowner Ballot
Voter Threshold	66%	N/A	55%	50%
Infrastructure Financing	Public	Private	Public	Public
Services Financing	Public	Limited Private, N/A	Very Limited Public, N/A	Limited Public (Only for Supporting Infrastructure Financing)
Enforcement Mechanism	Property Tax Lien	Property Tax Assessment	Ad Valorem Property Tax	Property Tax Assessment
FINANCIAL FACTORS				
Payment	Property Tax Line-Item	Property Tax Line-Item	Ad Valorem Property Tax	Property Tax Line-Item
Securitization	Tax-Exempt Bonds	Taxable Bonds	Tax-Exempt Bonds	Tax-Exempt Bonds
Market Demand	High	High	Medium	Low
Cost of Issuance	High	Medium	Medium	Medium-High
Administrative Costs	Medium	High	Low	Medium
Key Metric for Bond Sizing	Value-to-Lien Ratio	Loan-to-Value Ratio	Ad Valorem Tax Increment	Value-to-Lien Ratio
Bond Sizing	High	Medium	Low, with Exceptions	Low-Medium
ANALYSIS				
Strengths	Able to fund any service or infrastructure as long as the governing Public Agency is willing to accept them as "public". Strongest enforcement mechanism as the ability to lien supercedes all other forms of debt.	Able to fund a wide variety of private infrastructure.	Able to fund any public infrastructure with an estimated useful life of 15 years or longer. 55% voter threshold can be easier to achieve.	50% voter threshold can be easier to achieve. Administrative costs are typically lower due to cost efficiencies of administering multiple ADs simultaneously.
Weaknesses	66% voting threshold can be more difficult to achieve. Cost inefficient at bond sizes of $3 million or less.	Individual homeowner appetite has decreased, due to recent pushbacks from utilities companies. While legally able to fund private services, the practical application of it is very limited.	Maximum tax increment capped by ERAF shift. Negotiations for ad valorem tax increment can be a difficult and lengthy process with a low chance of success.	A different special district must be setup for each category of public infrastructure or public service. Benefit allocation is tricky and difficult to prove.
Additional Comments	Qualifies for green bonds.	Recent HERO PACE issuances are already being marketed as green bonds.	Qualifies for green bonds.	Untested for green bonds.

DTA DAVID TAUSSIG & ASSOCIATES

Source: David Taussig & Associates

CHAPTER 7:
Community-Scale Zero Net Energy Retrofit Master Plan

Abstract

This chapter describes and evaluates three preferred energy efficiency/electric system microgrid scenarios along with one “core” water systems strategy with four potential “bolt-on” strategies. These scenarios were developed based on detailed analyses of multiple scenarios described in chapters 2, 3, and 4. Their evaluation has led to the recommended Draft Master Community-Scale Zero Net Energy (ZNE) Retrofit Master Plan. It is explained and evaluated in detail, and the project sequencing and next steps are also described as a logical follow-on to Phase I of the project.

Introduction

The Community-Scale ZNE Retrofit Master Plan is the result of evaluating multiple design scenarios that are a synthesis of the system typologies developed and explored by the Deep Energy Efficiency Retrofit team, Integrated Electricity System Designs team, and Integrated Water System Designs team in Chapters 2, 3, and 4. The scenarios were developed with the knowledge gained from the explorations of regulatory and permitting issues; legal constraints; and innovative business, financing, and governance structures. Synthesizing the material into the design scenarios required two, daylong, all-team design charrettes that integrated the work of each task team into the scenarios. In the lead up to the charrettes, each task team developed multiple system typologies that were evaluated using multi-factor rating scales.

The Master Plan Design Scenarios (Table 7-1) are divided into three main scenarios for electricity (indicated by “e” in their name), and an initial scenario for water (indicated by “w” in its name), with additional scenarios (“bolt-ons”) that can be added, depending on the critical water issues and opportunities faced by different cities and neighborhoods. The scenarios are divided to illustrate different logical systems that can be mixed and matched, depending on the detailed evaluations.

Table 7-1. Master Plan Design Scenarios

Scenario Name	Scenario Type
Scenario 1e: AC Solar/Storage Microgrid with Energy Efficiency (EE) Retrofits and Existing AC Houses	Electricity
Scenario 2e: DC Solar/Storage/Electric Vehicle Microgrid with EE Retrofits and Existing AC Houses, at Block Scale	Electricity
Scenario 3e: DC Solar/Storage/EV Microgrid with EE Retrofits and AC/DC Houses, at Block Scale	Electricity
Scenario 1w: Core Project: Water Efficiency and Rainwater Capture and Use at House Scale	Water
Bolt-on A: Block-Scale Management of Rainwater Systems	Water (additional option)
Bolt-on B: Groundwater for Irrigation With possible “Green Infrastructure” in Public ROW (D below)	Water (additional option)
Bolt-on C: Sewer Mining—Reclamation for Irrigation for Non-Potable, at Neighborhood Scale	Water (additional option)
Bolt-on D: Green Infrastructure in ROW, at neighborhood scale	Water (additional option)

Source: UC Berkeley

A detailed description of each scenario’s energy and water efficiency measures and energy and water systems are illustrated in the figures under each scenario.

Performance estimates for each scenario were calculated in terms of three important metrics: (1) reduction in energy supply from the PG&E grid, (2) reduction in carbon dioxide (CO_2) emissions, and (3) reduction in water supply from the East Bay Municipal Utility District (EBMUD) and impacts on stormwater peak flow.

Cost estimates were developed for the construction of each scenario as an initial pilot project. The costs were broken out into each scenario’s major components to identify where major costs would be distributed (see Appendix E). These costs are extremely conservative by necessity, to account for the uncertainties in retrofitting the existing houses and to account for the first-time construction of the microgrid systems.

Therefore, they should not be used to project the cost feasibility of the EcoBlock concept.

Each scenario was evaluated in terms of the following criteria:

1. Technical issues and feasibility
2. Regulatory and permitting issues
3. Legal and governance issues and constraints
4. Business models
5. Ratepayer benefits
6. Homeowner acceptance
7. Social issues
8. Utility benefits
9. Resilience
10. Technological advancement/breakthroughs

A summary evaluation and recommendation is made for each scenario.

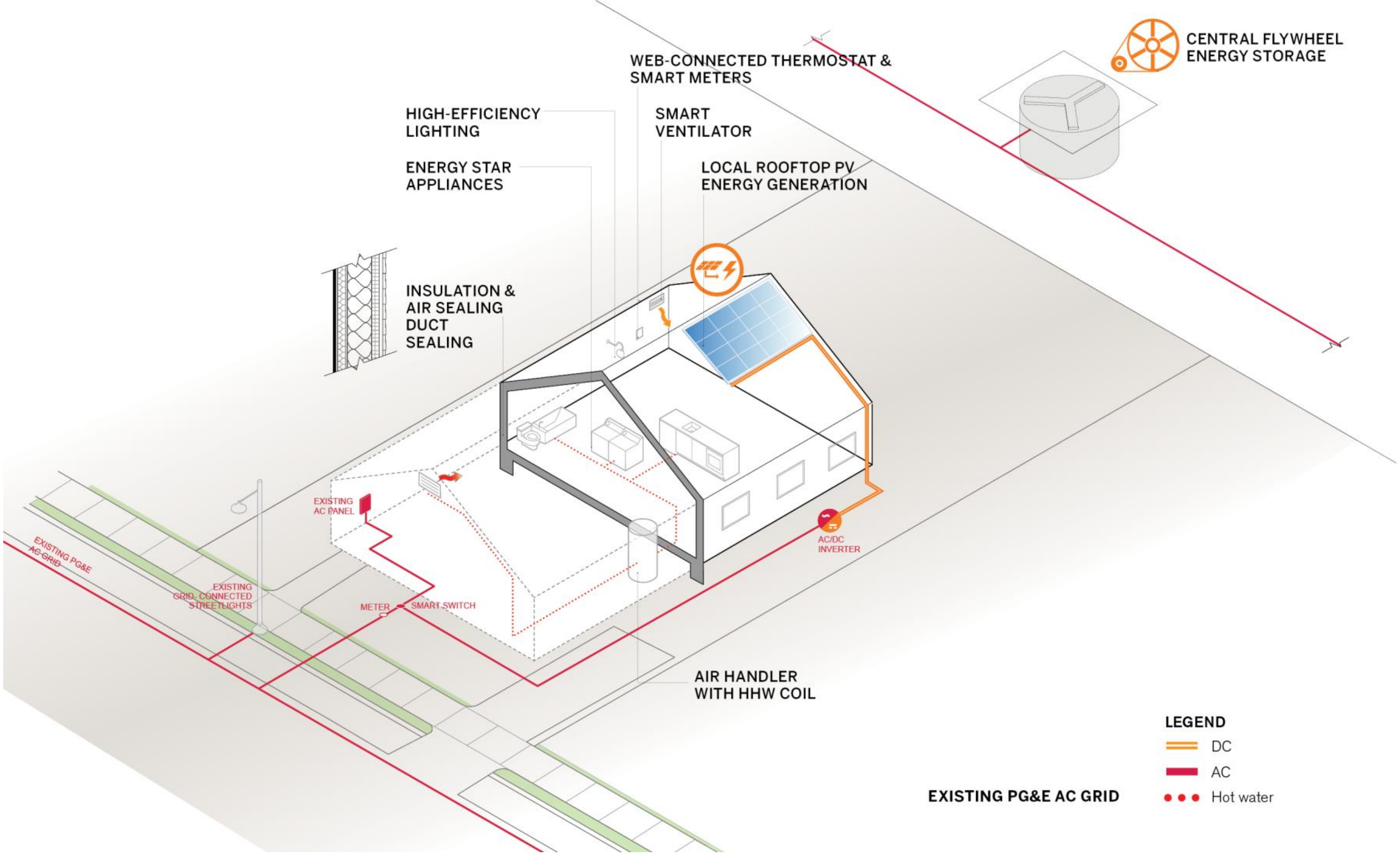
Performance Estimates

For those houses that opt into the energy-efficiency retrofits and the AC Solar/Storage Microgrid, their performance was estimated as follows: (1) ZNE, i.e., zero energy supplied from PG&E annually, or (2) an 85 percent reduction in CO_2 emissions for household energy (energy used for the gas stove remains).

Scenario 1e: AC Solar/Storage Microgrid

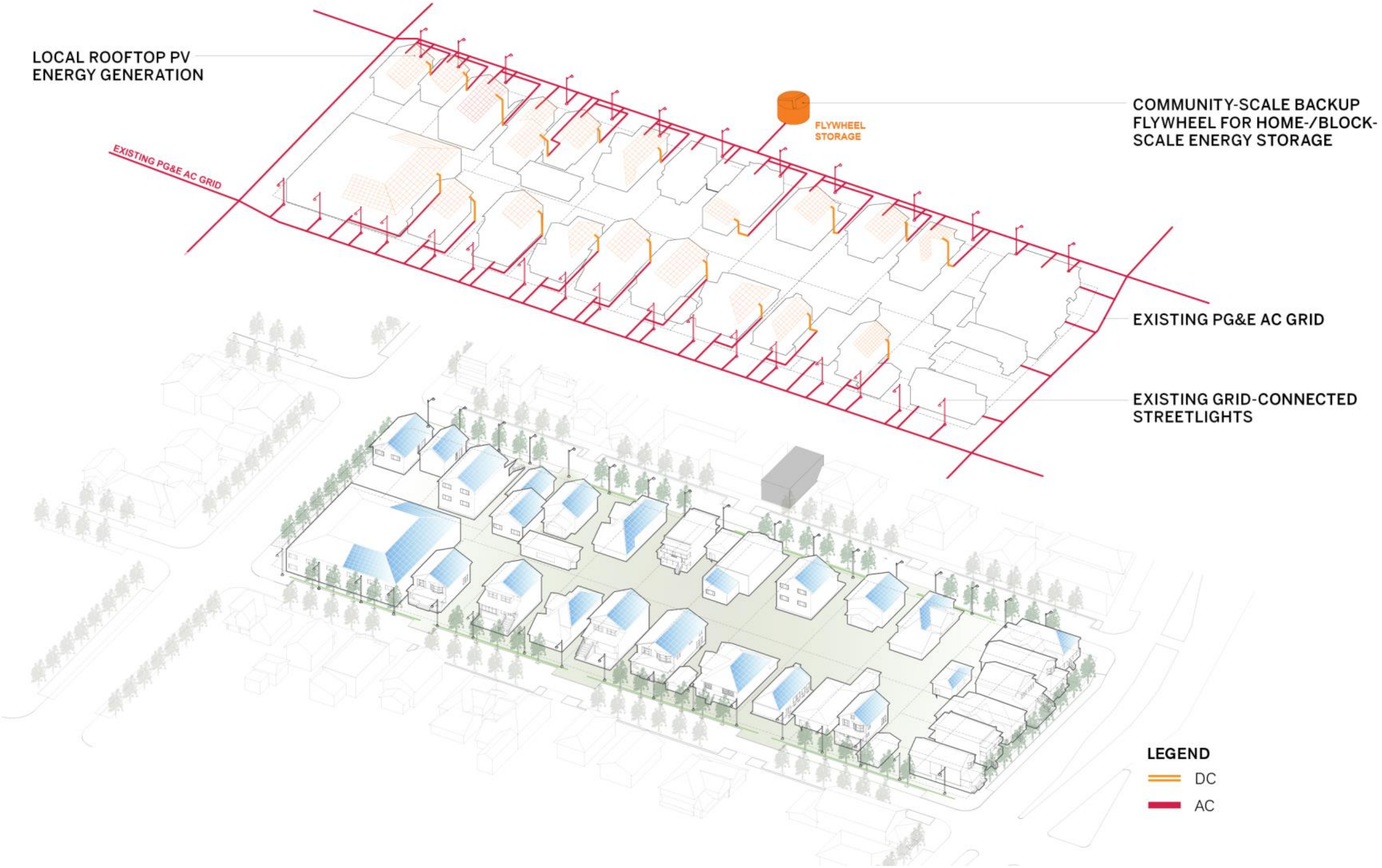
Figures 7-1 and 7-2 illustrate, on a house-scale and block-scale, respectively, the features of Scenario 1e. Table 7-2 outlines the elements in more detail.

Figure 7-1: Scenario 1e: AC Solar/Storage Microgrid – House Diagram



AC Solar/Storage, Microgrid with Energy Efficiency Retrofits and existing AC Houses.
Credit: Skidmore, Owings & Merrill, LLP

Figure 7-2: Scenario 1e: AC Solar/Storage Microgrid – Block Diagram



AC Solar/Storage, Microgrid with Energy Efficiency Retrofits and existing AC Houses.
Credit: Skidmore, Owings & Merrill, LLP

Table 7-2: Scenario 1e: AC Solar/Storage Microgrid – Energy Description

			Categorical Description	SCENARIO 1E	SCENARIO 1E.a
NARRATIVE	Type			**AC Solar/Storage, Microgrid w. Energy Efficiency Retrofits and existing AC Houses**	**Possible variants (any combination possible, 1E.a, 1E.b, 1E.c, etc.)**
BK/FRNT YARD					
RESIDENTIAL HOME RETROFIT					
	E		**Demand Response**	Web-connected thermostat, smart meters & HMS	
	E		**Rooftop PV each home/apt**	Local, rooftop PV energy generation (net metering)	
	E		**HVAC, Lighting, Envelope Upgrades**	EE measures	
	E	1	Space Heating	Air handler w/ HHW coil (possibly no AC)	
	E	2	Lighting	High-efficiency lighting, ceiling fan	
	E	3	Envelope Insulation & Air Sealing	Insulation & air sealing	
	E	4	Duct Sealing of Existing Ducts	Duct sealing	
	E	5	Ventilation	Smart ventilator (fan)	
	E	6	Water Heater & Domestic Hot Water (DHW)	HPWH & HHW Loop; Demand response	
	E	7	Appliances	ENERGY STAR new appliances	
PVT	E		**Block-scale Energy Storage**	Community-scale backup (DC flywheel w/ inverter)	
PUBLIC ROW	E		**Microgrid Software and Controls**	None	
	E		**Smart Street Lights**	Existing grid-connected streetlights	
	E		**EV Charging, EcoBlock**	Existing on-street parking with no electrical hook-up	
	E		**PV + Demand Management - block scale**	Net-metered PG&E grid (rooftop PV generation)	
	E		**AC/DC microgrid**	Existing PG&E AC grid	
	E		**Utility Trenching**	Existing utility configuration w/ no trenching	
🟨			**Social Outreach**	Private improvements underway (planting, houses, PV)	**Preferences?**
🟥			**Permitting & Regulations**	Community Co-op to purchase PV	**LU & Utility regs?**
🟥			**Technology & Knowledge Transfer**	Social innovation (Ratepayer benefit/Co-op)	**Transferability?**

KEY

HMS: Home Monitoring System
PV: Photovoltaic
HHW: Heating Hot Water
HPWH: Heat Pump Water Heater
PVT: Private
ROW: Right of Way
LU Regs: Land Use Regulations
PG&E: Pacific Gas & Electric

AC Solar/Storage, Microgrid with Energy Efficiency Retrofits and existing AC Houses.
Credit: Skidmore, Owings & Merrill, LLP

Evaluation

1. **Technical Issues:** All components and systems are market available, although vacuum flywheel storage is new to market. The AC smart microgrid and controls will be custom designed for the project and as a pilot project, their application is not a proven technology.
2. **Regulatory and Permitting Issues:** The energy-efficiency measures can permitted under existing planning or permitting procedures. Since the microgrid will be owned and operated by the utility, it should have no permitting issues.
3. **Legal/Governance Issues:** The pilot project will be governed by a homeowners association to manage and ensure owner participation in the PACE financing.
4. **Business Model:** The microgrid is owned and operated by the utility. The utility bill savings should cover the cost of installation over the life of the systems. PACE will be used to finance energy efficiencies in the homes, all of which will be governed by a homeowners association.
5. **Ratepayer Benefits:** Ratepayers will be charged through their normal utility bills. The renewable energy supply shields homeowners from utility energy price increases. Ratepayers benefit from the project's resilience, as it is able to operate if the PG&E grid goes down.
6. **Homeowner Acceptance:** Project outreach indicates high interest in homeowner participation (at least 50 percent), but actual participation will be determined in Phase 2.
7. **Social Issues:** The project uses savings in utility costs to fund major homeowner improvements, a form of shared prosperity, but covenants will have to be structured into the homeowners association to protect against individuals selling out and cashing in on improvements.
8. **Utility Benefits:** The provision of storage changes the load profile of the block to make it much more favorable to the utility. The EcoBlock is a potential new business model for the utility to upgrade its infrastructure.
9. **Resilience:** Provides significant block-scale resilience if the PG&E grid goes down. The block could operate on its own, indefinitely.
10. **Technical Advance:** This would be a major technical advance—the first AC Solar/Storage/EV microgrid at residential block scale. System integration and controls are a major contribution.

Summary

Scenario 1 is the most direct implementation of an AC microgrid because it takes advantage of the existing utility distribution infrastructure of poles and wiring, and thus is also potentially the cheapest. The addition of storage creates a much more favorable utility load profile for the block. However, it requires the full cooperation of the utility as the owner and operator of the microgrid system (or potentially the formation of an EcoBlock Utility by amendment to the Public Utility Code). It does not capture the efficiencies of a DC collection/distribution/storage system, nor the savings in transportation costs associated with DC/EV charging.

Performance Estimates

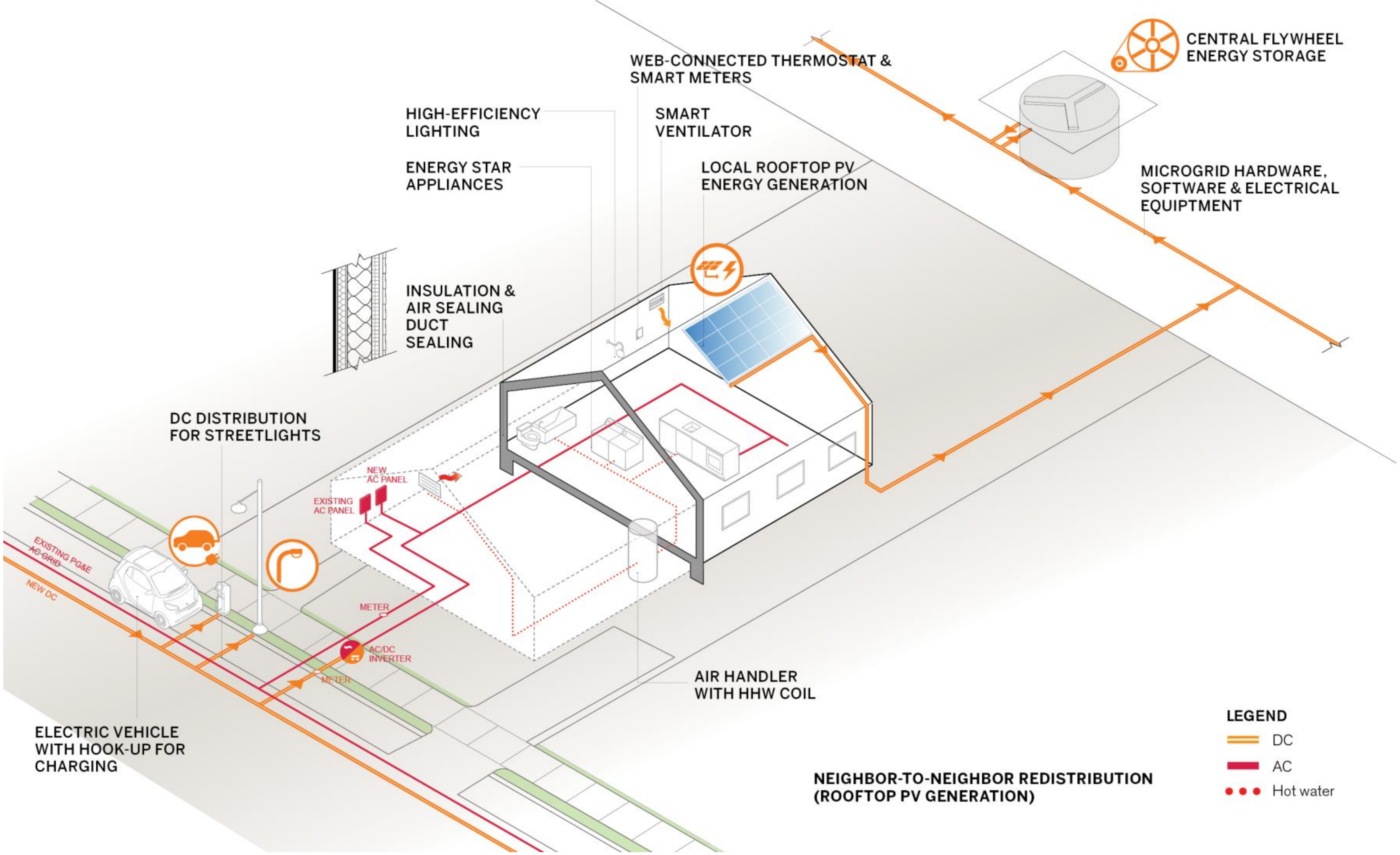
For those houses that opt into the block-scale microgrid (50 percent), their performance was estimated as follows: ZNE, i.e., zero energy supplied from the PG&E grid plus energy that could be used for electric vehicle (EV) charging equal to 20 percent of vehicle miles traveled per year (VMT/y).

Carbon dioxide emissions per year will be reduced by 80 percent in the homes, and 1.2 tons/y of carbon will be reduced by switching 20 percent of VMTs to EVs.

Scenario 2e: DC Solar/Storage/EV Microgrid

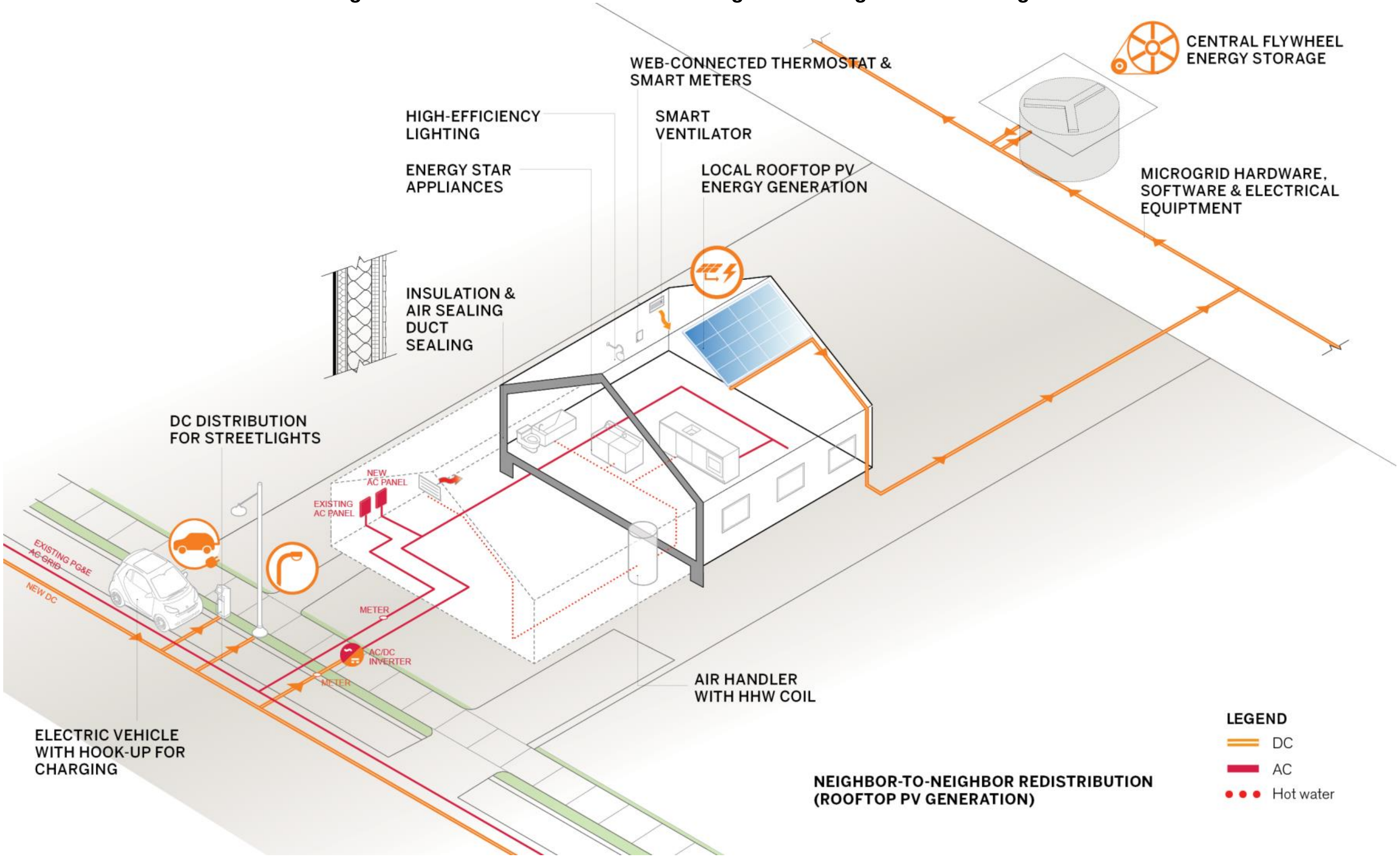
Figures 7-3 and 7-4 illustrate, on a house-scale and block-scale, respectively, the features of Scenario 2e. Table 7-3 outlines the elements in more detail.

Figure 7-3: Scenario 2e: DC Solar/Storage/EV Microgrid – House Diagram



DC Solar/Storage/Electric Vehicle Microgrid with Energy Efficiency Retrofits and AC/DC Houses.
Credit: Skidmore, Owings & Merrill, LLP

Figure 7-4: Scenario 2e: DC Solar/Storage/EV Microgrid – Block Diagram



DC Solar/Storage/Electric Vehicle Microgrid with Energy Efficiency Retrofits and AC/DC Houses.
Credit: Skidmore, Owings & Merrill, LLP

Table 7-3: Scenario 2e: DC Solar/Storage/EV Microgrid – Energy Description

		Categorical Description	SCENARIO 2E	SCENARIO 2E.a
NARRATIVE	Type		**DC Solar/Storage/Electric Vehicle Microgrid w. Energy Efficiency Retrofits and AC/DC Houses**	**Possible Variants (any combination possible, 2E.a, 2E.b, 2E.c, etc.)**
BK/FRNT YARD				
RESIDENTIAL HOME RETROFIT				
	E	**Demand Response**	Web-connected thermostat, smart meters & HMS	
	E	**Rooftop PV each home/apt**	Local, rooftop PV energy generation (net metering)	
	E	**HVAC, Lighting, Envelope Upgrades**	EE measures	
	E	1 Space Heating	Air handler w/ HHW coil (possibly no AC)	
	E	2 Lighting	High-efficiency lighting, ceiling fan	
	E	3 Envelope Insulation & Air Sealing	Insulation & air sealing	
	E	4 Duct Sealing of Existing Ducts	Duct sealing	
	E	5 Ventilation	Smart ventilator (fan)	
	E	6 Water Heater & Domestic Hot Water (DHW)	HPWH & HHW Loop; Demand response	
	E	7 Appliances	ENERGY STAR new appliances	
PVT	E	**Block-scale Energy Storage**	Community-scale backup (DC flywheel)	
PUBLIC ROW	E	**Microgrid Software and Controls**	Microgrid hardware, software, electrical equipment	
	E	**Smart Street Lights**	DC distribution for streetlights	
	E	**EV Charging, EcoBlock**	Electric vehicle with curbside hook-up for charging	
	E	**PV + Demand Management - block scale**	Neighbor-to-neighbor redistribution (rooftop PV generation)	
	E	**AC/DC microgrid**	Neighbor-to-neighbor redistribution (rooftop PV generation)	
	E	**Utility Trenching**	Existing utility configuration w/ no trenching	w/ trenching (opt.)
🟨		**Social Outreach**	Private & public cooperation (green infra., E/W storage)	Preferences?
🟥		**Permitting & Regulations**	Innovative legal/regulatory pathways	LU & Utility regs?
🟥		**Technology & Knowledge Transfer**	Social & technical innovation at block	Transferability?

KEY
HMS: Home Monitoring System
PV: Photovoltaic
HHW: Heating Hot Water
HPWH: Heat Pump Water Heater
PVT: Private
ROW: Right of Way
LU Regs: Land Use Regulations
PG&E: Pacific Gas & Electric

DC Solar/Storage/Electric Vehicle Microgrid with Energy Efficiency Retrofits and AC/DC Houses.
Credit: Skidmore, Owings & Merrill, LLP

Evaluation

1. **Technical Issues:** None, all components and systems are market available, although vacuum flywheel storage is new to market. The DC smart grid and controls will be custom designed for the project, and their integrated application is not a proven technology, even though all the components are available.
2. **Regulatory and Permitting Issues:** The energy-efficiency measures can be permitted under existing planning or permitting procedures. The DC microgrid infrastructure will most likely be designated an “Extensive Impact Civic Activity” and require a Major Conditional Use Permit. A new “Demonstration Ordinance” may facilitate the whole permitting process.
3. **Legal/Governance Issues:** The pilot project will be governed by an EcoBlock Trust to manage and ensure owner participation in the PACE and CFD financing agreements.
4. **Business Model:** The business model is a public–private partnership (P3) with third-party builder/operator, financed by a layering of models: PACE is used to finance energy and water efficiencies in the homes and a CFD is used to finance the microgrid—both with property tax assessments as payment, and all governed by an EcoBlock Trust.
5. **Ratepayer Benefits:** Ratepayers will be charged through property tax assessments that will be the same as (or lower) than their utility bill savings. The renewable energy supply shields homeowners from utility energy price increases. Ratepayers benefit from the project’s resilience, as it is able to operate if the electric grid goes down.
6. **Homeowner Acceptance:** Project outreach indicates high interest in homeowner participation (at least 50 percent), but actual participation will be determined in Phase 2.
7. **Social Issues:** The project uses savings in utility costs to fund major homeowner improvements—a form of shared prosperity—but protections will have to be structured into the EcoBlock Trust to protect against individuals selling out and thus cashing in on improvements.
8. **Utility Benefits:** The provision of storage changes the load profile of the block to make it much more favorable to the utility. The EcoBlock is a potential new business model for the utility to upgrade its infrastructure.
9. **Resilience:** Provides significant block-scale resilience if the PG&E grid goes down. The block could operate on its own, indefinitely.
10. **Technical Advance:** This would be a major technical advance—the first DC Solar/Storage/EV microgrid at residential block scale. System integration and controls are a major contribution, although unproven as a technology.

Summary

This scenario is a major breakthrough, demonstrating the value of systems integration and controls at larger-than-house scale. It enables the widescale application and penetration of energy efficiency with the first test of a distributed DC Solar/Storage/EV ,microgrid. It also enables the distributed charging of EVs at the block scale. By having a DC/AC inverter from the microgrid to each house, no changes in internal AC house wiring are necessary. The biggest unknown is the eventual mature market cost of the microgrid collection and distribution infrastructure, which is why a publically funded pilot project is necessary.

Performance Estimates

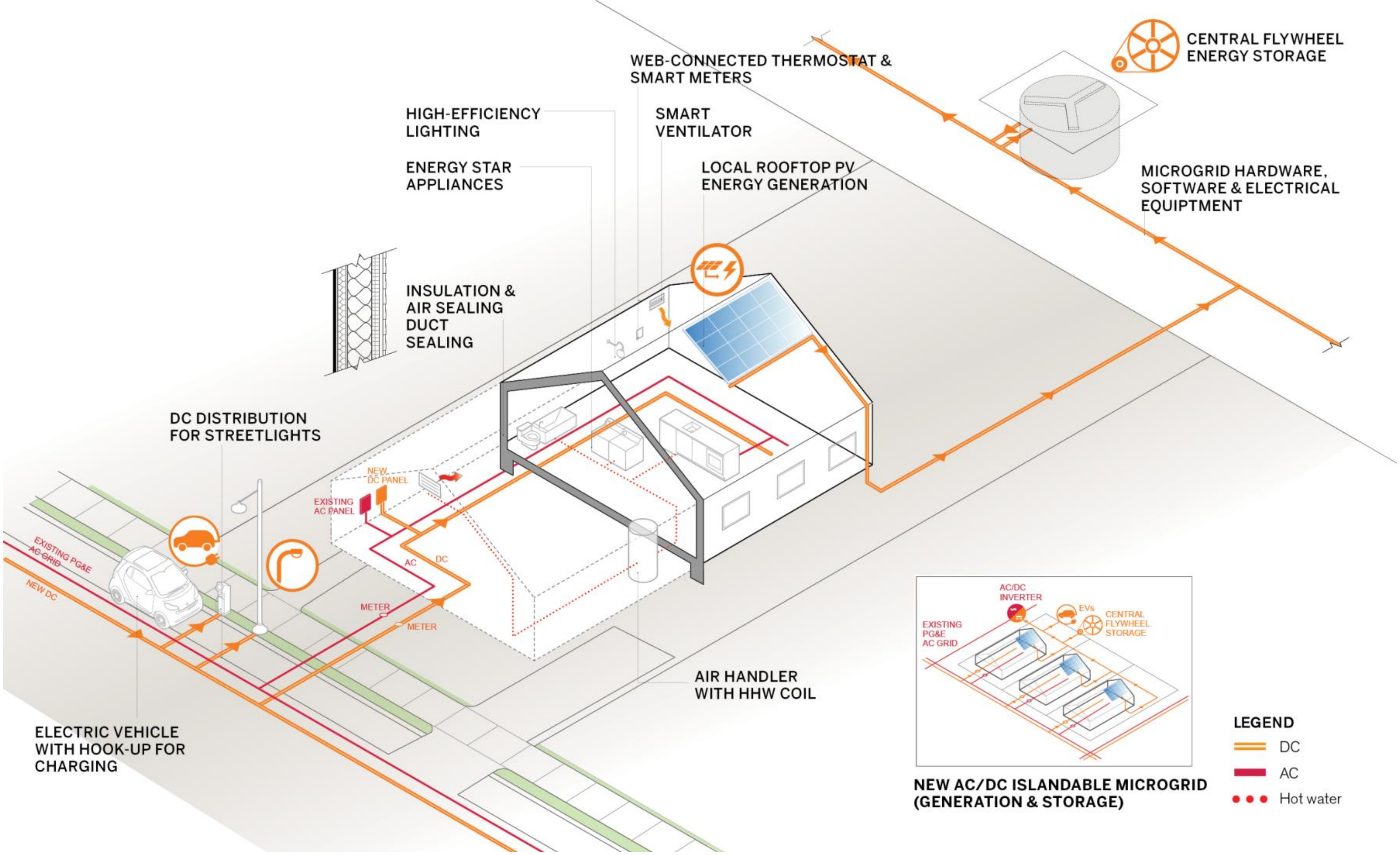
For those houses that opt into the block-scale microgrid (75 to 90 percent), their performance is estimated as follows: ZNE, i.e., zero energy supplied from the PG&E grid, plus energy that can be used for EV charging equal to 25 percent VMT/year

Carbon emissions in the household is reduced by 85 percent because of switching the fuel from gas to electric for heating and hot water, but the reduction could be 100 percent if homeowners adopt electric stoves and ovens.

Scenario 3e: DC Solar/Storage/EV Microgrid

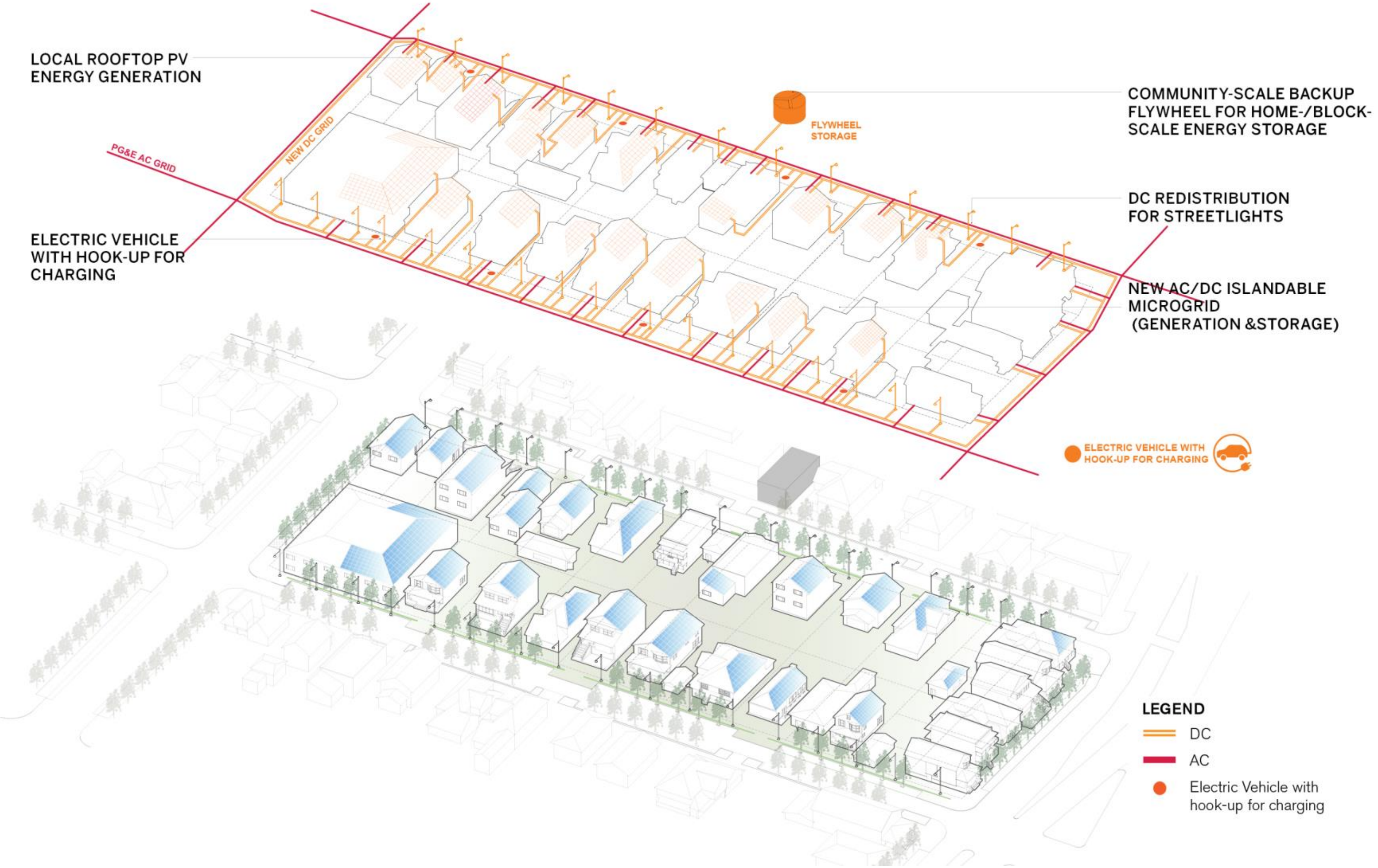
Figures 7-5 and 7-6 illustrate, on a house-scale and block-scale, respectively, the features of Scenario 3e. Table 7-4 outlines the elements in more detail.

Figure 7-5: Scenario 3e: DC Solar/Storage/EV Microgrid – House Diagram



DC Solar/Storage/Electric Vehicle Microgrid with Energy Efficiency Retrofits and AC/DC Houses.
Credit: Skidmore, Owings & Merrill, LLP

Figure 7-6: Scenario 3e: DC Solar/Storage/EV Microgrid – Block Diagram



DC Solar/Storage/Electric Vehicle Microgrid with Energy Efficiency Retrofits and AC/DC Houses.
Credit: Skidmore, Owings & Merrill, LLP

Table 7-4: Scenario 3e: DC Solar/Storage/EV Microgrid – Energy Description

			Categorical Description	SCENARIO 3E	SCENARIO 3E.a
NARRATIVE	Type			**DC Solar/Storage/Electric Vehicle Microgrid w. Energy Efficiency Retrofits and AC/DC Houses**	**Microgrid variant**
BK/FRNT YARD					
RESIDENTIAL HOME RETROFIT	E		**Demand Response**	Web-connected thermostat, smart meters & HMS	
	E		**Rooftop PV each home/apt**	Local, rooftop PV energy generation (net metering)	
	E		**HVAC, Lighting, Envelope Upgrades**	EE measures	
	E	1	Space Heating	Air handler w/ HHW coil (possibly no AC)	
	E	2	Lighting	High-efficiency lighting, ceiling fan	
	E	3	Envelope Insulation & Air Sealing	Insulation & air sealing	
	E	4	Duct Sealing of Existing Ducts	Duct sealing	
	E	5	Ventilation	Smart ventilator (fan)	
	E	6	Water Heater & Domestic Hot Water (DHW)	HPWH & HHW Loop; Demand response	
	E	7	Appliances	ENERGY STAR new appliances	
PVT	E		**Block-scale Energy Storage**	Community-scale backup (DC flywheel)	
PUBLIC ROW	E		**Microgrid Software and Controls**	Microgrid hardware, software, electrical equipment	
	E		**Smart Street Lights**	DC distribution for streetlights	
	E		**EV Charging, EcoBlock**	Electric vehicle with curbside hook-up for charging	
	E		**PV + Demand Management - block scale**	DC redistribution (rooftop PV generation)	
	E		**AC/DC microgrid**	New AC/DC islandable microgrid (generation & storage)	Invert/Meter AC/DC
	E		**Utility Trenching**	New joint trench with electrical distribution	
🟨			**Social Outreach**	Independent utilities, shared community elements	Preferences?
🟥			**Permitting & Regulations**	Redev. authority for reconfiguring utilities & neighborhood	LU & Utility regs?
🟥			**Technology & Knowledge Transfer**	Scale to multi-block and statewide	Transferability?

KEY
HMS: Home Monitoring System
PV: Photovoltaic
HHW: Heating Hot Water
HPWH: Heat Pump Water Heater
PVT: Private
ROW: Right of Way
LU Regs : Land Use Regulations
PG&E: Pacific Gas & Electric

DC Solar/Storage/Electric Vehicle Microgrid with Energy Efficiency Retrofits and AC/DC Houses.

Credit: Skidmore, Owings & Merrill, LLP

Evaluation

1. **Technical Issues:** All components and systems are market available, although the vacuum flywheel storage is new to market. The DC smart microgrid and controls will be custom designed for the project, and as a pilot project, their integrated application is not a proven technology, even though all the components exist.
2. **Regulatory and Permitting Issues:** The energy-efficiency measures can be permitted under existing planning or procedures. The microgrid infrastructure will most likely be designated as an "Extensive Impact Civic Activity" and require a Major Conditional Use Permit. A new "Demonstration Ordinance" may facilitate the whole permitting process.
3. **Legal/Governance Issues:** The pilot project will be governed by an EcoBlock Trust to manage and ensure owner participation in the PACE and CFD financing agreements.
4. **Business Model:** The business model is a P3 with a third-party builder/operator, financed by a layering of models: PACE is used to finance energy and water efficiencies in the homes, and a CFD is used to finance the microgrid, both with property tax assessments as payment, and all governed by an EcoBlock Trust.
5. **Ratepayer Benefits:** Ratepayers will be charged through property tax assessments that will be the same as or lower than their utility bill savings. The renewable energy supply shields homeowners from utility energy price increases. Ratepayers benefit from the project's resilience, as it is able to operate if the electric grid goes down.
6. **Homeowner Acceptance:** Project outreach indicates high interest in homeowner participation (at least 50 percent), but actual participation will be determined in Phase 2
7. **Social Issues:** The project uses savings in utility costs to fund major homeowner improvements, a form of shared prosperity, but protections will have to be structured into the EcoBlock Trust to protect against individuals selling out and cashing in on improvements.
8. **Utility Benefits:** The provision of storage changes the load profile of the block to make it much more favorable to the utility. The EcoBlock is a potential new business model for the utility to upgrade its infrastructure.
9. **Resilience:** Provides significant block-scale resilience, if the PG&E grid goes down. The block could operate on its own, indefinitely.
10. **Technical Advance:** This would be a major technical advance—the first DC Solar/Storage/EV microgrid at residential block scale, with the test of a DC house-scale application to power selected DC appliances. System integration and controls are a major contribution, although unproven as an integrated technology.

Summary

This scenario is a major breakthrough, demonstrating the value of systems integration and controls at larger-than-house scale. It enables the wide-scale application and penetration of energy efficiency with the first test of a distributed DC Solar/Storage/EV microgrid. The community solar renewable supply renders the fuel switching from gas to electric for heating and hot water a zero-carbon trade-out. It also enables the distributed charging of EVs at the block scale. The addition of DC house appliances increases the energy supply for EV charging, but the added cost of new wiring may not justify the installation of DC house circuits. The biggest unknown is the eventual mature market cost of the microgrid collection and distribution infrastructure (whereas the cost of PVs and storage has a market history and cost reduction curves), which is why a publically funded pilot project is necessary.

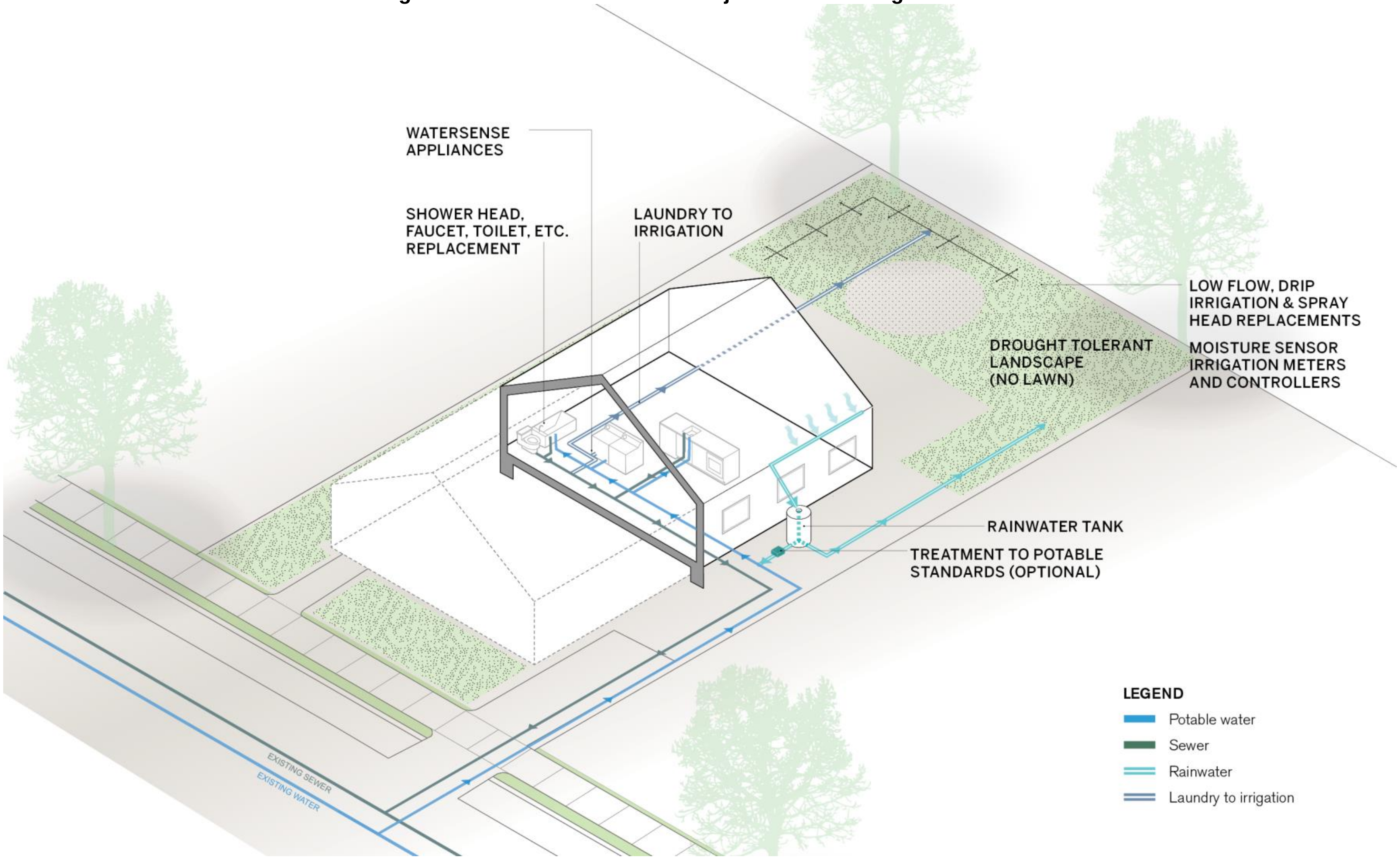
Scenario 1w: Core Project - Water Efficiency and Rainwater Capture and Use

Scenario 1w consists of the following elements:

1. Water-efficient fixture retrofits within homes (to be installed in coordination with the proposed deep energy retrofits) to include: toilets, kitchen and bath faucets, and showerheads, on an as-needed basis
2. Private rainwater harvesting for irrigation (with appropriate treatment and testing could be used for potable water)
3. Private “Laundry to Landscape” grey water diversion for irrigation as appropriate.
4. Native planting and efficient irrigation systems within private properties (yards) recommended, but at the homeowners’ expense.

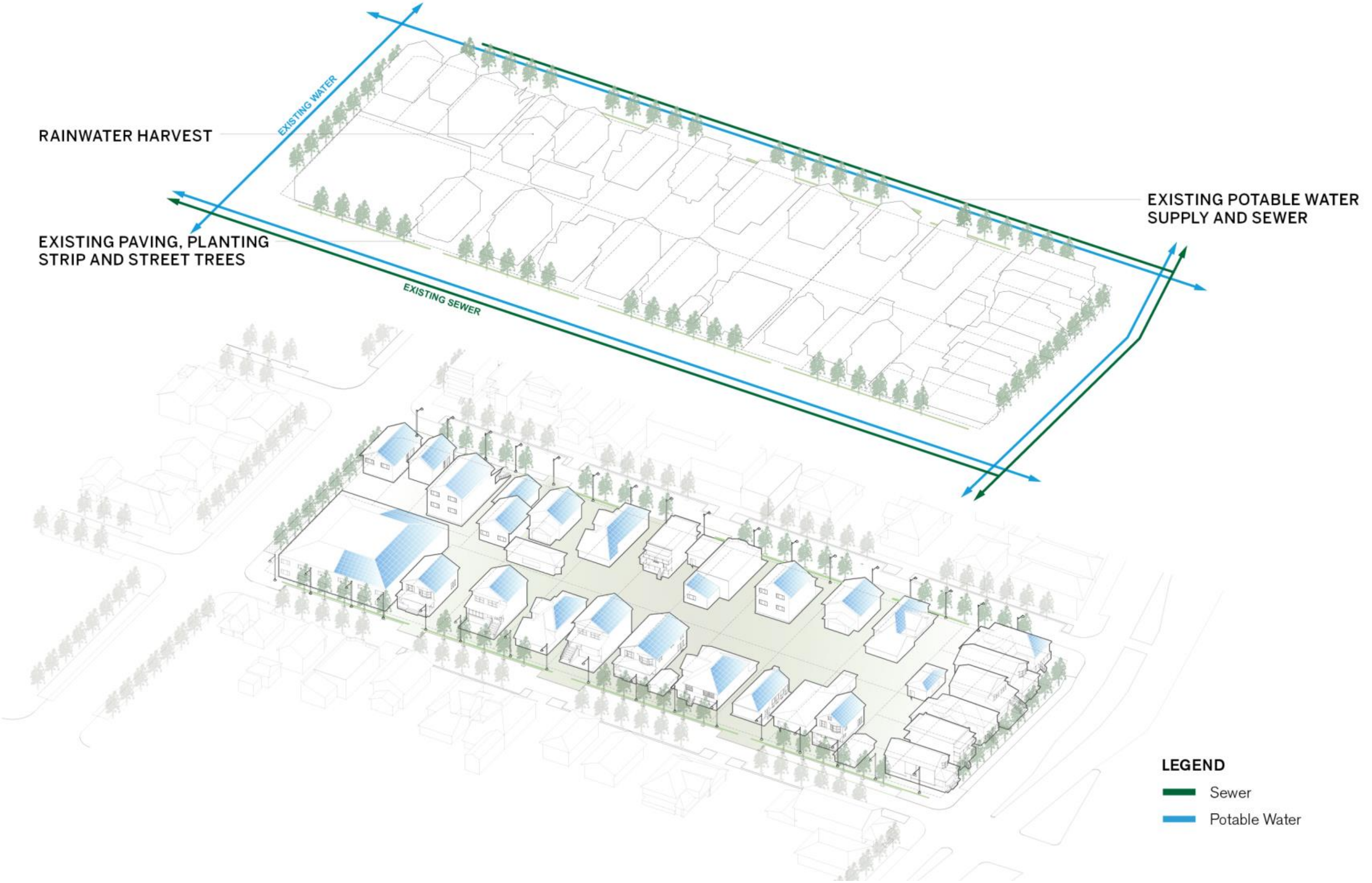
Figures 7-7 and 7-8 illustrate, on a house-scale and block-scale, respectively, the features of Scenario 1w. Table 7-5 outlines the elements in more detail.

Figure 7-7: Scenario 1w: Core Project – House Diagram



Core Project with Water Efficiency and Rainwater Capture and Use at House Scale.
Credit: Skidmore, Owings & Merrill, LLP

Figure 7-8: Scenario 1w: Core Project – Block Diagram



Core Project with Water Efficiency and Rainwater Capture and Use at House Scale.
Credit: Skidmore, Owings & Merrill, LLP

Table 7-5: Scenario 1w: Core Project – Water Description

		Categorical Description	SCENARIO 1 W: CORE PROJECT
NARRATIVE	Type		**Core Project w. Water Efficiency and Rainwater Capture and Reuse at House Scale.**
BK/FRNT YARD	W	**Native Landscaping**	Drought tolerant landscape (no lawn)
	W	**Efficient Irrigation Systems**	Low flow, drip irrigation & spray heads replacement
	W	**Enhanced Infiltration**	Existing stormwater runoff paved & planted surfaces
	W	**Irrigation Controllers**	Moisture sensors, irrigation meters, controls
	W	**Rainwater Harvest**	Rainwater tank (rain barrel)
	W	**Groundwater Clean & Store for Irrigation**	Existing potable water source (no well)
RESIDENTIAL HOME RETROFIT	W	**Water Fixture Upgrades**	Shower head, faucet, toilet, etc. replacement
	W	Appliances	WaterSense new appliances
	W	**Greywater to Non-Potable Standards**	Laundry to irrigation
	W	**Rainwater to Potable Standards**	Rainwater treated to potable standards (rain to tap)
	W	**Wastewater to Potable Standards**	Existing wastewater system (toilets to sewer)
PVT			
	W	**Block-Scale Wastewater Treatment**	N/A
	W	**Block-Scale Management**	N/A
PUBLIC ROW			
	W	**Green Stormwater Infrastructure**	Existing paving & planting strip
	W	**Street Trees**	Existing street trees (no change to ROW)
	W	**Sidewalk Pavement**	Existing sidewalk (no change to ROW)
	W	**Block-Scale, Non-Potable Water Distribution**	N/A
	W	**Utility Trenching**	Existing utility configuration w/ no trenching
🟨		**Social Outreach**	Private improvements underway (planting; houses, PV)
🟥		**Permitting & Regulations**	Community Co-op to purchase PV
🟥		**Technology & Knowledge Transfer**	Social innovation (Ratepayer benefit/Co-op)

KEY
HMS: Home Monitoring System
PV: Photovoltaic
HHW: Heating Hot Water
HPWH: Heat Pump Water Heater
PVT: Private
ROW: Right of Way
PG&E: Pacific Gas & Electric

Core Project with Water Efficiency and Rainwater Capture and Use at House Scale.

Credit: Skidmore, Owings & Merrill, LLP

Evaluation

1. **Technical Issues:** All water-efficient fixtures and components and rainwater harvesting (RWH) components are market available.
2. **Regulatory and Permitting Issues:** Water efficiency measures can be permitted under existing planning or permitting procedures, including RWH for irrigation. RWH for potable use will require a conditional use permit and may require plumbing code changes.
3. **Legal/Governance Issues:** The pilot project will be governed by a homeowners association to manage and ensure owner participation in the PACE financing of water efficiency and rainwater harvesting measures.
4. **Business Model:** PACE is used to finance water efficiency and rainwater capture measures in the homes, all governed by a homeowners association.
5. **Ratepayer Benefits:** Ratepayers will benefit from lower utility bills that more than offset property tax assessment for the water efficiency and rainwater capture **improvements.**
6. **Homeowner Acceptance:** Project outreach indicates high interest in homeowner participation (at least 50 percent), but actual participation will be determined in Phase 2.
7. **Social Issues:** The project uses savings in utility costs to fund major homeowner improvements—a form of shared prosperity—but covenants will have to be structured into the homeowners association to protect against individuals selling out and cashing in on improvements.
8. **Utility Benefits:** The utility benefits from lower water demand.
9. **Resilience:** This scenario lowers EBMUD water use adding to water resilience.
10. **Technical Advance:** There is no major technical advance for this scenario.

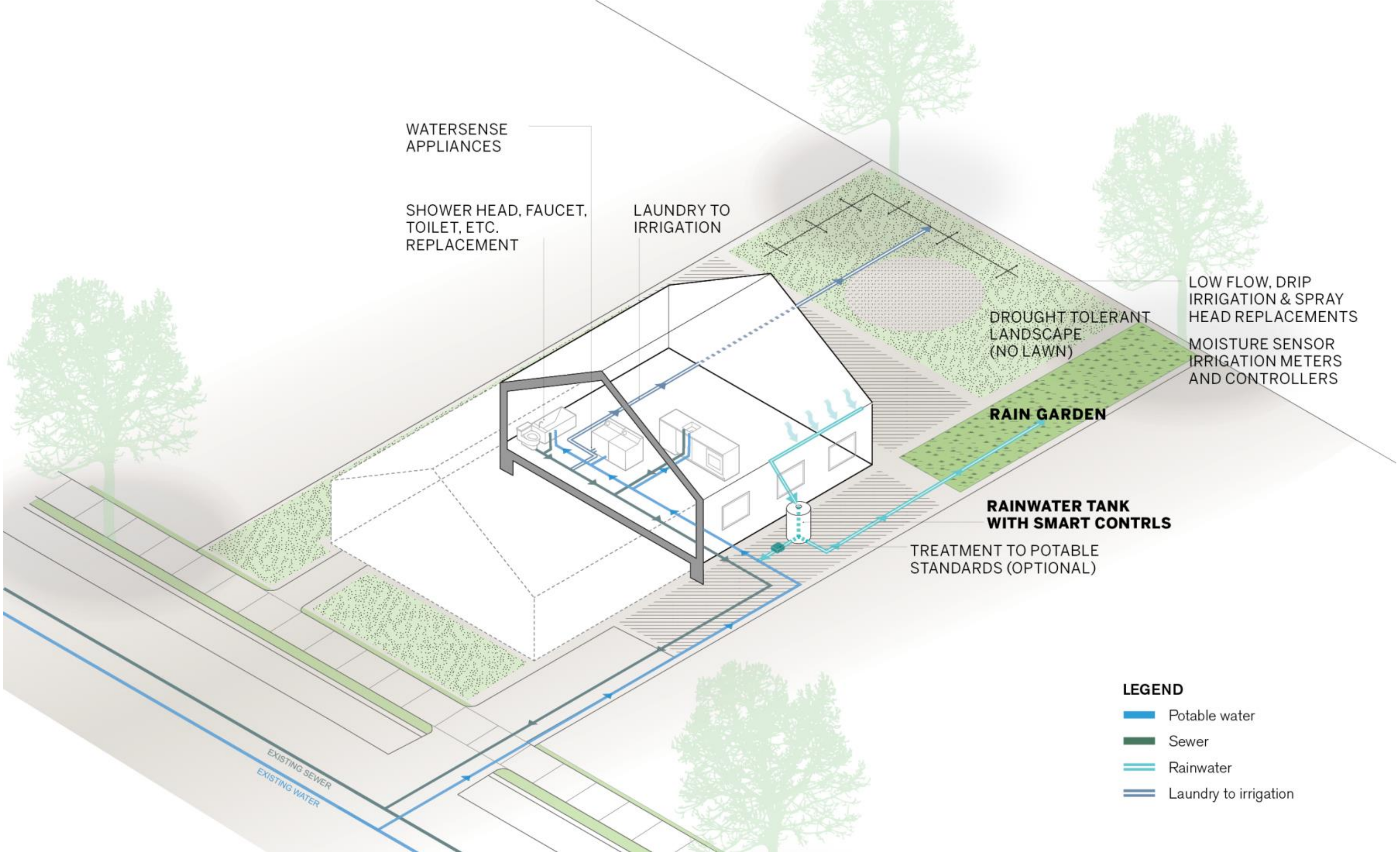
Water Bolt-on A: Block-Scale Management of Rainwater Systems

This bolt-on consists of smart block-scale managed rainwater system for flood mitigation and water storage optimization. The system, OptiNimbus, uses forecast information to predict the amount of rain that will enter a watershed and prepares the system to receive the forecasted water based on site objectives and regulations. This results in significant improvements in stormwater infrastructure performance and the ability to simultaneously meet what are otherwise competing goals—minimizing wet-weather discharge while maximizing harvesting potential.

The system would be used to optimize management of RWH systems described in the Core Project. Implementation is dependent on extensive private property participation, collaboration, and buy-in.

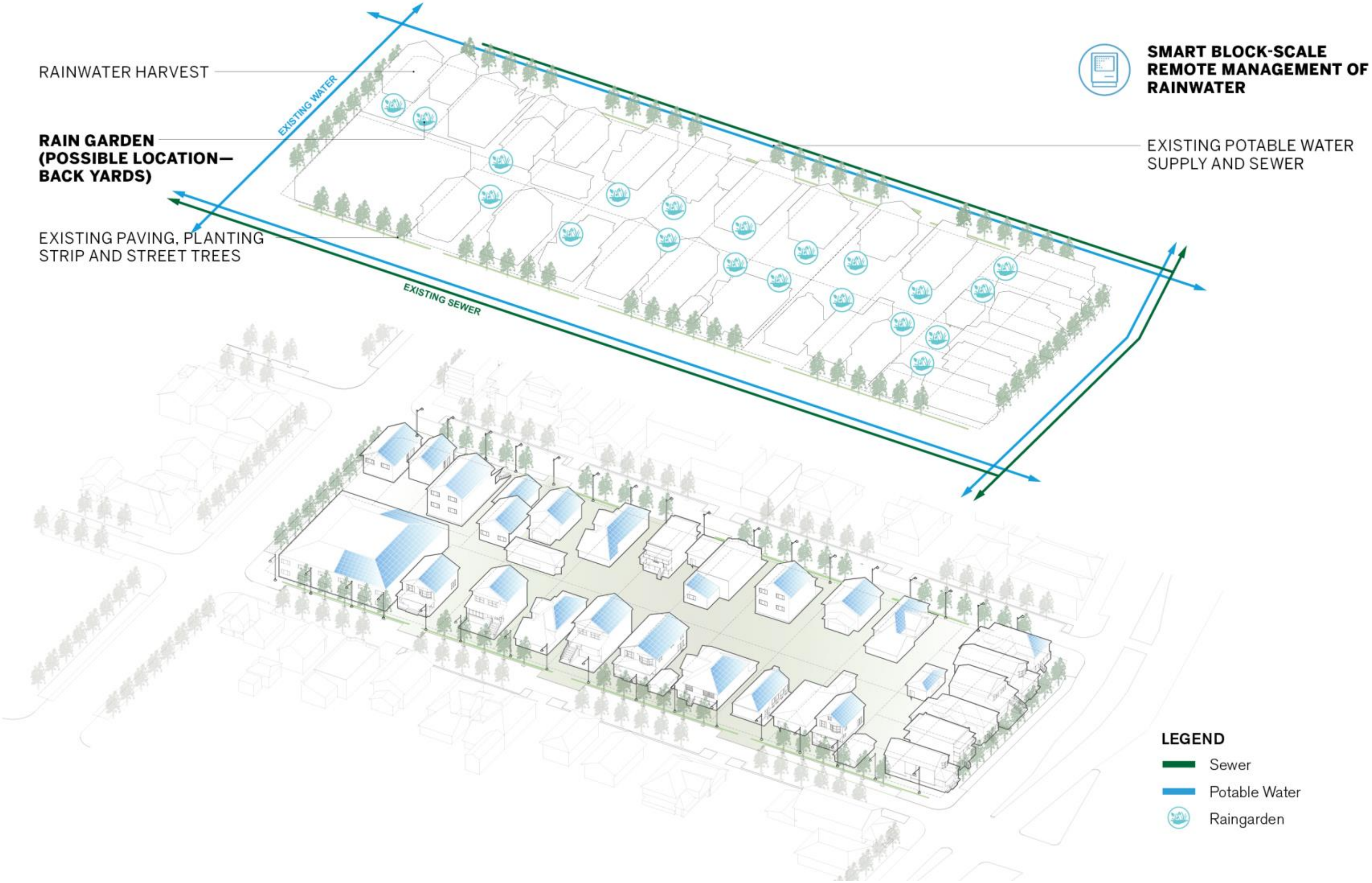
Figures 7-9 and 7-10 illustrate, on a house-scale and block-scale, respectively, the features of Water Bolt-on A. Table 7-6 outlines the elements in more detail.

Figure 7-9: Bolt-on A: Block-Scale Management of Rainwater Systems – House Diagram



Bolt-on A: Block-Scale Management of Rainwater Systems.
Credit: Skidmore, Owings & Merrill, LLP

Figure 7-10: Bolt-on A: Block-Scale Management of Rainwater Systems – Block Diagram



Bolt-on A: Block-Scale Management of Rainwater Systems.
Credit: Skidmore, Owings & Merrill, LLP

Table 7-6: Bolt-on A: Block-Scale Management of Rainwater Systems – Water Description

		Categorical Description	BOLT-ON A
NARRATIVE	Type		**Bolt-On A: Block Scale Rainwater Management**
BK/FRNT YARD	W	**Native Landscaping**	Drought tolerant landscape (no lawn)
	W	**Efficient Irrigation Systems**	Low flow, drip irrigation & spray heads replacement
	W	**Enhanced Infiltration**	Rain garden
	W	**Irrigation Controllers**	Moisture sensors, irrigation meters, controls
	W	**Rainwater Harvest**	Rainwater tank (rain barrel) with smart controls
	W	**Groundwater Clean & Store for Irrigation**	Existing potable water source (no well)
RESIDENTIAL HOME RETROFIT	W	**Water Fixture Upgrades**	Shower head, faucet, toilet, etc. replacement
	W	Appliances	WaterSense new appliances
	W	**Greywater to Non-Potable Standards**	Laundry to irrigation
	W	**Rainwater to Potable Standards**	Rainwater treated to potable standards (rain to tap)
	W	**Wastewater to Potable Standards**	Existing wastewater system (toilets to sewer)
PVT			
	W	**Block-Scale Wastewater Treatment**	N/A
	W	**Block-Scale Management**	Block-scale remote management of rainwater
PUBLIC ROW			
	W	**Green Stormwater Infrastructure**	Existing paving & planting strip
	W	**Street Trees**	Existing street trees (no change to ROW)
	W	**Sidewalk Pavement**	Existing sidewalk (no change to ROW)
	W	**Block-Scale, Non-Potable Water Distribution**	N/A
	W	**Utility Trenching**	Existing utility configuration w/ no trenching
🟨		**Social Outreach**	Private & public cooperation (green infra., E/W storage)
🟥		**Permitting & Regulations**	Innovative legal/regulatory pathways
🟥		**Technology & Knowledge Transfer**	Social & technical innovation at block

KEY
HMS: Home Monitoring System
PV: Photovoltaic
HHW: Heating Hot Water
HPWH: Heat Pump Water Heater
PVT: Private
ROW: Right of Way
PG&E: Pacific Gas & Electric

Bolt-on A: Block-Scale Management of Rainwater Systems.
Credit: Skidmore, Owings & Merrill, LLP

Evaluation

This is essentially a web-based “bolt-on” to Scenario 1w for smart management of RWH storage. It forecasts the amount of rain coming and directs the RWH storage to discharge to rain gardens, before the storm, to capture the maximum amount of stormwater, and thus reduce the amount the storm sewer infrastructure is required to handle. Its benefits come from the savings in the cost of stormwater infrastructure maintenance and upgrades. The cost benefit would have to be a credit on the homeowner’s property tax payments to the city.

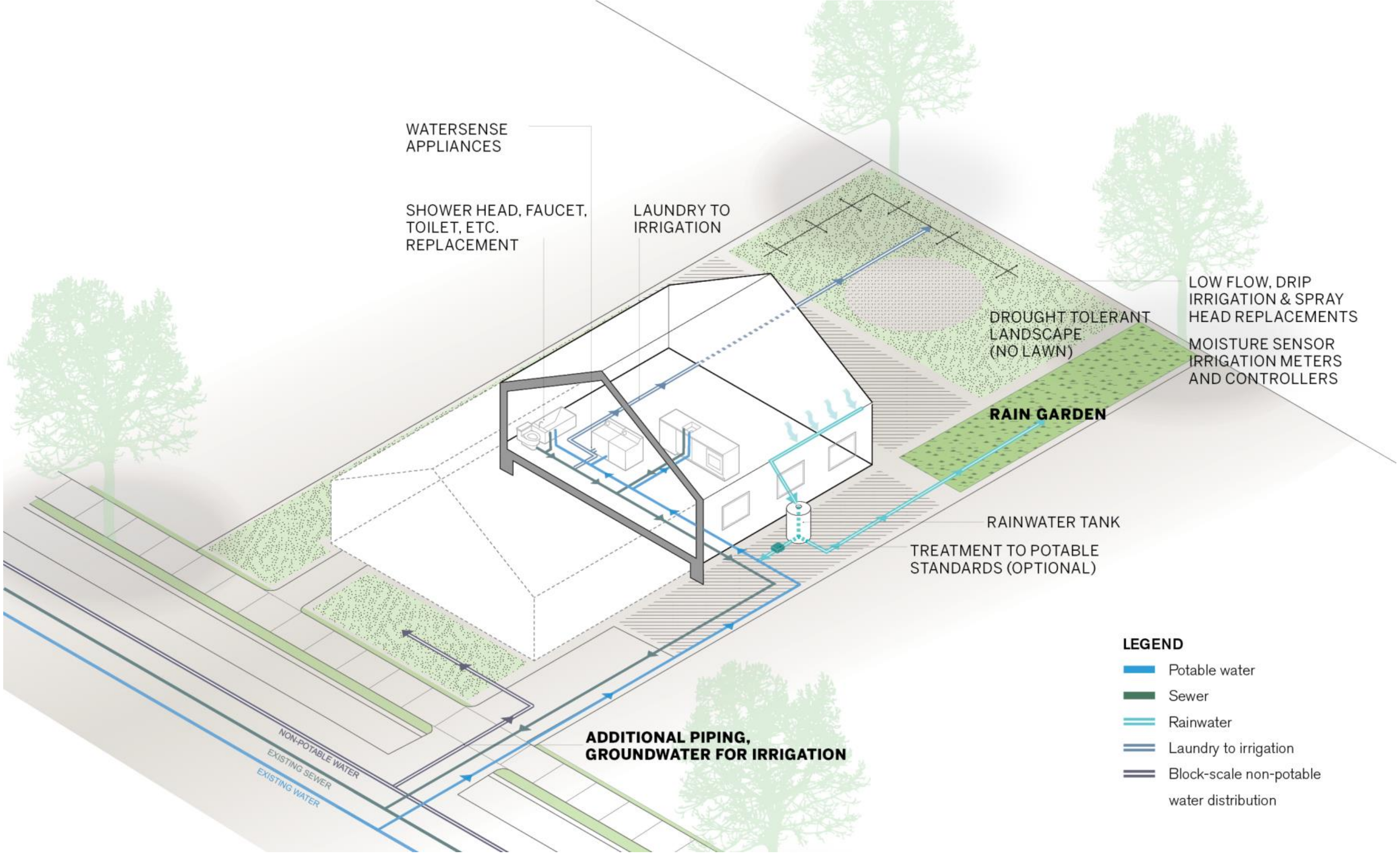
Water Bolt-on B: Groundwater for Irrigation at Neighborhood Scale

Bolt-on B includes development of a well or wells for non-potable (purple pipe) water distribution and reuse on the block. This could be coupled with a more focused and expanded green infrastructure that promotes infiltration of stormwater and aquifer recharge (see Bolt-on D, below). A watershed approach to stormwater management means that in theory, recharge does not have to happen on a specific block, but watershed and groundwater basinwide impacts need to be considered in the analysis.

This scenario’s implementation is dependent on soil conditions and groundwater resources, a possible watershed-scale initiative, a public ROW recharge initiative, private land for a well, and an adequate scale for financial viability.

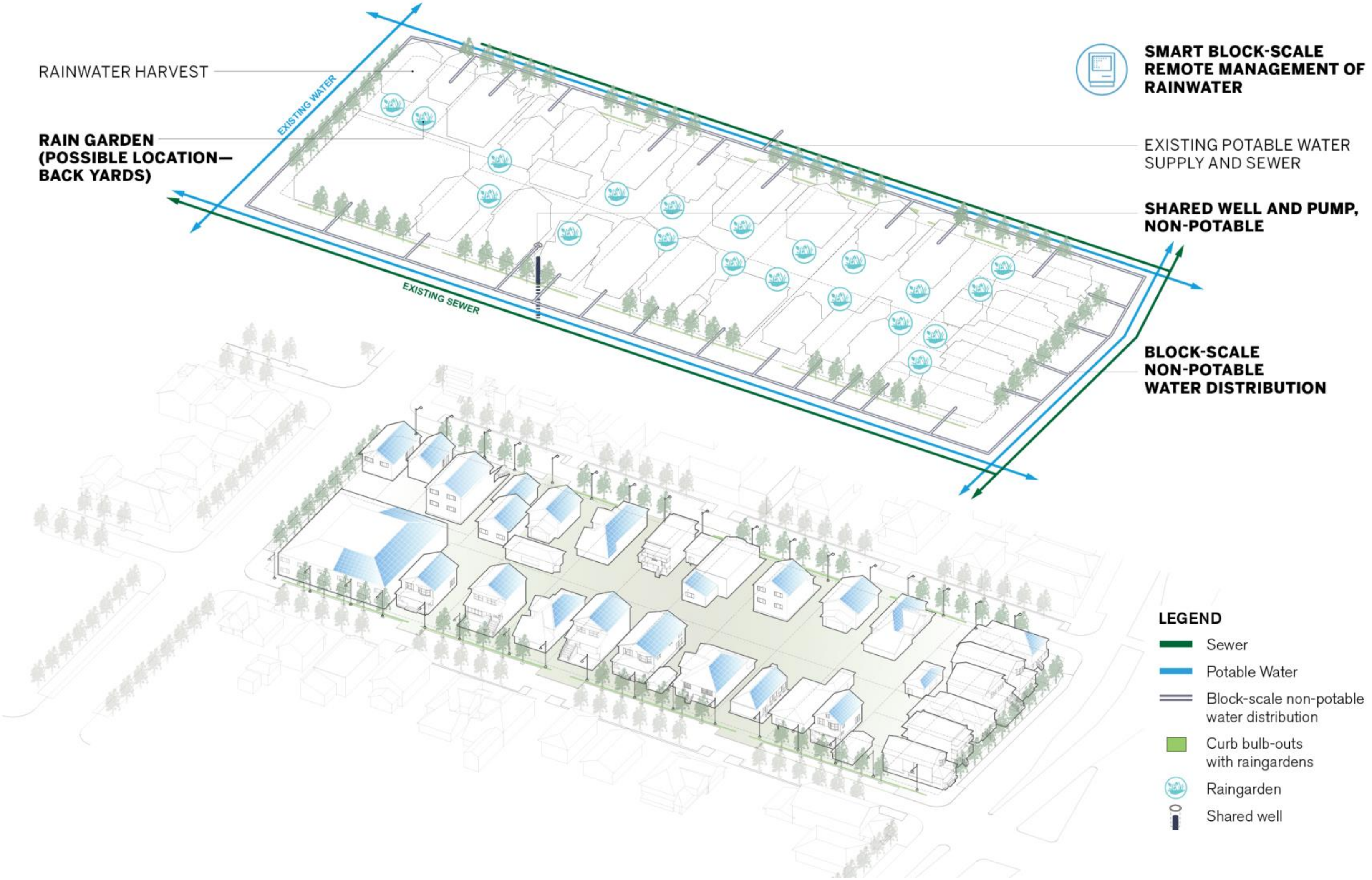
Figures 7-11 and 7-12 illustrate, on a house-scale and block-scale, respectively, the features of Water Bolt-on B. Table 7-7 outlines the elements in more detail.

Figure 7-11: Bolt-on B: Groundwater for Irrigation – House Diagram



Bolt-on B: Groundwater for Irrigation at Neighborhood Scale with Possible Green Infrastructure in a Public ROW.
Credit: Skidmore, Owings & Merrill, LLP

Figure 7-12: Bolt-on B: Groundwater for Irrigation – Block Diagram



Bolt-on B: Groundwater for Irrigation at Neighborhood Scale with Possible Green Infrastructure in Public ROW.
Credit: Skidmore, Owings & Merrill, LLP

Table 7-7: Bolt-on B: Groundwater for Irrigation – Water Description

		Categorical Description	BOLT-ON B
NARRATIVE	Type		Bolt-On B: Groundwater Recharge and Reuse for Non Potable at Neighborhood Scale w. Possible Green Infrastructure in Public ROW
BK/FRNT YARD	W	Native Landscaping	Drought tolerant landscape (no lawn)
	W	Efficient Irrigation Systems	Low flow, drip irrigation & spray heads replacement
	W	Enhanced Infiltration	Rain garden
	W	Irrigation Controllers	Moisture sensors, irrigation meters, controls
	W	Rainwater Harvest	Rainwater tank (rain barrel)
	W	Groundwater Clean & Store for Irrigation	Groundwater (shared well)
RESIDENTIAL HOME RETROFIT	W	Water Fixture Upgrades	Shower head, faucet, toilet, etc. replacement
	W	Appliances	WaterSense new appliances
	W	Greywater to Non-Potable Standards	Laundry to irrigation
	W	Rainwater to Potable Standards	Rainwater treated to potable standards (rain to tap)
	W	Wastewater to Potable Standards	Existing wastewater system (toilets to sewer)
PVT			
	W	Block-Scale Wastewater Treatment	N/A
	W	Block-Scale Management	Block Scale Remote Management of Rainwater
PUBLIC ROW			
	W	Green Stormwater Infrastructure	Permeable paving street, parking & sidewalk swales
	W	Street Trees	Addition/replacement with native, drought tolerant trees
	W	Sidewalk Pavement	Replacement with permeable pavement
	W	Block-Scale, Non-Potable Water Distribution	Additional piping
	W	Utility Trenching	Existing utility configuration w/ no trenching
🟨		Social Outreach	Private & public cooperation (green infra., E/W storage)
🟥		Permitting & Regulations	Innovative legal/regulatory pathways
🟥		Technology & Knowledge Transfer	Social & technical innovation at block

KEY
HMS: Home Monitoring System
PV: Photovoltaic
HHW: Heating Hot Water
HPWH: Heat Pump Water Heater
PVT: Private
ROW: Right of Way
PG&E: Pacific Gas & Electric

Bolt-on B: Groundwater for Irrigation at Neighborhood Scale with Possible Green Infrastructure in a Public ROW.

Credit: Skidmore, Owings & Merrill, LLP

Evaluation

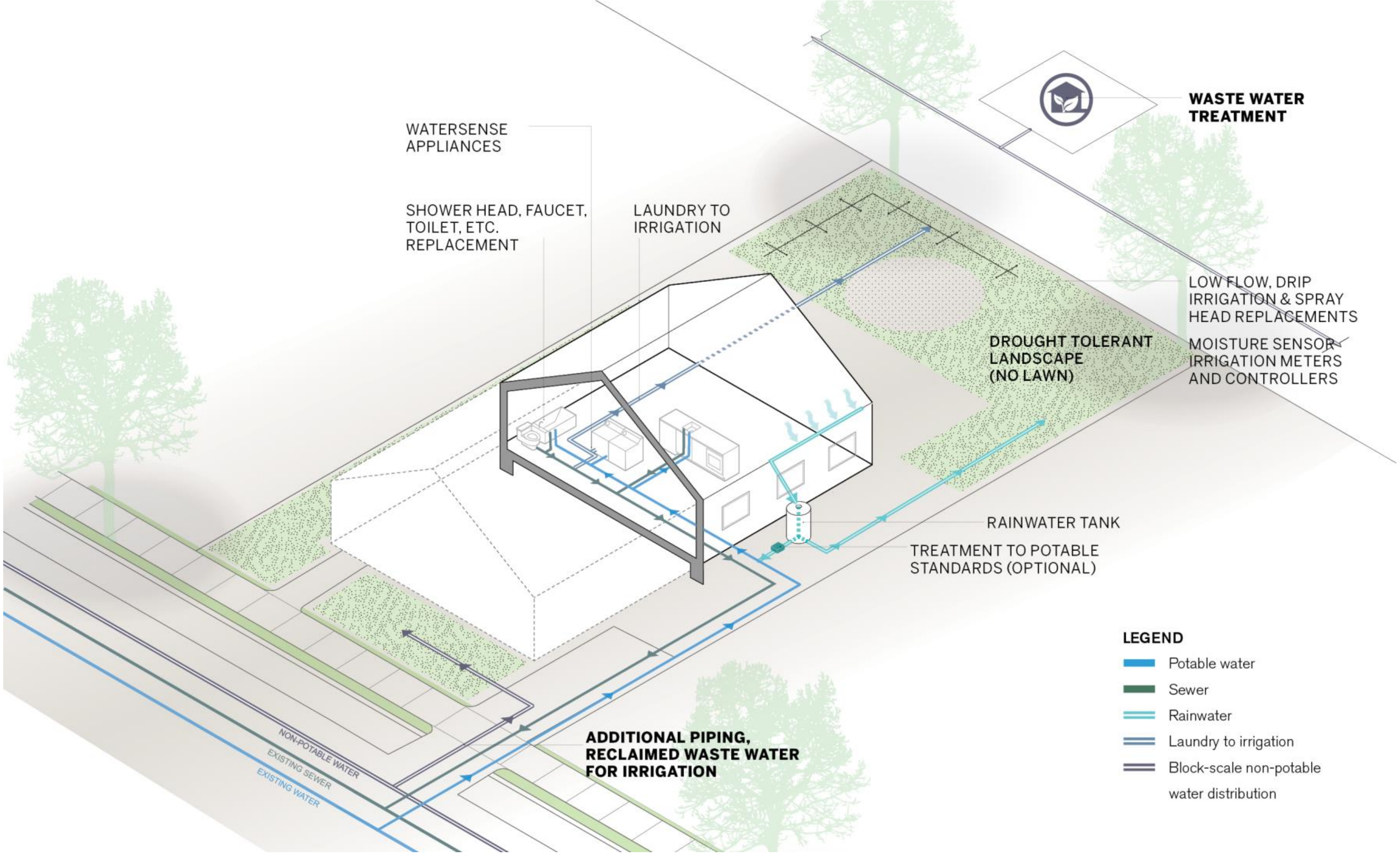
Based on the cost evaluations conducted by the Integrated Water Systems Designs team, the cost of this system is prohibitive because of the high cost of distribution piping and because the demand for non-potable use at the current EcoBlock scale is very low. If on the other hand, there were a neighborhood with a high demand for non-potable use, this system could become a cost-effective alternative means of supply. Also, if treated to potable water, it could become a cost-effective means of potable supply that replaces the existing system with a new infrastructure that avoids any deferred maintenance on the existing system.

Water Bolt-on C: Sewer Mining—Reclamation for Irrigation for Non-Potable Water at a Neighborhood Scale

Bolt-on C consists of sewer mining and distribution of treated wastewater for non-potable reuse. Its implementation is dependent on community buy-in of wastewater as a source and scaling and broader participation to become a viable financial model, which would require significant legal changes.

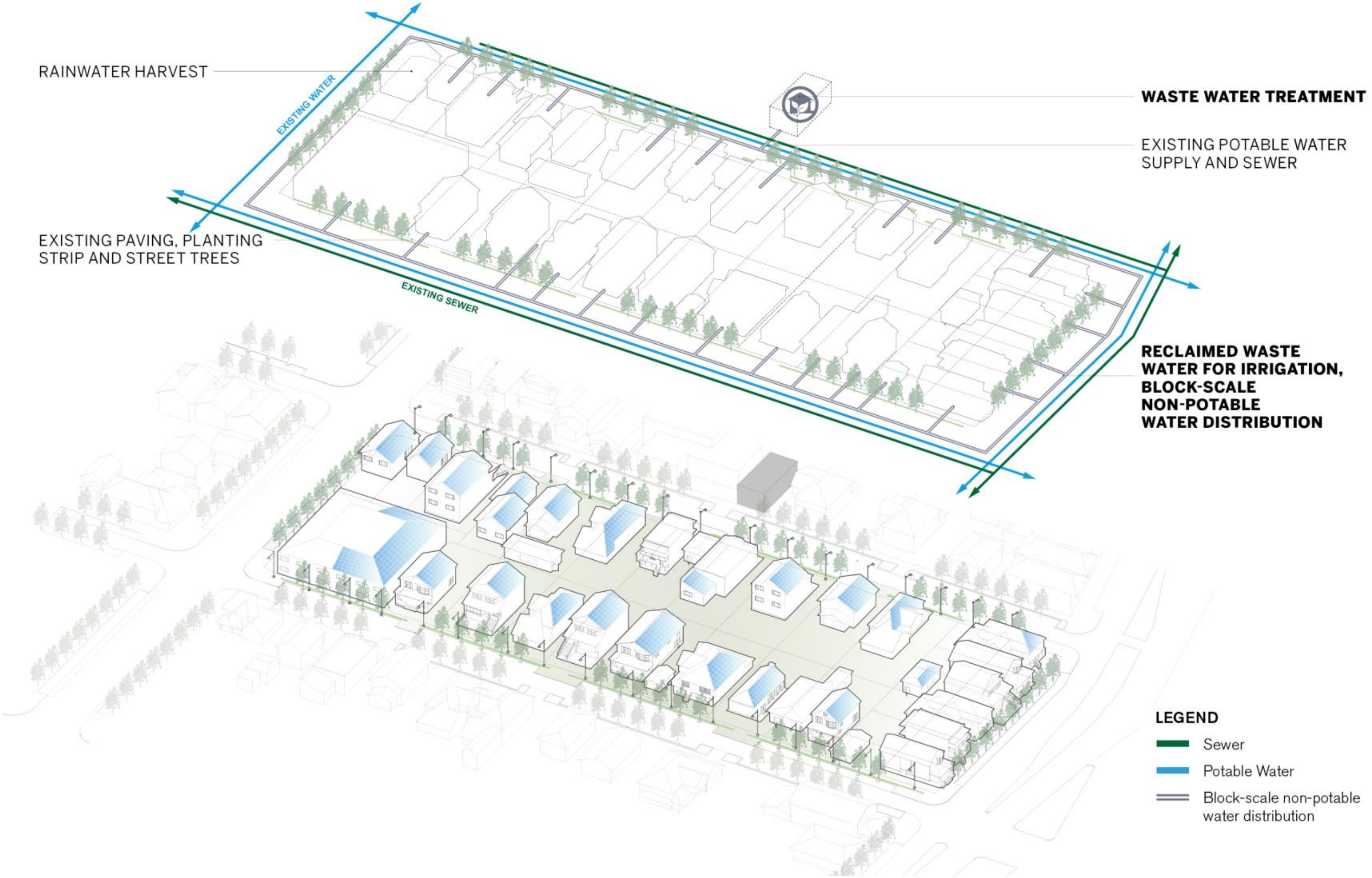
Figures 7-13 and 7-14 illustrate, on a house-scale and block-scale, respectively, the features of Water Bolt-on C. Table 7-8 outlines the elements in more detail.

Figure 7-13: Bolt-on C: Sewer Mining—Reclamation for Irrigation – House Diagram



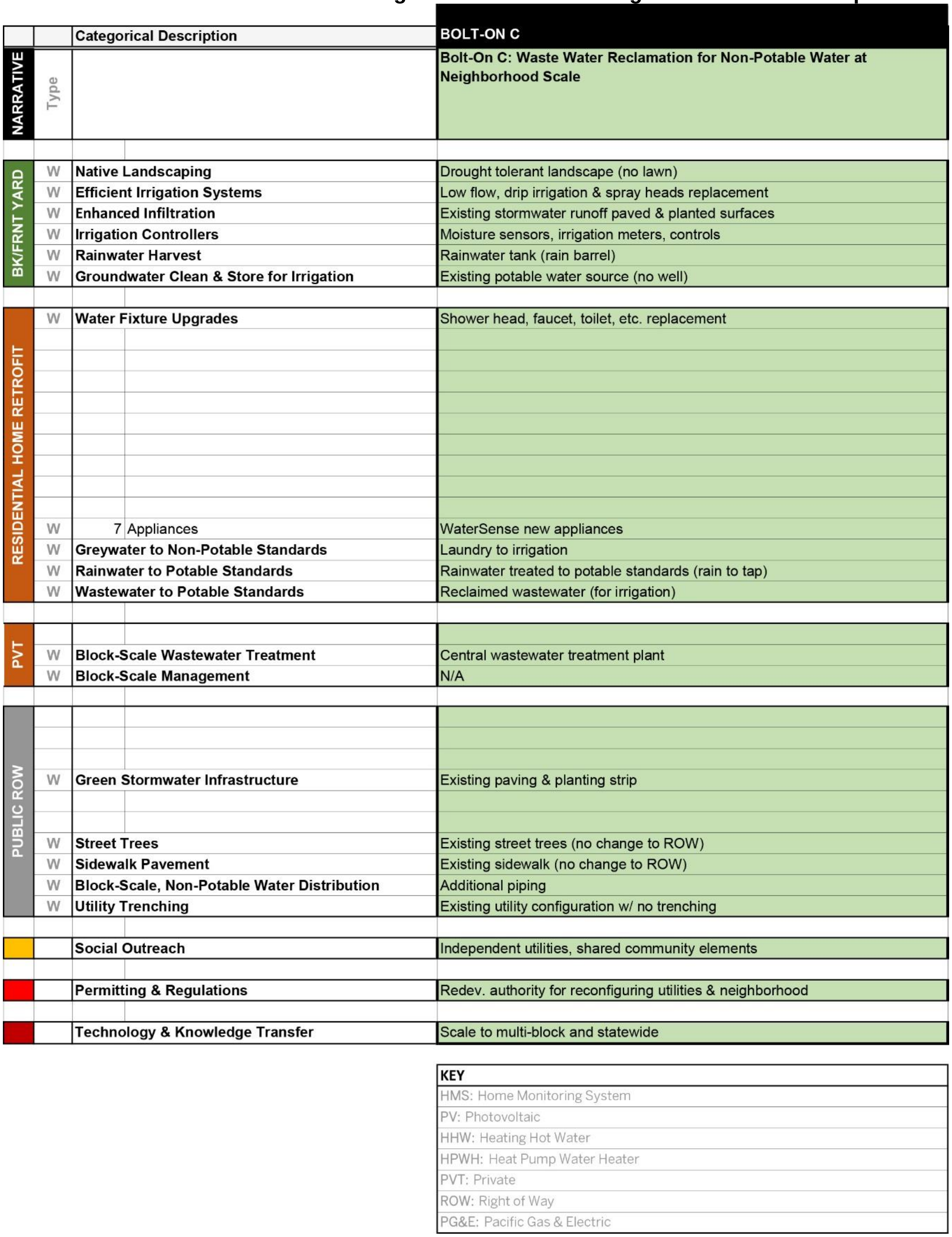
Bolt-on C: Sewer Mining—Reclamation for Irrigation for Non-Potable Water at Neighborhood Scale.
Credit: Skidmore, Owings & Merrill, LLP

Figure 7-14: Bolt-on C: Sewer Mining—Reclamation for Irrigation – Block Diagram



Bolt-on C: Sewer Mining—Reclamation for Irrigation for Non-Potable Water at Neighborhood Scale.
Credit: Skidmore, Owings & Merrill, LLP

Table 7-8: Bolt-on C: Sewer Mining—Reclamation for Irrigation – Water Description



		Categorical Description	BOLT-ON C
NARRATIVE	Type		Bolt-On C: Waste Water Reclamation for Non-Potable Water at Neighborhood Scale
BK/FRNT YARD	W	Native Landscaping	Drought tolerant landscape (no lawn)
	W	Efficient Irrigation Systems	Low flow, drip irrigation & spray heads replacement
	W	Enhanced Infiltration	Existing stormwater runoff paved & planted surfaces
	W	Irrigation Controllers	Moisture sensors, irrigation meters, controls
	W	Rainwater Harvest	Rainwater tank (rain barrel)
	W	Groundwater Clean & Store for Irrigation	Existing potable water source (no well)
RESIDENTIAL HOME RETROFIT	W	Water Fixture Upgrades	Shower head, faucet, toilet, etc. replacement
	W	7 Appliances	WaterSense new appliances
	W	Greywater to Non-Potable Standards	Laundry to irrigation
	W	Rainwater to Potable Standards	Rainwater treated to potable standards (rain to tap)
	W	Wastewater to Potable Standards	Reclaimed wastewater (for irrigation)
PVT			
	W	Block-Scale Wastewater Treatment	Central wastewater treatment plant
	W	Block-Scale Management	N/A
PUBLIC ROW			
	W	Green Stormwater Infrastructure	Existing paving & planting strip
	W	Street Trees	Existing street trees (no change to ROW)
	W	Sidewalk Pavement	Existing sidewalk (no change to ROW)
	W	Block-Scale, Non-Potable Water Distribution	Additional piping
	W	Utility Trenching	Existing utility configuration w/ no trenching
🟨		Social Outreach	Independent utilities, shared community elements
🟥		Permitting & Regulations	Redev. authority for reconfiguring utilities & neighborhood
🟥		Technology & Knowledge Transfer	Scale to multi-block and statewide

KEY
HMS: Home Monitoring System
PV: Photovoltaic
HHW: Heating Hot Water
HPWH: Heat Pump Water Heater
PVT: Private
ROW: Right of Way
PG&E: Pacific Gas & Electric

Bolt-on C: Sewer Mining—Reclamation for Irrigation for Non-Potable Water at Neighborhood Scale.
Credit: Skidmore, Owings & Merrill, LLP

Evaluation

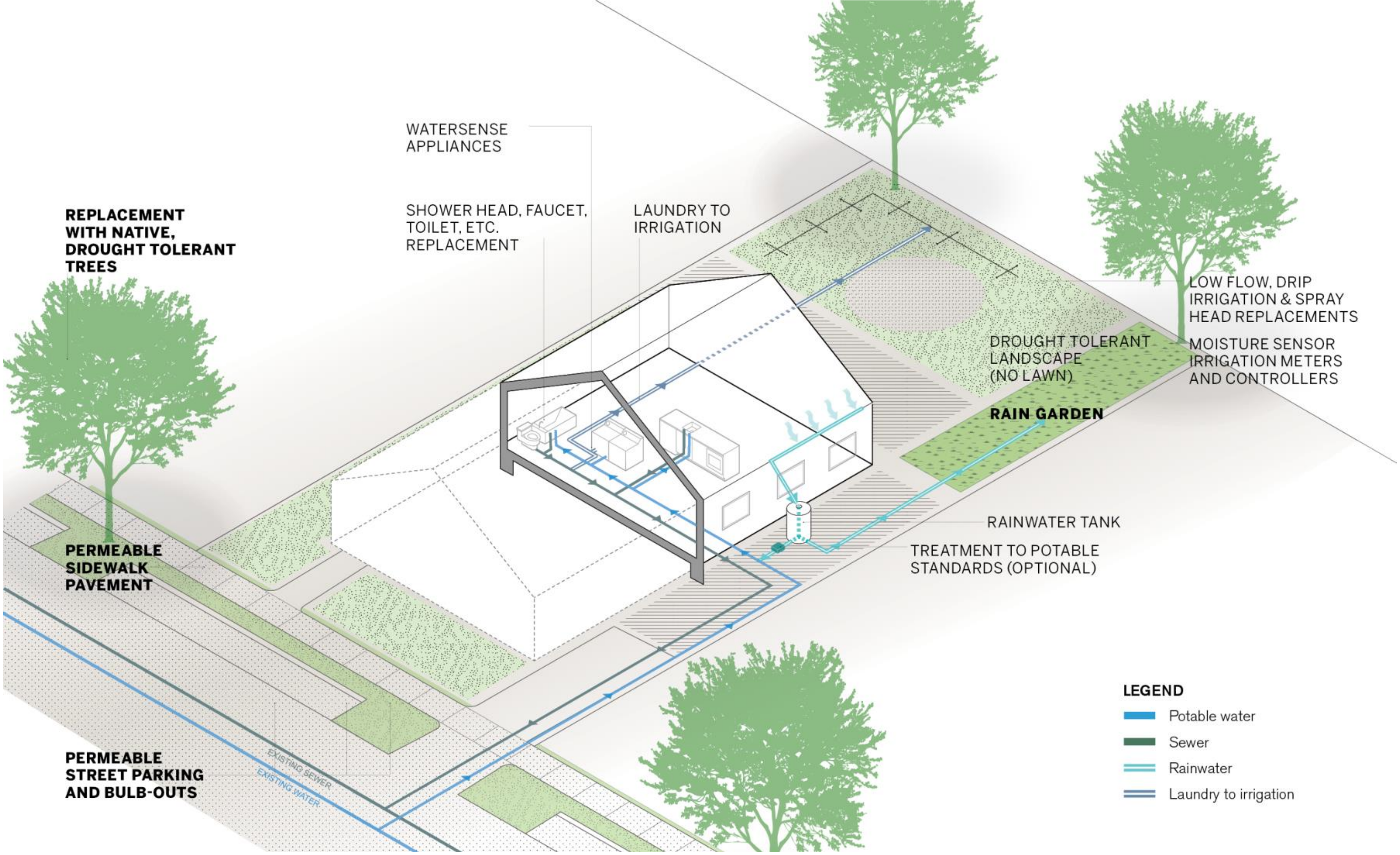
Based on the cost evaluations conducted by the Integrated Water Designs team, the cost of this system is prohibitive, not only because of the high cost of distribution piping and wastewater treatment, but also because of the low demand for non-potable water at the current EcoBlock scale. This could change in a neighborhood with high non-potable water demand or if it was legal to treat wastewater for potable use and there were appropriate measures to guarantee its water quality.

Water Bolt-on D: Green Infrastructure in ROW, at Neighborhood Scale

The Water Bolt-on D includes permeable parking and streets, biofiltration, significant increase in shade trees and shade tree irrigation from RWH (See illustrations of examples p. 154–167). Its implementation is dependent on such city-scale initiatives as stormwater permits, flood mitigation, and repaving bonds.

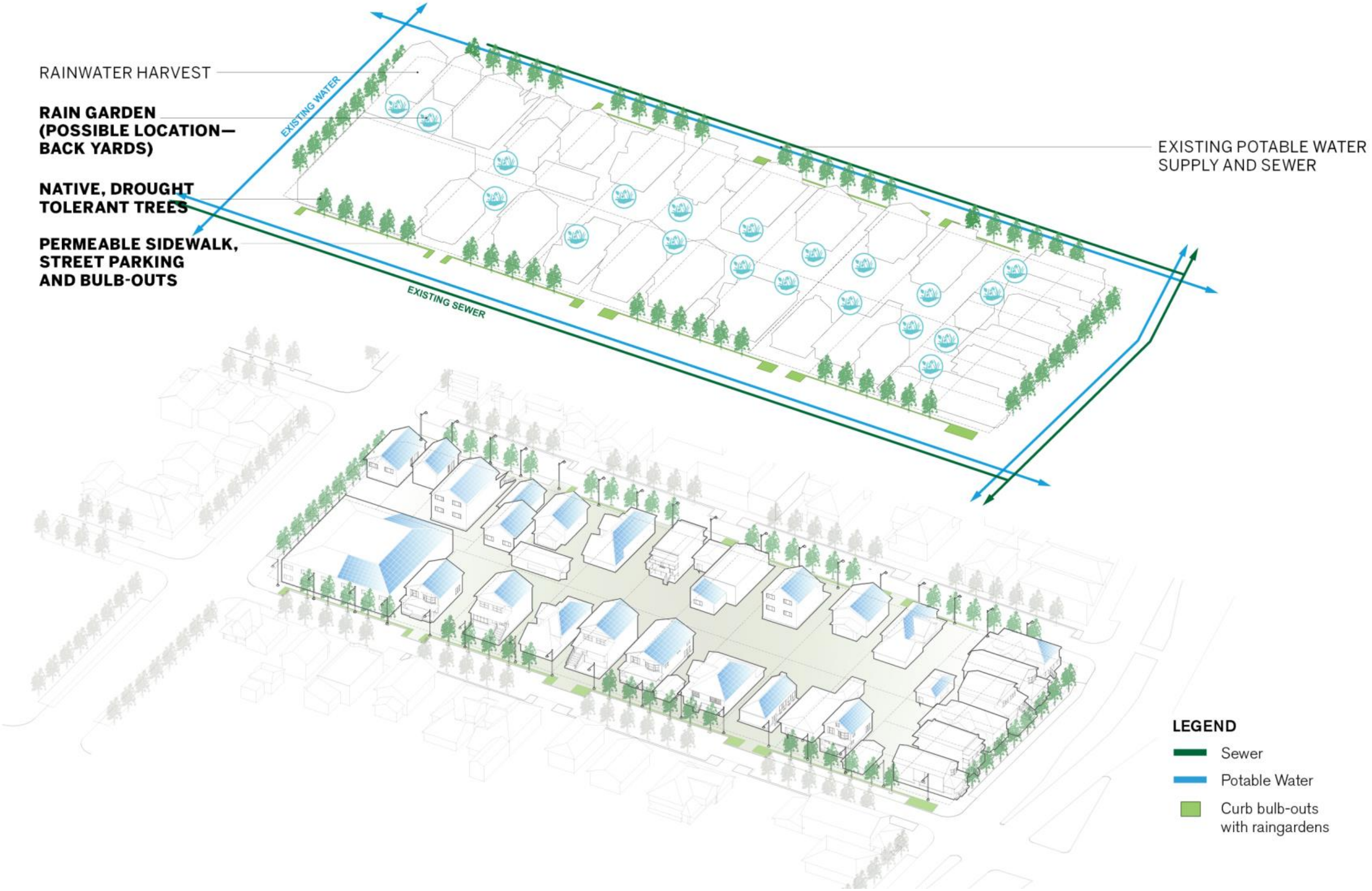
Figures 7-15 and 7-16 illustrate, on a house-scale and block-scale, respectively, the features of Water Bolt-on D. Table 7-9 outlines the elements in more detail.

Figure 7-15: Bolt-on D: Green Infrastructure in ROW – House Diagram



Bolt-on D: Green Infrastructure in ROW at Neighborhood Scale.
Credit: Skidmore, Owings & Merrill, LLP

Figure 7-16: Bolt-on D: Green Infrastructure in ROW – Block Diagram



Bolt-on D: Green Infrastructure in ROW at Neighborhood Scale.
Credit: Skidmore, Owings & Merrill, LLP

Table 7-9: Bolt-on D: Green Infrastructure in ROW – Water Description

		Categorical Description	BOLT-ON D
NARRATIVE	Type		**Bolt-On D: Green Infrastructure in ROW at Neighborhood Scale**
BK/FRNT YARD	W	**Native Landscaping**	Drought tolerant landscape (no lawn)
	W	**Efficient Irrigation Systems**	Low flow, drip irrigation & spray heads replacement
	W	**Enhanced Infiltration**	Rain gardens
	W	**Irrigation Controllers**	Moisture sensors, irrigation meters, controls
	W	**Rainwater Harvest**	Rainwater tank (rain barrel)
	W	**Groundwater Clean & Store for Irrigation**	Existing potable water source (no well)
RESIDENTIAL HOME RETROFIT	W	**Water Fixture Upgrades**	Shower head, faucet, toilet, etc. replacement
	W	Appliances	WaterSense new appliances
	W	**Greywater to Non-Potable Standards**	Laundry to irrigation
	W	**Rainwater to Potable Standards**	Rainwater treated to potable standards (rain to tap)
	W	**Wastewater to Potable Standards**	Existing wastewater system (toilets to sewer)
PVT			
	W	**Block-Scale Wastewater Treatment**	N/A
	W	**Block-Scale Management**	N/A
PUBLIC ROW			
	W	**Green Stormwater Infrastructure**	Permeable street parking & bulb-outs
	W	**Street Trees**	Addition/replacement with native, drought tolerant trees
	W	**Sidewalk Pavement**	Replacement with permeable pavement
	W	**Block-Scale, Non-Potable Water Distribution**	N/A
	W	**Utility Trenching**	Existing utility configuration w/ no trenching
🟨		**Social Outreach**	Independent utilities, shared community elements
🟥		**Permitting & Regulations**	Redev. authority for reconfiguring utilities & neighborhood
🟥		**Technology & Knowledge Transfer**	Scale to multi-block and statewide

KEY
HMS: Home Monitoring System
PV: Photovoltaic
HHW: Heating Hot Water
HPWH: Heat Pump Water Heater
PVT: Private
ROW: Right of Way
PG&E: Pacific Gas & Electric

Bolt-on D: Green Infrastructure in ROW at Neighborhood Scale.
Credit: Skidmore, Owings & Merrill, LLP

Evaluation

Bolt-on D is beyond the scope of the EcoBlock's financial capacity, but if other funding mechanisms (city or state) were available, it could be part of a more comprehensive system of groundwater recharge and reuse. For those areas of California with limited water supply and the challenges created by severe heat waves and the Urban Heat Island (UHI) effect, this comprehensive approach could be an excellent source of new water and irrigation for enhancing the shading of the streetscape; thus reducing the temperature of the local microclimate, with multiple health benefits.

Community-Scale Zero Net Energy Retrofit Master Plan

The Community-Scale Zero Net Energy (ZNE) Retrofit Master Plan is a synthesis of: **Energy Scenario 3e – Option B,** with the selective application of **Energy Efficiency Retrofits, Scenario 1**, refined by estimates acquired from the detailed energy audit in Phase 2, and the application of **Water Scenario 1w – Core Project** with the potential of additional "bolt-ons."

The components and systems are summarized as follows:

Electric Scenario 3e – Option B

This scenario will provide homes with a community PV system that will be tied to a block-scale DC microgrid containing a shared flywheel storage system and shared EV chargers. Each home will have a DC/AC inverter, connected from the DC microgrid to the existing AC load center and a separate DC circuit to new DC appliances, as available on a selective basis. This scenario will be sized for approximately 50 percent of metered units (i.e., 25 out of 64).

Energy-Efficiency Retrofits, Scenario 1

1. Air sealing improvement of 25 percent
2. Upgrade the cavity wall to the maximum possible
3. Upgrade the existing attic or roof to a minimum of R30
4. Convert to a high efficiency heat pump water heater, delivering domestic hot water (DHW) and heating hot water (HHW)
5. Replace the furnace with a new hydronic fan coil furnace
6. Seal ducts
7. Convert lighting to light-emitting diode (LED) lamps and fixtures as possible
8. Install a web-connected smart thermostat and home monitoring system
9. Install a smart ventilation system to Title 24 standards
10. Install new ENERGY STAR appliances on a selective basis

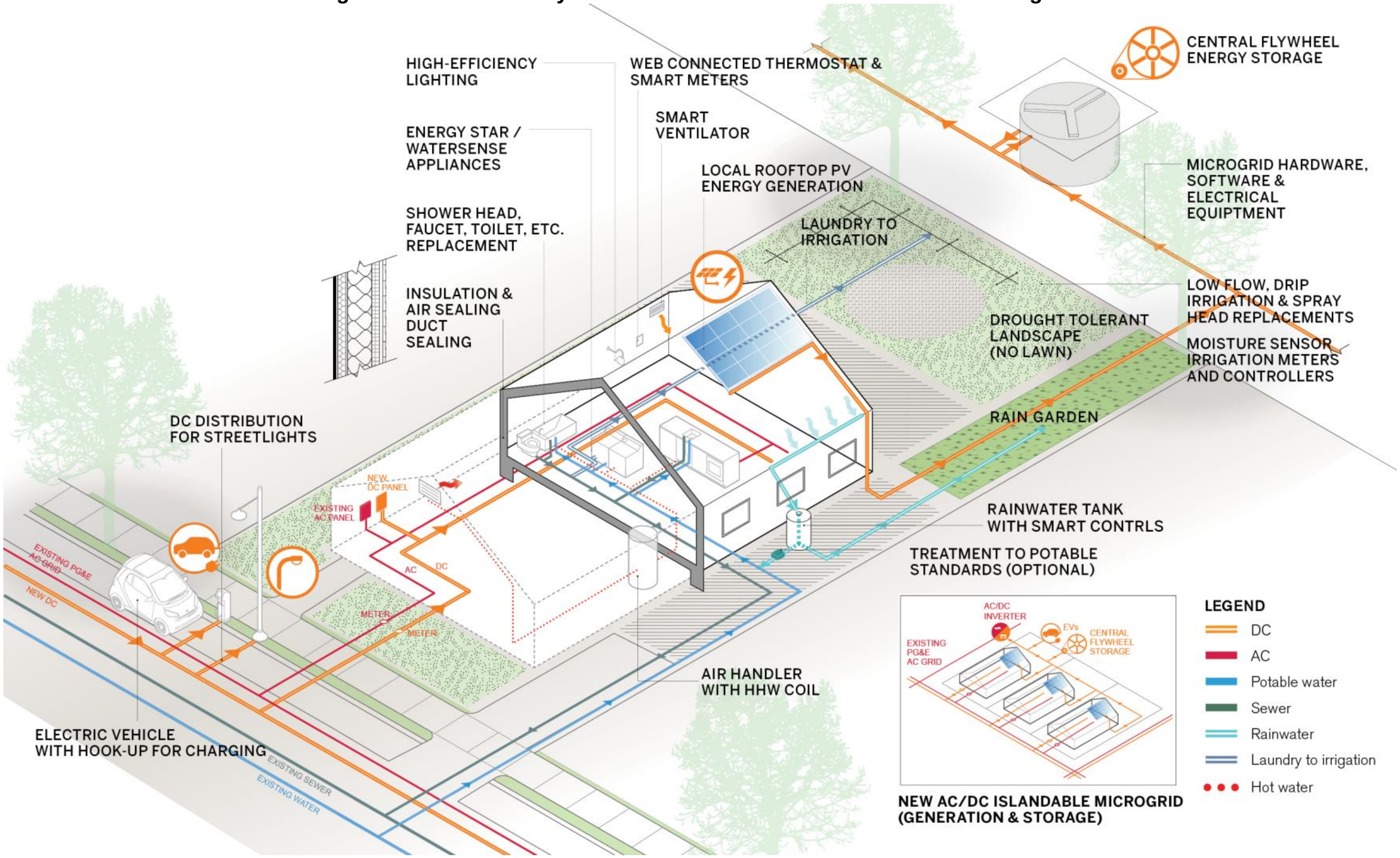
Water Scenario 1w – Core Project

1. Water-efficient fixture retrofits within homes (to be installed in coordination with the proposed deep energy retrofits) to include toilets, kitchen and bath faucets, and showerheads, on as-needed basis.
2. Private rainwater harvesting for irrigation (with treatment and testing can be used for potable)

3. Private “Laundry to Landscape” grey water diversion for irrigation
4. Native planting and efficient irrigation systems are recommended within private properties (yards), but at the homeowner’s choice and expense.

Figures 7-17 and 7-18 illustrate, on a house-scale and block-scale, respectively, the features of the Community-Scale ZNE Retrofit Master Plan. Table 7-10 outlines the elements in more detail.

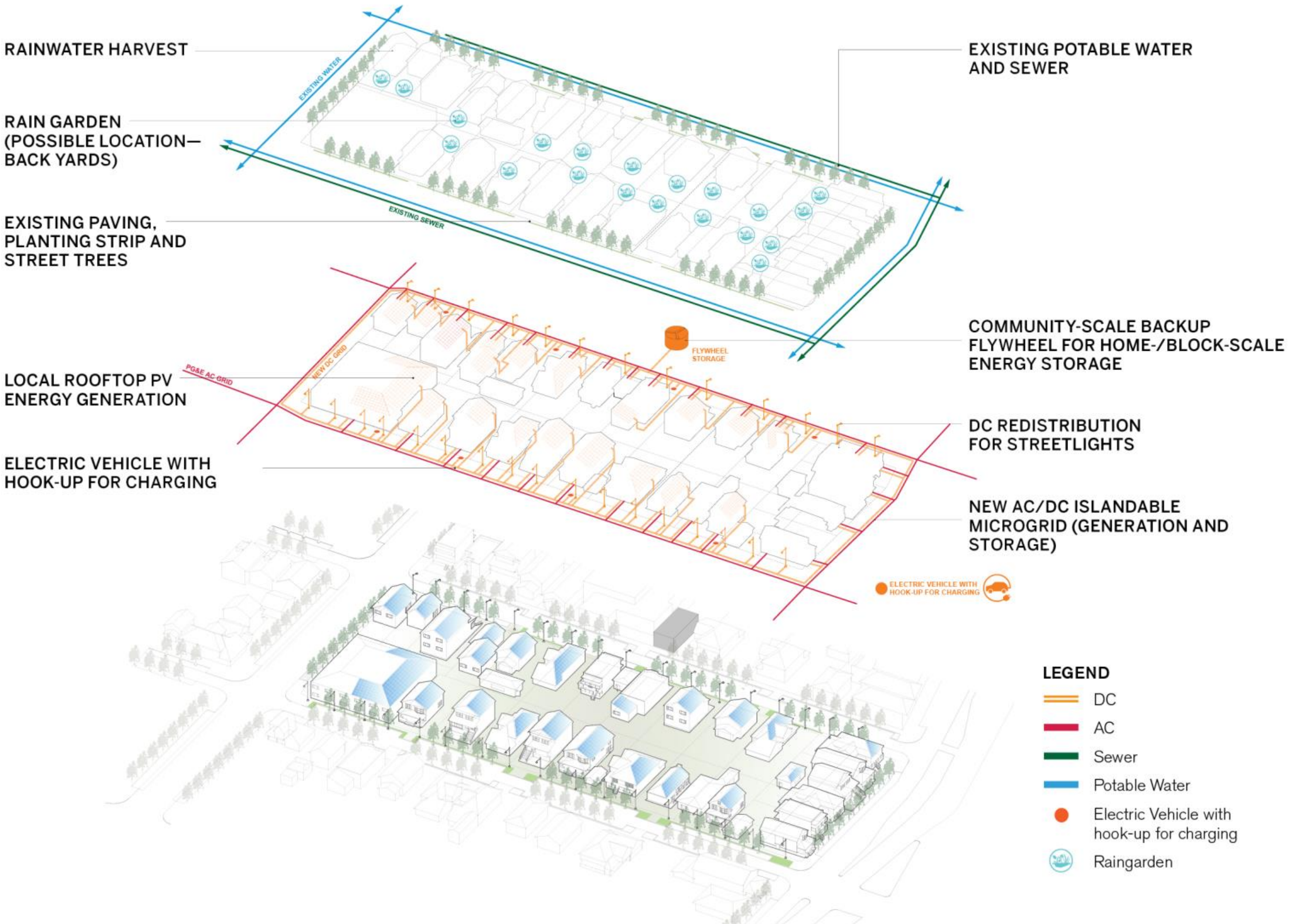
Figure 7-17: Community-Scale ZNE Retrofit Master Plan – House Diagram



DC Solar/Storage/Electric Vehicle Microgrid with Energy Efficiency Retrofits and AC/DC Houses. Water Efficiency and Rainwater Capture and Use at House Scale.

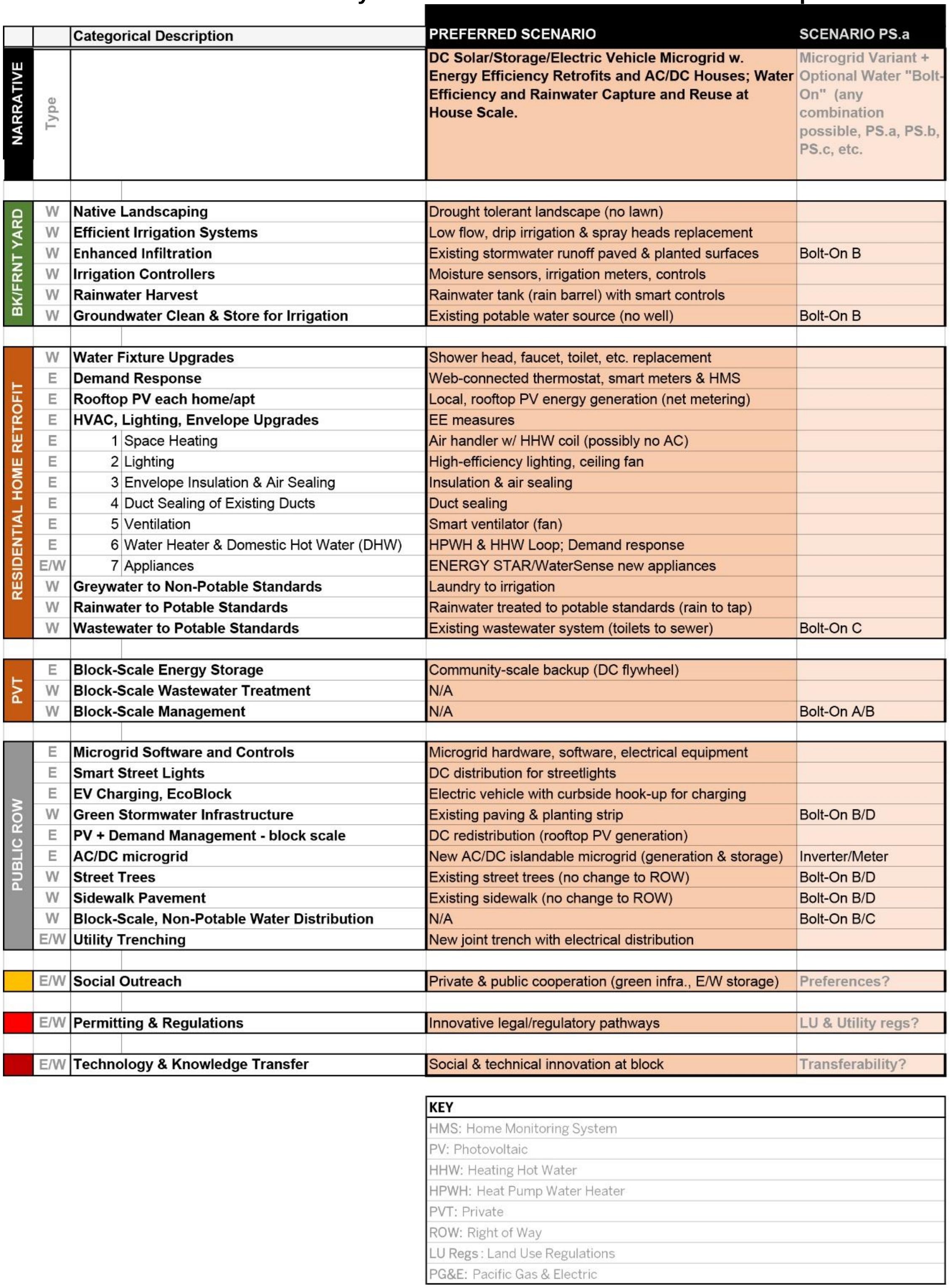
Credit: Skidmore, Owings & Merrill, LLP

Figure 7-18: Community-Scale ZNE Retrofit Master Plan – Block Diagram



DC Solar/Storage/Electric Vehicle Microgrid with Energy Efficiency Retrofits and AC/DC Houses. Water Efficiency and Rainwater Capture and Use at House Scale.
Credit: Skidmore, Owings & Merrill, LLP

Table 7-10: Community-Scale ZNE Retrofit Master Plan – Description



		Categorical Description	PREFERRED SCENARIO	SCENARIO PS.a
NARRATIVE	Type		**DC Solar/Storage/Electric Vehicle Microgrid w. Energy Efficiency Retrofits and AC/DC Houses; Water Efficiency and Rainwater Capture and Reuse at House Scale.**	Microgrid Variant + Optional Water "Bolt-On" (any combination possible, PS.a, PS.b, PS.c, etc.
BK/FRNT YARD	W	**Native Landscaping**	Drought tolerant landscape (no lawn)	
	W	**Efficient Irrigation Systems**	Low flow, drip irrigation & spray heads replacement	
	W	**Enhanced Infiltration**	Existing stormwater runoff paved & planted surfaces	Bolt-On B
	W	**Irrigation Controllers**	Moisture sensors, irrigation meters, controls	
	W	**Rainwater Harvest**	Rainwater tank (rain barrel) with smart controls	
	W	**Groundwater Clean & Store for Irrigation**	Existing potable water source (no well)	Bolt-On B
RESIDENTIAL HOME RETROFIT	W	**Water Fixture Upgrades**	Shower head, faucet, toilet, etc. replacement	
	E	**Demand Response**	Web-connected thermostat, smart meters & HMS	
	E	**Rooftop PV each home/apt**	Local, rooftop PV energy generation (net metering)	
	E	**HVAC, Lighting, Envelope Upgrades**	EE measures	
	E	1 Space Heating	Air handler w/ HHW coil (possibly no AC)	
	E	2 Lighting	High-efficiency lighting, ceiling fan	
	E	3 Envelope Insulation & Air Sealing	Insulation & air sealing	
	E	4 Duct Sealing of Existing Ducts	Duct sealing	
	E	5 Ventilation	Smart ventilator (fan)	
	E	6 Water Heater & Domestic Hot Water (DHW)	HPWH & HHW Loop; Demand response	
	E/W	7 Appliances	ENERGY STAR/WaterSense new appliances	
	W	**Greywater to Non-Potable Standards**	Laundry to irrigation	
	W	**Rainwater to Potable Standards**	Rainwater treated to potable standards (rain to tap)	
	W	**Wastewater to Potable Standards**	Existing wastewater system (toilets to sewer)	Bolt-On C
PVT	E	**Block-Scale Energy Storage**	Community-scale backup (DC flywheel)	
	W	**Block-Scale Wastewater Treatment**	N/A	
	W	**Block-Scale Management**	N/A	Bolt-On A/B
PUBLIC ROW	E	**Microgrid Software and Controls**	Microgrid hardware, software, electrical equipment	
	E	**Smart Street Lights**	DC distribution for streetlights	
	E	**EV Charging, EcoBlock**	Electric vehicle with curbside hook-up for charging	
	W	**Green Stormwater Infrastructure**	Existing paving & planting strip	Bolt-On B/D
	E	**PV + Demand Management - block scale**	DC redistribution (rooftop PV generation)	
	E	**AC/DC microgrid**	New AC/DC islandable microgrid (generation & storage)	Inverter/Meter
	W	**Street Trees**	Existing street trees (no change to ROW)	Bolt-On B/D
	W	**Sidewalk Pavement**	Existing sidewalk (no change to ROW)	Bolt-On B/D
	W	**Block-Scale, Non-Potable Water Distribution**	N/A	Bolt-On B/C
	E/W	**Utility Trenching**	New joint trench with electrical distribution	
🟨	E/W	**Social Outreach**	Private & public cooperation (green infra., E/W storage)	Preferences?
🟥	E/W	**Permitting & Regulations**	Innovative legal/regulatory pathways	LU & Utility regs?
🟥	E/W	**Technology & Knowledge Transfer**	Social & technical innovation at block	Transferability?

KEY
HMS: Home Monitoring System
PV: Photovoltaic
HHW: Heating Hot Water
HPWH: Heat Pump Water Heater
PVT: Private
ROW: Right of Way
LU Regs: Land Use Regulations
PG&E: Pacific Gas & Electric

DC Solar/Storage/Electric Vehicle Microgrid with Energy Efficiency Retrofits and AC/DC Houses. Water Efficiency and Rainwater Capture and Use at House Scale.

Credit: Skidmore, Owings & Merrill, LLP

Evaluation

1. **Technical Issues:** None. All components and systems are available, although vacuum flywheel storage is new to market and DC smart grid and controls are custom designed for the pilot project. System integration is a pilot application.
2. **Regulatory and Permitting Issues:** Energy and water efficiency measures can be permitted with existing planning or permitting procedures. Rainwater to potable water will require a conditional use permit and may require plumbing code changes. Microgrid infrastructure will most likely be designated an "Extensive Impact Civic Activity" and require a Major Conditional Use Permit. A new "Demonstration Ordinance" may facilitate the whole permitting process.
3. **Legal/Governance Issues:** The pilot project will be governed by an EcoBlock Trust to manage and ensure owner participation in the PACE and CFD financing agreements.
4. **Business Model:** A P3 with a third-party builder/operator. It will be financed by a layering of models: PACE is used to finance energy and water efficiencies in the homes, and a CFD is used to finance the microgrid—both with property tax assessments as payment, all governed by an EcoBlock Trust.
5. **Ratepayer Benefits:** Ratepayers will be charged through property tax assessments that will be the same as (or lower) than their utility bill savings. The renewable energy supply shields homeowners from utility energy price increases. Ratepayers benefit from the project's resilience, as it is able to operate if the electric grid goes down.
6. **Homeowner Acceptance:** Project outreach indicates high interest in homeowner participation (at least 50 percent), but actual participation will be determined in Phase 2
7. **Social Issues:** The project uses savings in utility costs to fund major homeowner improvements, a form of shared prosperity, but protections will have to be structured into the EcoBlock Trust to protect against individuals selling out.
8. **Utility Benefits:** The provision of storage changes the load profile of the block to make it much more favorable to the utility. The EcoBlock is a potential new business model for the utility to upgrade its infrastructure.
9. **Resilience:** Provides significant block-scale resilience, if PG&E grid goes down. The block could operate on its own, indefinitely.
10. **Technical Advance:** This would be a major advance—the first DC Solar/Storage/EV microgrid at residential block scale. System integration and controls are a major contribution.

For a more detailed discussion of project benefits, see Chapter 10: Evaluation of Project Benefits.

Community-Scale Energy Assessment

The essence of the EcoBlock concept is its community-scale energy assessment. It maximizes the energy saved from the energy efficiency retrofits (within reasonable cost constraints) to provide extra renewable solar supply (energy plus) from the PV microgrid to charge EVs and to fuel the switch from gas to electric heating and hot water. The value of the EV charging is a game changer in that it provides additional savings to the homeowner, the cash flow from which pays for the new DC/Storage/EV microgrid. The project is close to zero CO_2 emissions because of the fuel switching.

Phase 2 Roadmap

This section provides an outline of the activities necessary to implement the project at the Oakland EcoBlock, should Phase 2 be approved.

Design, Development, and Permitting

Obtain Agreements with the Selected Deployment Site

The goals are to: (1) confirm the availability of the project demonstration site, and (2) execute any agreements necessary to secure the demonstration site and the terms of involvement by homeowners.

- Recruit households from the Oakland EcoBlock site to participate in the microgrid demonstration project. Reach agreement with the residents and owners of the selected households regarding their participation in the project and factors such as project timeline, space reserved for the project, equipment installation, permit and insurance requirements, indemnity, and the homeowner's use of any removal or support staff. Secure similar agreements with any commercial properties involved in the microgrid demonstration.
- Prepare and provide a Site Readiness Verification document, such as a contract or memorandum of understanding.

Microgrid Electrical Design

The goal is to conduct all design, engineering, and planning activities necessary to finalize the EcoBlock microgrid system design and prepare for construction. All design activities will start from the EcoBlock Phase 1 schematic design.

- Conduct appropriate site surveys for microgrid design (e.g., trenching, utilities).
- Confirm sufficiency of building structures to support PV arrays and condition or residential roofs.
- Design and engineer the PV systems on the selected buildings (sizing, siting).
- Design and engineer the flywheel energy storage system (sizing, siting).
- Design and engineer the EV charging stations (siting, interconnection).
- Design and engineer the microgrid power conversion and protection equipment (DC hub, storage controller, DC/DC converters, residential inverters).
- Design and engineer the utility grid intertie (bidirectional converter and medium-voltage transformer), including hardware required for island operation.
- Integrate engineering designs into an Microgrid Engineering Plan Set (50 percent, 90 percent, and 100 percent iterations) for the full system, including all microgrid components exterior to the residential buildings (including the residential breaker panels).
- Develop Engineering Specifications (50 percent, 90 percent, and 100 percent iterations).
- Develop Engineering Cost Estimates (50 percent, 90 percent, and 100 percent iterations).
- Complete a Design and Engineering Memo that describes the design objective and design process and refers to the complete set of design documents.
- Participate in Critical Project Review (CPR) meetings.

- Prepare a CPR report for each CPR meeting.

Products:

- Microgrid Engineering Plan Set (50 percent, 90 percent, and 100 percent iterations)
- Microgrid Engineering Specifications (50 percent, 90 percent, and 100 percent iterations)
- Microgrid Engineering Cost Estimates (50 percent, 90 percent, and 100 percent iterations)
- Microgrid Design and Engineering Memo
- CPR Report

Residential Energy Retrofit Design and Planning

The goals are to: (1) develop the deep energy retrofits from conceptual design to construction documents ready for permit submittal, and (2) select a general contractor to implement the energy retrofits.

- Conduct on-site audits of participating homes and refine the residential energy modeling conducted in EcoBlock Phase 1.
- Update the EcoBlock Deep Energy Efficiency Retrofit Plan and Specifications to reflect the detailed audits and modeling. Identify a package of efficiency upgrades for deep energy savings that address space conditioning (heating and cooling), lighting, appliances, miscellaneous electrical plug loads, and water heating energy end uses. Identified energy efficiency retrofits will be designed such that the indoor environmental conditions (indoor air, lighting, urban noise, and thermal comfort quality) of each building are maintained or improved per any applicable California Building Code.
- Conduct engagement with selected households to confirm participation and scope of work for homeowners opting in to deep energy retrofits.
- Identify energy efficiency incentives that can be used to defray the cost of measures in the deep energy retrofit package.
- Develop Energy Retrofit Construction Documents and Specifications for each home retrofit adequate for permit submission for home retrofits. Specifications documents will inform product selection and installation to meet resource conservation, as well as occupant health and comfort.
- Conduct an analysis to align the budget and available funding with the scope of work for all homes that opted to participate in the microgrid.
- Complete the scope of work for the residential contractor and conduct contract negotiations with qualified contractors experienced in deep energy retrofits and zero net energy construction.
- Select Design-Build Contractor for home retrofits and document the results in a Residential Contractor Selection Memo.
- Develop a permit-submission information packet.

Products:

- Deep Energy Efficiency Retrofit Plan and Specifications
- Energy Retrofit Construction Documents and Specifications

- Residential Contractor Selection Memo

Microgrid Control System Design, Development, and Testing

The goals are to design and engineer the information technology, communications, and controls systems needed to operate the microgrid system.

- Confirm the requirements and architecture for a microgrid control system, and document them in a Microgrid Control System Design Report.
- Develop a Microgrid Control System Test Plan to document scenarios for testing control system and communications infrastructure functionality, including islanding scenarios.
- Design and develop control algorithms, including a supervisory control layer for economic power balancing and a voltage control layer for reliability.
- Design and develop forecasting algorithms, including load forecasting, solar generation forecasting, and EV charging load forecasting.
- Design and develop information communication technology infrastructure, including a centralized database, communication and control between assets, and user interfaces.
- Design and develop a user interface for (1) centralized monitoring and management by an electricity system operator and (2) monitoring for individual residences.
- Test the microgrid control system according to the Microgrid Control System Test Plan. Document the results in a Microgrid Control System Testing Report.

Products:

- Microgrid Control System Design Report
- Microgrid Control System Test Plan
- Microgrid Control System Testing Report

System Permitting and Interconnection

The goal is to secure the required permits, execute an interconnection agreement with Pacific Gas and Electric (PG&E) for the distributed energy system, and establish the proper tariff.

- Obtain the required electrical and/or building permits from the City of Oakland, for both the microgrid and the residential energy retrofits.
- Work with PG&E to facilitate system interconnection.
- Execute an interconnection agreement with PG&E.
- Schedule and execute PG&E inspections and testing as necessary.
- Document the results of the permit process in System Permitting Memo.

Products:

- System Permitting Memo

Project Measurement and Verification

The goal is to develop a Measurement and Verification Plan for the demonstration project.

- Develop a detailed Measurement and Verification Plan to include:
  - A description of the monitoring equipment and instrumentation that will be used.
  - A description of the key input parameters and output metrics that will be measured.
  - Identification of required data acquisition criteria, such as sampling frequency for various parameters.
  - A description of the analysis methods to be employed. Analysis methods will allow for measurement of all performance criteria.
  - Identification of additional information that will be necessary to complete the measurement and verification task (e.g., costs for implementing conventional individual-house DER).
  - Identification of system operating modes and/or procedures to enable comparison of the microgrid system with a conventional individual-house solar and stand-alone battery system. Operating modes will include islanded mode (where the microgrid is disconnected from the local utility grid) and demand-response mode (where the microgrid provides services, such as load shed or load shift, to the utility grid).
- Install any required baseline data collection equipment and software.

Products:

- Measurement and Verification Plan

Construction and Commissioning

The goal is to procure the required equipment and materials, and complete installation and commissioning of the advanced microgrid system and the home energy retrofits.

Microgrid Construction

The goal is to procure equipment and materials, and complete construction of the microgrid components needed to generate, store, and distribute power.

- Construct and install the following, according to the design from the tasks above:
  - Rooftop solar arrays
  - Energy storage system
  - Power distribution system (including power converters, protection equipment, distribution wiring, power meters, and communication infrastructure)
  - EV charging stations
  - Grid interconnection (bidirectional converter, medium voltage transformer)
  - Microgrid controller
  - Any additional instrumentation identified in the measurement and verification plan
- Prepare a Microgrid Construction Memo to document the substantial completion of the microgrid construction phase.

Products:

- Microgrid Construction Memo

Residential Retrofit Construction

The goal is to procure equipment and materials, and implement the energy efficiency retrofits in the selected homes.

- Retrofit and install the following, according to the designs and specifications described in Phase 1:
    - Heat pump water heaters for combined space and water heating
    - Ceiling, wall, and floor insulation
    - Duct sealing
    - Thermal envelope sealing
    - Efficient ventilation fans
    - Efficient appliances (where selected)
    - Efficient LED lighting
    - Home gateway for communication with the microgrid
    - Any additional instrumentation identified in the M&V plan
- Prepare a Residential Retrofit Construction Memo to document the substantial completion of the home retrofit construction.

Products:

- Residential Retrofit Construction Memo

System Commissioning and Interconnection

The goal is to verify the proper operation of the newly installed microgrid and home energy systems, particularly the control systems, and put the systems into operation.

- Develop an EcoBlock System Commissioning Plan.
- Implement the plan to verify the proper operation of the system components and the overall microgrid system.
- Prepare an EcoBlock System Commissioning Report.
- Complete the interconnection of the microgrid with the utility distribution grid.
- Connect the homes to the microgrid distribution system.
- Prepare a CPR Report in accordance with the CPR meetings.
- Participate in a CPR meeting.

Products:

- EcoBlock System Commissioning Plan
- EcoBlock System Commissioning Report
- CPR Report

Measurement, Verification, and Proving the Business Case

The goals are to operate the microgrid for a full year under varying conditions, measure and document its performance, and use the lessons learned from constructing and operating the microgrid to refine the business case for future scale-up of EcoBlock microgrids.

Operate and Evaluate the Microgrid

The goal is to operate the microgrid, assess its performance, determine its long-term effectiveness, and identify operational issues that may affect future EcoBlock installations.

- Operate and maintain the microgrid for one year after commissioning.
- Collect data specified in the measurement and verification plan.
- Publish anonymized data through the Open Data Online Portal.
- Perform islanding tests each quarter, preferably within two weeks of the solstices and equinoxes, as described in the measurement and verification plan.
- Perform demand response tests described in the measurement and verification plan.
- Assess performance and customer value of the EcoBlock microgrid system.
- Develop a Microgrid Operational Plan to guide operation of the microgrid for three years after the end of the EPIC project.
- Prepare a Microgrid System Performance Report to document assessment results.

Products:

- Baseline Data Collection
- Operational Data Collection
- Open Data Online Portal
- Microgrid Operational Plan
- Microgrid System Performance Report

Confirm the EcoBlock Business Case

The goal is to evaluate and refine the EcoBlock business model developed in Phase 1, using the experience and data collected during the design, construction, and operation of the Oakland EcoBlock microgrid. In addition, assess the replicability and scalability of the EcoBlock technical design and business model.

- Compile lessons learned from throughout the EcoBlock demonstration project phases.
- Refine the suite of financing, governance, and ownership structures developed in EcoBlock Phase 1 to facilitate and manage the EcoBlock investments.
- Conduct scalability analysis (verify Phase 1 scalability analysis with empirical data).

Develop an EcoBlock Business Case Report.

Products:

- EcoBlock Business Case Report

Rough Order of Magnitude Cost Estimate

- The rough order of magnitude (ROM) cost estimate for the ZNE Master Plan is presented in detail in Chapter 10: Evaluation of Project Benefits, under the heading of “Mature Market Cost Estimates.” A detailed breakdown of the pilot project costs is presented in Appendix E.

CHAPTER 8:
Evaluation of Project Benefits

Abstract

This chapter explains the process of evaluating EcoBlock project benefits. It is a complex process because it involves many evaluation criteria; a number of scenarios and different performance estimates for each; and a complex interaction of legal, regulatory, governance, and business models. In addition, for the Oakland EcoBlock, it involved the challenges associated with the project being both a pilot project and a retrofit. This chapter proposes an evaluation method based on using the estimated cash flow savings in utility bills as the means of financing the project. It demonstrates that this approach is promising enough to proceed with a Phase 2 pilot project. It further documents the multiple benefits associated with the project's implementation and how they fulfill the state's goals for DER deployment.

Introduction and General Discussion

The Oakland EcoBlock Team explored multiple scenarios for the project's integrated energy, water/wastewater, and transportation systems. Each scenario's performance was evaluated relative to its reduction in energy consumption, CO_2 emissions, and potable water consumption. Each was further evaluated on 10 criteria: (1) technical issues, (2) planning, zoning, and permitting issues, (3) legal/governance issues, (4) business models, (5) ratepayer benefits, (6) homeowner acceptance, (7) social issues, (8) utility benefits, (9) resilience, and (10) technical advancement (see Chapter 5). Choosing a preferred scenario to use to assess project benefits becomes complicated when assessing multiple scenarios, performance estimates for each, and 10 evaluation criteria, Questions of the optimum scale for deployment; how different urban contexts, climates, and loads influence system selection and integration; how the scenarios will be influenced by different responses to regulatory issues; and homeowner participation levels were all considered. Based on these evaluations, the project team decided to take an approach that recommends a preferred scenario—the ZNE Master Plan—but one that allows for optional add-ons or "bolt-ons." Whether the add-ons should be part of the pilot demonstration will be determined through discussions with the Energy Commission during Phase 2 of the project.

The evaluation of project benefits is further complicated by the fact that the EcoBlock is both a pilot project (i.e., first-time construction) and a retrofit project (i.e., many unknowns in existing homes). As a response, the team's preliminary cost estimates, by necessity, are extremely conservative. They assume the worst case in implementing the energy and water efficiency strategies (i.e., all walls and roofs will need new insulation and all toilets will need to be replaced), and they assume high-end material and labor costs for the alternate PV/DC distribution/storage/microgrids and the alternate water treatment and reuse systems. The estimates also built in multiple design and construction contingencies, as well as high-end escalation figures (even though some component costs will go down over time). In addition, the estimates have assumed a "Construction Manager" delivery system that adds an additional layer of overhead costs, which might be avoided with a third-party "design-build" contractor. Nonetheless, there is no question that the costs of building the first EcoBlock as a pilot/retrofit project will be more expensive than its costs when deployed at scale. This is why public subsidies are necessary to enable a real-world test of the project's feasibility. It is also why the preliminary cost estimates for the pilot project should not be used as an indicator of the project's long-term cost-effectiveness.

Cash Flow Savings from a ZNE Master Plan

An alternative approach to evaluating cost feasibility (and thus project benefits) is to start with the savings in utility costs generated by the preferred ZNE Master Plan. Using these savings as cash flow, it is possible to estimate how much funding would be available for construction, operation, and maintenance of the EcoBlock systems, and thus to see if they have the potential to be deployed within the cash flow capacity. Such an estimate for a typical average house participating in the EcoBlock yields the potential annual cash flow range (in round numbers) in Table 8-1.

Table 8-1: Annual Potential Cash Flow Savings per Household from a ZNE Master Plan

	Low ($/year)	High ($/year)
Electricity and Natural Gas*	1,300	1,700
Water savings (50% reduction)	400	500
Gasoline savings*	1,000	1,200
Value of CO_2 reductions (6.6 tons @ $30/ton)	200	200
Total	2,900	3,600

*Utility and gasoline savings are based on integrated energy systems modeling from chapters 2 and 3.

Source: UC Berkeley

Using the range of annual savings from Table 8-1, and assuming a 20- to 30-year life of the systems (many major components will last longer), the discounted lifetime cash flow could yield as much as $45,000 to $80,000 per household, on average, for capital improvements to build the EcoBlock systems. The value of this discounted cash-flow savings will depend on many factors, such as the discount rate, O&M costs, and escalation in utility costs. For purposes of this calculation, the values above assume no O&M costs and no escalation of utility rates.

Mature Market Cost Estimates for a ZNE Master Plan

Fortunately, many of the systems and components proposed for the EcoBlock have a market history of cost-effectiveness that make it possible to assess the potential for the cash flow savings to fund the EcoBlock. The cost and performance of the energy- and water-efficiency strategies are well understood. The unknown lies in how extensively they will have to be deployed, given the variable conditions of the homes. The cost and performance of the PV systems and their components are also well understood, and their installed cost curve is projected to continue to fall below the current cost of $1 per installed watt. The unknown with PV is how much improvement in the roofs will be necessary to install the arrays. The cost of EV charging also has an early market history. The cost of storage (flywheel) does not have a market history, but it is commercially available with projected costs. The remaining unknowns are: (1) the cost of the AC or DC microgrid collection, distribution, and controls, which will vary widely depending on who installs, owns, and operates the system, (2) the rainwater harvesting for potable use, and (3) the two water supply scenario "bolt-ons"—Bolt-on B: Groundwater for Irrigation at Neighborhood Scale, and Bolt-on C: Sewer Mining—Reclamation for Irrigation for Non-Potable —both of which are highly dependent on their water utility context and water demand for NP.

The average cost estimates per house for deployment at scale are shown in Table 8-2. These estimates assume that the most cost-effective, least disruptive energy- and water-efficiency strategies are chosen, using mature market cost estimates and adjusting for the extent of retrofits in each home to an average of 50 percent.

Table 8-2: Average Cost Estimates per House for Deployment at Scale

	Per House ($)	Block (25)
Energy Efficiency Retrofits		
Insulation – External blow-in insulation, assume 50% of area	6,000	
Air Sealing	2,000	
LED lighting switch out	1,500	
Smart Ventilation – Exhaust only, smart control	1,000	
Energy Efficient Appliances	4,000	
Fuel Switching – New Heat Pump DHW with new HW coil in furnace	9,000	
Total Energy Efficiency Retrofits	23,500	587,500
Microgrid		
PV Collectors – 215 KW at $1.50 per watt installed	13,000	
Roof upgrade, assume 50% of area	6,000	
Storage – 480 kWh @ $300/kWh + installation	7,000	
EV Charging – Assume 24 charging stations @ $4,000 ea.	3,800	
DC Microgrid Collection / Distribution / Controls	10,000	

Total Microgrid	39,800	995,000
Water Efficiency Retrofits		
Toilets – 2 @ $350	700	
Kitchen Faucet	200	
Bath Faucet	200	
Showerheads – 2 @ 500	1,000	
Total Water Efficiency Retrofits	2,100	72,500
Rainwater Harvesting + Potable Reuse	6,000	150,000
Total Mature Market ZNE Master Plan	**71,400**	**1,805,000**

Source: UC Berkeley

The mature market cost estimates at scale (approximately $70,000 per house) show that funding the EcoBlock with the discounted cash flow from the operational savings ($45,000 to $80,000) provided from the energy and water utility savings and the reduction in travel costs from the EV charging is sufficiently promising to recommend building the ZNE Master Plan as a pilot project.

Project Benefits

General Benefits

- The most important societal benefit of the EcoBlock is that it uses the cash flow savings from utility bills and gasoline to fund the energy and water system upgrades for middle- to low-income homeowners who could otherwise not afford them. This opens up a sector of the existing housing stock for significant reductions in energy consumption and carbon emissions (see below) that previously was unavailable.
- The savings also fund the conversion to a locally distributed renewable energy supply with built-in storage that balances the load profile of the neighborhood for the utility and allows for significant resilience.
- The conversion to renewables decouples the neighborhood from increases in utility bills caused by fluctuations in fuel prices and thus makes the cost of utilities predictable over the 30-year life of the systems.
- The energy savings from the energy efficiency retrofits creates enough capacity in the rooftop renewable PV supply and storage to charge EVs for the equivalent of 25 percent of VMTs, and has the capacity to do more. This is a “game changer” because the cost savings in the household transportation budget help to pay for the cost of all the systems. Furthermore, the reduction in gasoline-fueled VMTs is an important additional reduction in energy consumption and carbon emissions previously unavailable.
- The renewable supply has enough capacity to allow fuel switching from gas domestic hot water and home heating to an electric heat pump; and, because the supply is renewable (not from the utility grid), the change results in zero CO_2 emissions for the heating and hot water loads.

Technological Advancement and Breakthroughs:[38] The project will lead to technological advancement and breakthroughs that overcome barriers to the State of California's statutory energy goals by using a holistic process to block-scale retrofit residential and mixed-use neighborhoods. The Oakland EcoBlock (1) undertakes deep efficiency and electrification retrofits in buildings, and (2) harnesses local renewable resources to significantly reduce the households' energy and transportation footprint. The EcoBlock's microgrid provides a unique, large deployment opportunity for a resilient microgrid that uses commercially available technologies. The EcoBlock microgrid demonstration includes five DERs applied in the California loading order:

- DER 1: energy efficiency retrofits and electrification of major home equipment
- DER 2: controllable/deferrable loads for demand response
- DER 3: electrification of transportation using EVs
- DER 4: serving remaining load with a DC microgrid system powered by communal rooftop PV
- DER 5: a central energy storage system

Besides facilitating DER deployment, the Oakland EcoBlock offers a suite of solutions that directly addresses SB 350 implementation. The California Energy Commission recently adopted targets to achieve the doubling of energy efficiency savings in electric and natural gas uses by 2030 as required by SB 350. Much of the untapped energy efficiency potential to meet the targets can be achieved by improving the energy efficiency of existing buildings, as well as appliances and other devices used in those buildings, as laid out in the Energy Commission's *Existing Building Energy Efficiency Action Plan.* The EcoBlock project proposal specifically addresses the untapped energy efficiency potential in homes by (1) driving energy efficiencies in the existing residential stock through deep energy efficiency retrofits implemented across entire blocks of homes, (2) substituting high-efficiency electric appliances (e.g., heat pump water heating and space heating) for gas-fired end-use appliances, and (3) replacing old, inefficient electrical appliances with high-efficiency units.

Impacts and Benefits to California Ratepayers

The proposed project will benefit California Investor-Owned Utility (IOU) electricity ratepayers with respect to the EPIC goals through greater reliability, lower costs, and increased safety.

Greater Reliability: Reduced electricity consumption and peak demand reduction, achieved by the deep energy retrofits, local storage, and the microgrid controller scheme proposed in this project, will avoid reliance on least-reliable generation sources at the margin. In addition, the microgrid's ability to operate independently ("island") of the

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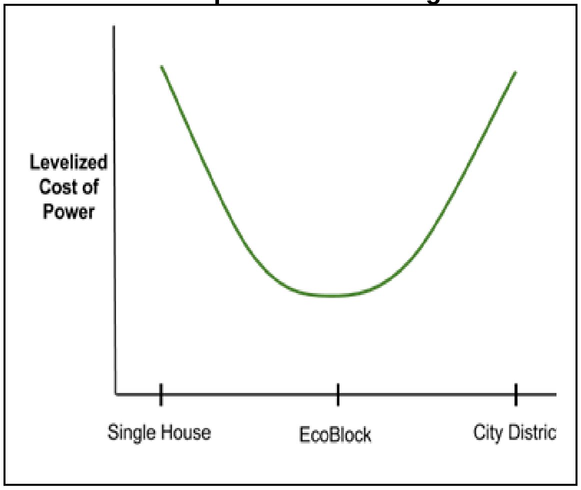
[38] California Public Resources Code, Section 25711.5(a) also requires EPIC-funded projects to lead to technological advancement and breakthroughs to overcome barriers that prevent the achievement of the state's statutory and energy goals.

PG&E grid in case of emergency or natural catastrophe will protect consumers from grid outages, thanks to the robustness its own DC grid reliability.

Lower Costs: By aggregating the required design, permitting, financing, and construction work across a block of homes, the EcoBlock concept reduces transaction costs, overcomes information barriers, and allows access to lower-cost financing mechanisms that are not available to individual building owners. Moreover, aggregating and collectively controlling the electrical load of an entire block allows the cost-effective construction of a microgrid with shared DERs that further lowers capital costs and improves operational efficiency. Overall, thanks to the economies of scale that its collective approach allows, the EcoBlock leads to lower utility bills and other benefits that translate into lower costs for ratepayers, as shown in Figure 8-1.

Figure 8-1: Relationship Between Microgrid Size and Cost



Source: UC Berkeley

Increased Safety: Consumers are safer when more appliances can be switched to locally generated power during grid outages. More important, the microgrid's islanding capabilities enable consumers to gain access to critical electrical end uses (like heating, hot water, lighting, and refrigeration) during outages and potential catastrophic events. Finally, the conversion of end-uses to electricity avoids the dangers of natural gas in the home, including fires, explosions, and combustion products in indoor air.

Quantitative Estimates of Potential Benefits

Table 8-3 shows our quantitative estimates of potential benefits to ratepayers for the funded project scope (assuming 40 percent of housing units in the block participate in the project). The table shows electricity savings, cost savings, and demand and emissions reductions through the different phases of implementation: from the current baseline to the energy efficiency and electrification measures in the homes, adding the EcoBlock's microgrid (which includes rooftop solar PV and energy storage [ES]) and using the excess solar-generated power to charge EVs.

Table 8-3: Oakland EcoBlock Quantitative Benefits Estimates, Preferred Scenario

	Energy Savings (MBtu/year)	Cost Savings ($1,000/year)	Demand Reduction (kW)	CO_2 Emissions Reduction (MT/year)
Home energy efficiency and electrification*	960	3.66	-8	44
Solar PV microgrid	392	33.91**	28	87
Electric vehicles***	1,150	27.83	0	82
Water savings		16.0		
Carbon credits******		8.0		
TOTAL	**2502**	**103**	**20**	214

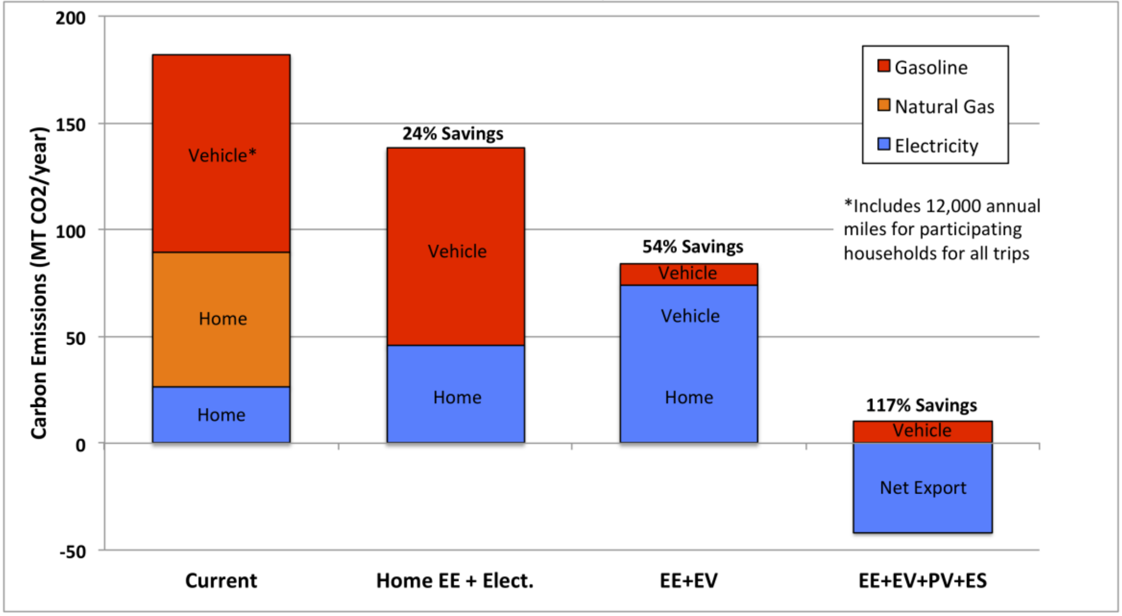
MBtu = million British thermal units; MT = metric tons

* All participating EcoBlock homes will replace all natural gas appliances with electric appliances (e.g., heat pump water and space heating, induction cooking). Note that the negative cost savings from EE measures and electrification are due to replacement of the gas-fired appliances which lower fuel costs per unit of energy compared to electric appliances.
** Includes power export sales to grid.
*** Assumes 6,500 local vehicle miles driven per household per year for EVs.
**** Assumes $100/MT CO_2 credit price for 6.6MT of CO_2 avoided.

Source: UC Berkeley

Figure 8-2 shows the breakdown of CO_2 emissions reductions for the project scope through the different phases of project implementation.

Figure 8-2: EcoBlock Carbon Emissions During the Various Steps of DER Implementation



Source: UC Berkeley

For full implementation in California IOU service territories, it is estimated the following benefits for ratepayers (Table 8-4), which lead to a 5.5 percent reduction of California's annual carbon emissions.[39]

Table8-4: EcoBlock Quantitative Benefits Estimates (Full Implementation in California)

	Energy Savings (million MBtu/ year)	Cost Savings ($billion/year)	Demand Reduction (GW)	CO_2 Emissions Reduction (million MT/year)
TOTAL	433	9.0	1.8	24.4

Source: UC Berkeley

Key Assumptions for Full Implementation Quantitative Estimates and Affected Market Segments

Benefits calculations are based on results from DER-CAM optimizations, which determine energy-cost optimal DER operation strategies.

- The EcoBlock model is scaled to other residential city blocks of similar age and construction type. There are roughly 14 million homes in California IOU territories. If 25 percent[40] of these homes are assumed to be a similar age and construction type (first-ring streetcar suburbs or other medium-density block-based developments), then 25 percent would be 3.5 million potential homes. At 40 homes per block, there are 87,500 potential EcoBlocks in California, or 725,000 nationally, at a minimum.
- In each block, 100 percent of residential units are converted (as opposed to 40 percent of units for the preferred scenario).
- Electricity is purchased from the grid on PG&E's A10 Tariff.
- Excess solar production is sold to the Alameda County Community Choice Aggregation program at a $0.07/kWh wholesale price (assuming a feed-in tariff like the Marin and Sonoma CCA offer at $0.09/kWh).
- Carbon footprint reduction is estimated at 0.28 kilograms per kilowatt-hour (kg/kWh) for electricity and 5.3 kg/therm for natural gas no longer required.

Qualitative Benefits

Some of the EcoBlock strategies offer significant non-energy benefits to end users, which will spur further adoption. Potential non-energy benefits include: increased comfort (warmer in winter, cooler in summer) and well-being in the homes due to the thermal shell retrofits, improved power quality from the DC microgrid, and improved

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[39] According to the California Air Resources Board, California GHG emissions in 2015 were 440 million metric tons of CO_2. https://www.arb.ca.gov/cc/inventory/data/data.htm

[40] According to the American Housing Survey, the fraction of urbanized and "urban cluster" housing units built in 1950 or earlier, nationally, is 25 percent. https://www.census.gov/programs-surveys/ahs/data.html

indoor air quality by means of better air flow and by eliminating indoor natural gas combustion. It could also decrease the higher projected impacts of urban heat island effects due to the accelerating effects of climate change, which are predicted to cause higher temperatures and more frequent heat waves. Any mitigation of these effects will be a large benefit to health and quality of life.

Finally, a considerable projected benefit is increased real estate value for individual homeowners, and greater employment in the communities in which they live due to the extensive construction activity needed to implement EcoBlocks—a tide that can lift all boats.

Cost-Benefit Analysis and Assumptions

The anticipated benefits and costs of deploying EcoBlocks statewide in California are summarized in Table 8-5, using the same assumptions presented earlier for Table 27. The analysis also assumes a conservative 2 percent discount rate based on low-risk, home-asset-backed green bonds (in fact, the more likely percentage rate would be 1 to 1.5 percent) over a 30-year lifetime, applied to annual energy and water bill savings of $9 billion.

Table 8-5: California Statewide Cost-Benefit: Energy + Load + Property Value + Income Benefits

	Mature Market, California
Benefit	$351 billion
Cost	$271 billion
Benefit/Cost Ratio	1.3

Source: UC Berkeley

The mature market cost estimate assumes a $3.1 million cost for a full EcoBlock implementation on a single block, based on current market prices for equipment and materials. Any project management, overhead and profit fees are assumed to be counterbalanced by the capital cost reductions due to economies of scale. The project is then scaled to the projected California market (100 percent of homes in each block participating) in 87,500 EcoBlocks.

The analysis includes two other benefits not previously considered: property value and household income. Due to the energy efficiency and solar improvements to each home, a conservative, one-time, 10 percent property value gain is assumed for all participating California IOU residential units (3.5 million households with a baseline property value of $300,000). It also assumes a 1 percent increase in annual household income due to increased local economic activity from economic multiplier effects of EcoBlock capital investment, applied to a $50,000/year baseline household income.

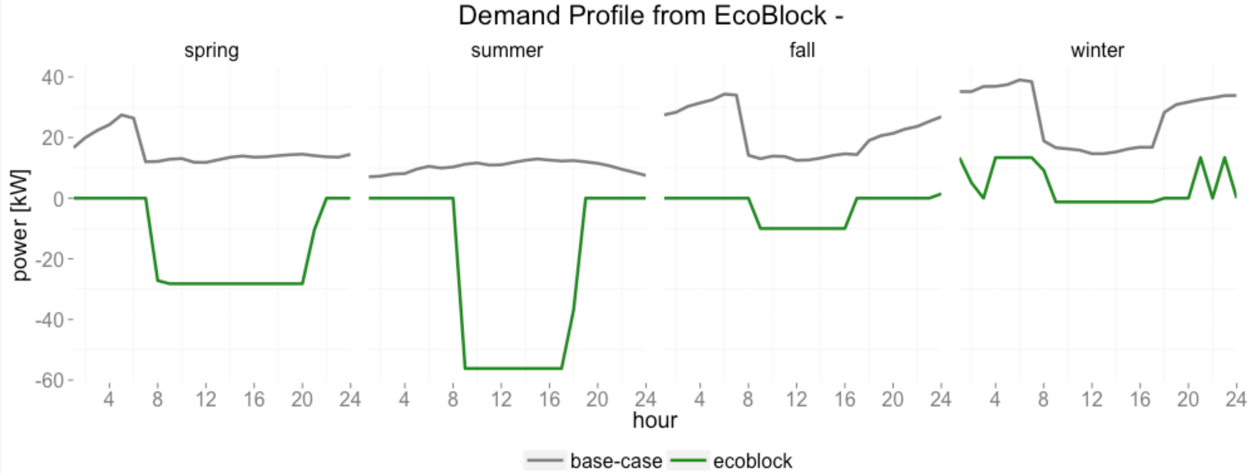
Energy generated with on-site renewables

The total peak capacity of the solar PV systems installed on 40 percent of the EcoBlock's housing units amounts to 215 kW. Based on the DER-CAM analysis presented earlier, the electricity generated by this solar capacity is approximately 444 MWh/year.

Microgrid Net Load Shape

Figure 8-3 shows the EcoBlock's demand profile for different seasons, pre- and post-implementation. As shown in the figure, the overall load is not only *reduced,* it also *reduces* overgeneration during the middle of the day and places virtually no load on the grid during the peak morning and evening demand periods. Even in the winter, the load during the peak periods is reduced by approximately two-thirds from the pre-EcoBlock condition.

Figure 8-3: EcoBlock Average Load Shape by Season, Before and After Retrofit



Source: UC Berkeley

Benefits of Water Efficiency Retrofits and Rainwater Capture and Use

The Water Team conducted a net present value (NPV) economic assessment and a weighted evaluation criteria matrix of the multiple water systems explored to arrive at the recommended Scenario 1w - Core Proposal (see Chapter7).

The benefits of Scenario 1w to homeowners are significantly reduced water consumption and monthly water bills. The water efficiency retrofits reduce consumption by 45 percent, and the rainwater capture and use reduces consumption further by an additional 15 percent (if it can be used for potable water), totaling a 60 percent reduction. All of the measures have a positive NPV over the life of the systems.

The only "bolt-on" that has a positive NPV is the groundwater system for potable use. It is dependent on both groundwater quality and availability in the neighborhood. If positive on both accounts, this is an excellent strategy for creating a new distributed water supply system infrastructure, but it is currently outside the pilot project's scope

Critical Factors for Success, and Risks and Barriers

The project's successful outcome will depend not only on creating an innovative technical solution, but also on developing an innovative business model that creates compelling value across stakeholders; value that is not only monetary but enhances the residents' health, convenience, and quality of life. The biggest risks and barriers to success lie in the built-in incentives in the existing economic model and the legal constraints that govern the role and responsibilities of utilities, ratepayers and the city at both the local and state levels. The goal of the integrated electricity system designs is to develop an innovative business model that can create the kind of value that makes the project scalable; and that takes into account what is reasonably feasible under today's local and state laws, knowing that there is considerable discussion and debate over innovative legal, regulatory and code reforms on both municipal and state levels across California. To address this challenge, our team is working very closely with the City of Oakland's Legal Office, Chief Sustainability Officer, Departments of Public Works and Transportation. Moreover, our legal counsels Morgan Lewis and Perkins Coie are advising us on all issues relating to electricity regulations, land use, zoning, CEQA rules, and permitting constraints. To date, this collective "braintrust" has determined a number of clear pathways toward legal feasibility—and permitting, regulatory, and code changes—necessary to enable the various system configurations (topologies) under consideration and development.

The project team recognizes that what constitutes an "EcoBlock" could have multiple interpretations and configurations, which is another reason to undertake a research study on this complex question. Is an "Eco-Block" made up of the contiguous properties on a single block, or is it the properties on two sides that front a street? Both? Each has a different relationship with the public right-of-way, its shared infrastructure and different implications on legal constraints. The Project Team has explored these two alternatives in preliminary analyses, uncovering their influence on different system configurations (topologies) and costs. The Project Team will hold these definition questions open, pending the recruitment of the homeowners who sign up for the pilot project and join the proposed EcoBlock Trust.

A further issue for success is the fact that the proposed formulation of the EcoBlock might not end up being the right scale. The Team acknowledges that while the EcoBlock concept is larger than a single building or house, a residential block is only one step up in scale, and still relatively small in terms of supply and demand for energy and water. Yet the team has chosen this scale because it is still manageable as a demonstration project, while just large enough to model "community"-scale benefits and performance of the integrated systems. In many ways the EcoBlock represents the smallest building block in creating a sustainable neighborhood, or "ecohood" and may not be the optimum scale for ultimate deployment. Nonetheless, this proposal will be able to test the proof of concept, and from it, should be able to answer the question of whether the EcoBlock is the appropriate scale or whether it should be expanded to include ten, twenty or even a hundred blocks, given the many decision parameters of: energy performance, GHG reductions, costs, ratepayer benefits, and the most advantageous legal and business models required to accelerate the deployment of advanced energy communities across district scales.

The success of the project will depend on implementing the innovative, integrated technical systems and putting in place the innovative business model within the legal, financing, and governance models proposed. Although the EcoBlock team has modeled the performance of the recommended systems and estimated the costs of the pilot project as well as projected the “mature market” costs, with promising results, the biggest unknown is whether these estimates will prove to be accurate under the reality of construction. This is one of the important reasons for undertaking the pilot project.

Finally, the most important factor for success is the acceptance of the homeowners, their willingness to participate in the process of retrofitting their home and becoming a part of an EcoBlock Trust to manage the participation of the group. While there is a clear indication of enthusiasm for the project, the participation level will not be known until the homeowners actually sign on to the project with its innovative finance, governance and business model. This fact is one of the most compelling reasons for funding the pilot project; for this is the only way it will known how feasible it is.

Benefits Summary

The EcoBlock team determined that retrofitting at the block scale can be more efficient and cost-effective than retrofitting at the house scale in achieving maximum energy efficiency, renewable solar energy supply and storage, EV charging, fuel switching from gas to electric, smart controls, and load leveling, and that it results in water conservation and rainwater capture/use.

Performance estimates indicate that the ZNE Master Plan can be zero net energy on an annual basis, provide EV charging for 25 percent of VMTs of the participating homeowners, be close to zero CO_2 emissions because of fuel switching (depending on homeowner acceptance of electric stoves) and reduce water consumption by 60 percent.

Mature market cost estimates at scale indicate that the project’s capital costs and O&M costs can be covered by the cash flow from the savings in utility bills and gasoline savings over the life of the systems. The major contribution to California (and the country) is a model that enables energy efficiency, renewable supply and storage, EV charging, and water conservation for neighborhoods that could not afford it on an individual house-by-house basis.

CHAPTER 9: Technology/Knowledge Transfer Activities

Abstract

As Phase 1 of this project is a “paper study” conducted to determine the process, feasibility, and economics of retrofitting an EcoBlock, there is no specific technology to be transferred at this time. This report and its appendices communicate the knowledge gained from the design explorations and the analysis of the integrated energy efficiency, electric system microgrids, and water systems to arrive at the ZNE Master Plan. The findings include a promising neighborhood-scale model for retrofitting an EcoBlock, which can contribute to helping the state achieve its goals at all five DER levels deployed in the California loading order. This knowledge could be transferred at conferences and symposia, but that was not done during Phase 1 of the project. The EcoBlock team believes it is only appropriate to transfer this knowledge once the construction and monitoring of the Phase 2 pilot project has been done.

Introduction

This study developed and analyzed alternate design scenarios to arrive at a preferred Master Community-Scale ZNE Retrofit Plan for the Oakland EcoBlock. As such, there are no specific technologies and test results to transfer. The knowledge gained is based on scientific analysis and multi-factorial evaluations of the different scenarios. While most of the system components are mature and well-understood technologies, some are not, and the integrated system application has never been built.

The real knowledge as to the cost and performance of the proposed Master Plan will only become available after the pilot project has been built, instrumented, and monitored for performance.

The work effort of the EcoBlock teams has focused on arriving at the preferred Master Plan; therefore, only limited technology/knowledge transfer activities have been undertaken during the project involving the following stakeholders:

- The homeowners and neighborhood association have been informed of the overall concept and hypotheses for the project through meetings and interviews, but not the specifics of the zero net energy Master Plan because those details are only just available as a result of this report.
- The City of Oakland has participated in the “design charrettes,” and the evaluation of the multiple scenarios analyzed, and are thus informed about the recommended systems, the permitting issues, and the innovative finance, governance and business model.

- Our additional industry sponsors (the Rexel Foundation, the Veolia Foundation, and the Ramboll Foundation) have been briefed on the progress of the work undertaken in the report.

The Technology/Knowledge Transfer Plan (T/KPL) for the findings of the project will include the following:

Goal

The goal of the T/KTP is to assist and facilitate the widespread deployment of the EcoBlock Master Plan concept. The innovative business/financing/governance model makes energy and water efficiency retrofits, distributed PV Solar/Storage/EV electric supply available to middle to lower income communities that otherwise would not be able to afford access to ZNE and low carbon technologies. The application of these technologies to existing California housing stock will be essential to reach CA's goals for reduction in CO_2 emissions.

Target Audience

The following are the targeted audiences:

- Homeowners
- Neighborhood Associations
- Local Government Planning Offices
- Mayors
- Utilities – energy and water
- Developers
- Large Technology/Engineering Firms

Findings and Transfer Information

- Detailed description of the Master Community-Scale ZNE Retrofit Plan
    1. Energy efficiency retrofits
    2. DC Solar/Storage/EV Microgrid
    3. Water efficiency retrofits
    4. Alternate water supply "bolt-ons"
- Innovative business/finance/governance model
- Regulatory and permitting issues and policy recommendations
- Project benefits

Transfer Materials and Methods

Materials:

- Homeowners Guide
- Neighborhood Association Information Packet
- Local Government Information Packet
- Mayors Executive Summary Brochure
- Utilities fact sheet and information packet

- Developers Brochure
- Engineering Firms Information Packet

Methods:

- Individual meetings with homeowners
- Town meetings with Block and Neighborhood Associations
- Local Government workshops
- Presentations at the Mayors' Institute for City Design (sponsored by NEA)
- Presentations to the PUC and utilities
- Developer workshops
- Engineering Firm Workshop

All of these could be hosted through the UC Berkeley Siebel Energy Institute, which was created to help the rapid deployment of innovative renewable energy systems.

This plan will be further developed if Phase 2 is conducted.

Presentation Material

Chapter 5 of this report outlines the Master Plan; other presentation materials will be developed if Phase 2 is conducted.

CHAPTER 10:
Case Study of the Oakland EcoBlock Project

Abstract

The Oakland EcoBlock is a community-scale sustainability project that will retrofit an existing city block to promote a change in resource use and energy production. The block scale is believed to be more efficient and cost effective than the individual house scale, and little is known about how action at this scale can transform the consumptive characteristics of America's existing urban and sub-urban residential landscape. The study contributes a detailed description of the planning process for a block-scale project that seeks to address today's challenges of resource scarcity, greenhouse gas emissions, and enhanced resilience. Drawing on interview data with members of the Oakland EcoBlock project team in the San Francisco Bay Area of California, USA, the team identified key decision-making points and factors (positive and negative) that informed this community-scale residential retrofit project. The team also identify which factors are more likely to lead to scaling up of water, energy (and associated transportation) sectors. The project reveals that social barriers, on balance, outweigh technical limitations; cost, and to a lesser degree valuation, is a primary input for critical decision-making points throughout the project planning process, and a consistently shared understanding of benefits requires varied processes to demonstrate, measure, and communicate those same benefits.

Introduction

This chapter documents the process by which the interdisciplinary team arrived at an optimum design of the integrated system and components for the Oakland EcoBlock demonstration project. It also discusses the design development documents, specifications and cost estimates, and a schematic monitoring plan used for the project. It documents key decision-making points in the critical path and the key constraints that informed them. The case study is intended to characterize the transformative nature of the Oakland EcoBlock effort for a broad audience, researchers, residents, practitioners, academics, regulatory officials, and community leaders.

The Oakland EcoBlock project is an urban sustainability experiment in Oakland, California, that brought together residents of a local neighborhood block and a multidisciplinary team of urban designers, engineers, social scientists, and policy experts. Devised in partnership with the local community, the project applies a whole-systems design approach to retrofitting the block from high energy and water dependency to the lowest energy and water footprint possible—transforming an obsolete, resource-wasteful model into a resilient design that guarantees residents' long-term comfort and security.

In this study, the team undertook a survey to identify the strengths and weaknesses of the EcoBlock approach. More specifically, how the project team develops an understanding of whether retrofitting the block-scale is more efficient and cost-effective is answered (because it combines the flows and efficiencies across multiple units) than the individual house-scale in achieving maximum renewable energy, water conservation, and local wastewater treatment and reuse.

Key Facts

- Project Name: Oakland EcoBlock
- Project Location: Oakland, California, USA
- Project Neighborhood: Golden Gate Neighborhood
- Properties: 26
- Rate-Paying Buildings: 27
- Rooftop Buildings (includes cottages): 31
- Water Meters: 34
- Dwelling Units: 64 single-family and multifamily residential
- Population: approximately 100 persons
- Program: 59,640 gross square feet, residential
- Project Team: (see Table 10-1)

Table 10-1: Project Team

ACADEMIC	RESEARCH	MUNICIPAL	UTILITY	SYSTEMS	OUTREACH	LEGAL
University of California (UC), Berkeley	Lawrence Berkeley National Laboratory (LBNL)	City of Oakland	East Bay Municipal Utility District (EBMUD)	Integral Group	Kearns & West	Arnold & Porter
Stanford University	NASA Ames Research Center		Pacific Gas and Electric (PG&E)	Sherwood Design Engineers	Skidmore, Owings & Merrill (SOM)	Morgan Lewis
				Build It Green		Perkins Coie
				Ramboll Environ		Bridgett Hanson
				Platt		David Taussig

Source: Skidmore, Owings & Merrill, LLP

Organizations [18 interviews, All major constituencies]

1. Sustainability Manager, City of Oakland
2. Senior Principal of Sustainability and Resources, Integral Group
3. Assistant Professor, Civic and Environmental Engineering, UCB
4. Principal Scientific Engineering Associate, LBNL
5. Senior Manager, Ramboll Environ
6. Partner, Arnold & Porter
7. Associate, Perkins Coie
8. Partner, Morgan Lewis
9. Executive Director, Green Advisor
10. Partner + Founder, Sherwood Design Engineers
11. Principal, Ramboll Environ
12. Director, Kearns & West
13. Research Scientist, LBNL
14. Acting Manager of Integrated Grid Planning, PG&E
15. Staff Scientists & Individual Environmental Group Leader, LBNL
16. Staff Scientist, LBNL
17. Professor of Architecture & Urban Design, UCB
18. Water Utility Representative, EBMUD

Figures 10-1 through 10-3 show the project timelines of when each group heard about the concept and joined the EcoBlock team, and each team's perception of the concept and involvement in the project.

Figure 10-1: Project Timeline: When Each Group First Heard About the Concept

WHEN DID YOU FIRST HEAR ABOUT THE CONCEPT?

2015 DECEMBER
Grant Submitted

2016 MARCH
California Energy Commission Electric Program Investment Charge (EPIC) Grant 15-312.
Notice of Proposed Award.

2017 DECEMBER
Final Report

2018 MARCH
California Energy Commission Electric Program Investment Charge (EPIC) Grant 15-312 Concludes.

UC Berkeley College of Environmental Design (CED) & Energy Resources Group (ERG)
I was frustrated with a new project in China and had written a book looking at successful examples in Europe. Retrofit idea appealed.

Lawrence Berkeley National Laboratory (LBNL)
Knew about the concept for a long time, since 1994 when I studied under Sym Van Der Ryn; The OEB was on my radar in early 2015.

East Bay Municipal Utility District (EBMUD)
Early to middle 2000's

UC Berkeley Center for Green Chemistry (CGC)
Fall 2014; before a discussion in Mountain View at Moffatt Field; Heard about the concept 2013 or earlier.

Sherwood Design Engineers (SDE)
Wrote portions of the grant application; We were engaged with Stanford.

Kearns & West
I was introduced to Tony Nahas through a friend who is on the Sherwood Foundation.

Arnold & Porter

LBNL
Spoke with Tony in 2014

Morgan Lewis
September 2014

Perkins Coie
September 2014; April 2016

LBNL
Late 2014

Pacific Gas & Electric (PG&E)
2014-2015

Ramboll Environ
February 2015

LBNL
There was a talk at LBNL February 17, 2015; I talked with Tony shortly after.

LBNL
There was a general meeting held for the OEB. This was before the CEC solicitation. The meeting included Rick Diamond, Ian Walker, Leo Ranier, Michael Stadler. Early 2015 pending the release of the EPIC CEC grant. We helped develop the preliminary budget and the scope.

UC Berkeley Civil and Environmental Engineering (CEE)
March 2015

Ramboll Environ
Worked on the proposal; sponsor role; April 2015

Integral Group
Kevin, the CEO of Integral Group had a conversation with Tony Nahas at the Verge Conference and we became involved in the application process.

City of Oakland
Tony Nahas approached and asked if the City could support and play a role. At that time, there were a few academic team members who had identified top priorities.

Skidmore, Owings & Merrill
February 2017

Responses from interviews, sorted by group chronologically and compared to project milestones at the top of the timeline
Credit: Skidmore, Owings & Merrill, LLP

Figure 10-2: Project Timeline: When Each Group Joined the Oakland EcoBlock Team

WHEN DID YOU JOIN THE OEB TEAM?

2015 DECEMBER
Grant Submitted

2016 MARCH
California Energy Commission Electric Program Investment Charge (EPIC) Grant 15-312.
Notice of Proposed Award.

2017 DECEMBER
Final Report

2018 MARCH
California Energy Commission Electric Program Investment Charge (EPIC) Grant 15-312 Concludes.

2014

UC Berkeley College of Environmental Design (CED) & Energy Resources Group (ERG)
Developed idea 2014; Fall 2015 proposal; Award 2015 late spring.

Kearns & West
In the process of the grant application. End of 2014 or Early 2015.

Sherwood Design Engineers (SDE)
We had a class going in 2015 or 2014.

Lawrence Berkeley National Laboratory (LBNL)
At that time at beginning.

2015

Pacific Gas & Electric (PG&E)
Feels like it has been going on forever. 2015. We were approached before the CEC grant. We participated pre-grant.

Perkins Coie
April 2015; April 2016

Ramboll Environ
May 2015

Morgan Lewis
June 2015

LBNL
Fall 2015

UC Berkeley Civil and Environmental Engineering (CEE) September 2015

City of Oakland
2015 Later summer/fall.

Integral Group

LBNL
October 13, 2015 Rick Diamond, C. Kurcha, Leo Rain, Norm Bourassa, Tony Nahas.

LBNL
Not part of team. I have been to meetings and encouraged the team. I advised and did some early brainstorming.

2016

UC Berkeley Center for Green Chemistry (CGC)
I didn't really join. Stepped down from Berkeley Center for Green Chemistry in January 2016; close to kick-off for OEB. Tom McKeag was the new director.

East Bay Municipal Utility District (EBMUD)
First engaged on the first quarter proposed/received funding.

Ramboll Environ
September 2016

Arnold & Porter
December 2016

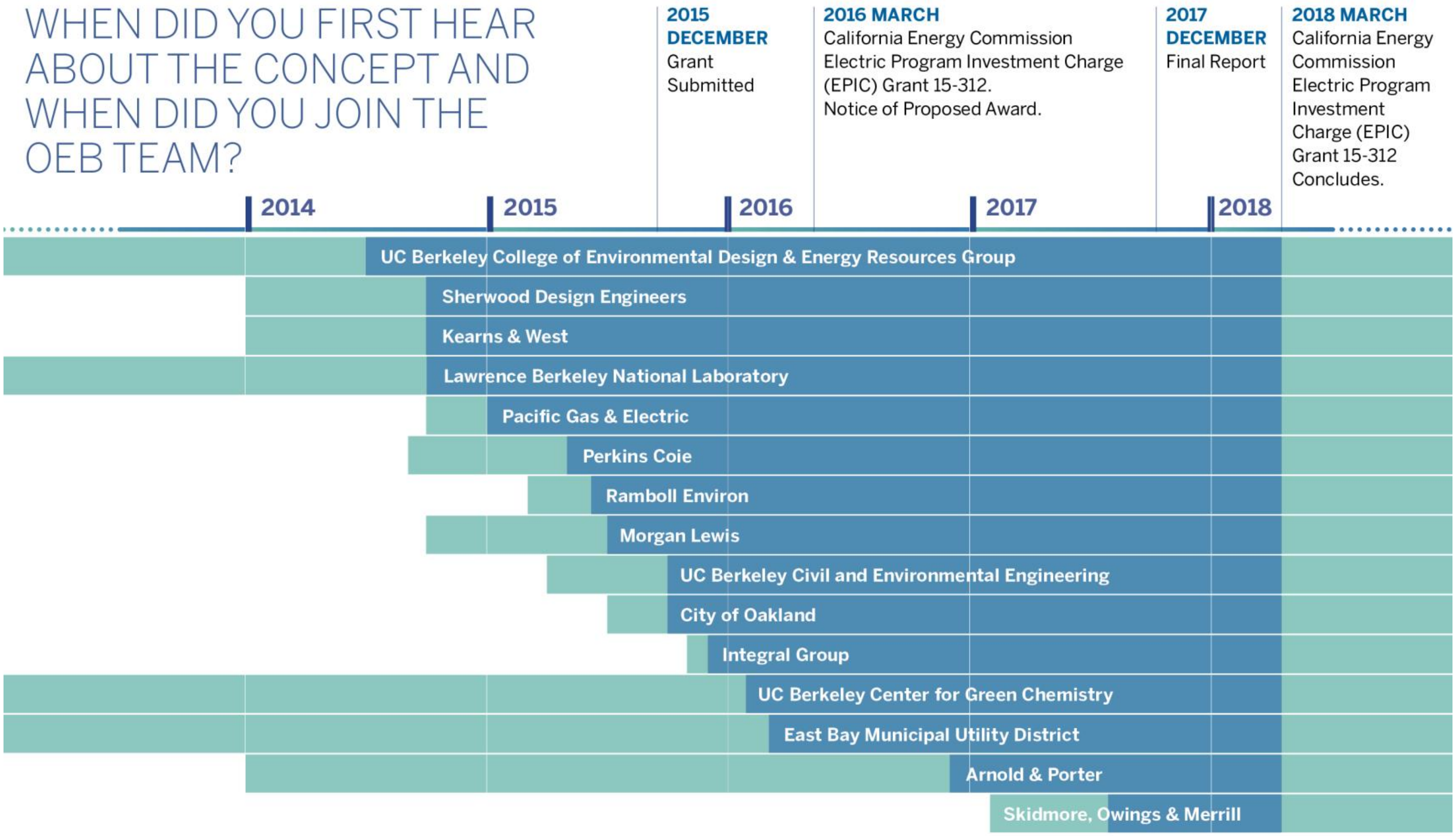
2017

Skidmore, Owings & Merrill
September 2017

2018

Responses from interviews, sorted by group chronologically and compared to project milestones at the top of the timeline
Credit: Skidmore, Owings & Merrill, LLP

Figure 10-3: Project Timeline Diagram: Time Frame of Each Team's Perception of the Concept and Involvement in the Project



The timeline diagram is drawn based on responses from interviews. Green bars represent the time frame of each team's perception of the concept. Blue bars represent the time frame of each team's involvement in the project.

Credit: Skidmore, Owings & Merrill, LLP

Literature Review

Politics and Governance of Climate Change

The politics and governance of climate change at the city and subnational level have been gaining traction in the last two decades. In the recent report by the International Panel on Climate Change (IPCC) *Climate Change 2014: Impacts, Adaptation, and Vulnerability*, local governments were, for the first time, recognized as actors in efforts to mount a climate response (IPCC 2014). Despite an entire chapter (Chapter 8) devoted to urban areas, efforts have remained context specific and varied (Joss 2011; Foss 2016).

As action at the local level has gained importance, ecological modernization theories (EMTs) have developed alongside efforts to construct a new carbon economy. Despite the opportunity provided by carbon governance in the form of emissions trading or global offset markets, pessimism exists around EMTs' failure to consider the extent to which climate change can be addressed without a change in society-nature or social values. In addition, EMTs are blind to problems with distributional justice and ignore how growth logic is fundamentally at odds with addressing the root causes of climate change (Bailey et al. 2011). Alternative theories—ones that avoid the empowerment and legitimation of pragmatists and address not only the industrial, but also the capitalistic aspects—are being sought.

Even though city and subnational experience addressing climate change has been varied, urban environments are still viewed as an important site of greenhouse gas (GHG) reduction because cities are sites of high consumption and waste generation with a degree of local control (Bulkeley and Betsill 2013). In addition, city governments have shown that they are capable of taking on complex sustainability agendas and can coordinate key actors. Finally, local authorities now have experience addressing these types of issues and can undertake innovative measures, underpinning policy experimentation and demonstration projects (Bulkeley et al. 2015). However, limitations still exist to the authority and technical competencies of governmental actors, and constraints continue to hamper the ways in which urban development and transportation problems are defined and discussed.

As local governments are recognized alongside nation-states addressing climate change, public participation and cultural framing have gained in importance. A significant body of literature is devoted to developing typologies of citizen participation associated with urban climate change adaptation with respect to engagement, public participation, and civic capacity (Sarzynski 2015). Different trajectories of city sustainability plans have been chronicled to show the importance of public participation and cultural framing (Foss 2016). This work reveals that citizen steering models, public-private partnerships, and the nonprofit sector are essential to understanding the network of multiple actors and hybrid arrangements working at the local level (Joss 2011; Broto 2017).

Neighborhood/Urban/Regional Planning for Sustainability and Climate Change

Nation-state climate change activity at the local level has traditionally focused on GHG-emitting facilities such as power plants, or has been propelled by questions around environmental justice or vulnerability, as opposed to concerns with climate change directly (Cushing et al. 2016). Despite this, urban-scale climate change mitigation and adaptation efforts can address the 60 to 80 percent of world energy use, contribute to a large proportion to national gross domestic product (GDP), and preserve social, environmental, and health service that occur in cities. Such efforts also can deliver significant co-benefits, such as cleaner air, green jobs, urban environmental quality, and water and energy security (Hallengate and Corfee-Morlot 2011). Action at the local level is increasingly viewed as an effective scale at which to tackle climate change, being undertaken by a variety of actors, in addition to nation-states, and driven by exposure to the effects of sea level rise and natural hazards.

Cities are looking for ways to implement immediate and lasting transformation at the local scale. Regional, urban, and neighborhood efforts and are increasingly finding that technology alone is not likely to result in broader societal transformations (Bouteligier 2010). Pilot projects are often criticized as a “techno-fixes” that do not provide information about best practices and omit social aspects, particularly learning and social organization, that are crucial to lasting change. In addition, municipal governance, including scale, organization, and culture, are highly influential (Foss and Howard 2015; Dierwechter and Wessells 2013). Finally, implementation of potential risk mitigation strategies has been shown to be limited by institutional constraints and barriers (Hallengate and Corfee-Morlot 2011).

Traditionally, the United States has looked to power plants, public facilities, and policy to address climate change, with Europe and Asia pursuing a greater number of eco-district development projects (Fraker 2013; Fu and Zhang 2017; Fitzgerald and Lenhart 2016). In Sweden and Germany, local authorities often retain ownership of land, granting only the right to develop, or acting as the developer themselves, while in China local authorities commonly pursue smart and eco-cities (Fraker 2013; Fu and Zhang 2017). The Unites States has had far fewer neighborhood scale eco-district development projects and has shown reluctance to tamper with private land ownership and development markets.

In general, community-scale sustainability transitions (e.g., eco-districts, transition towns) have shown that change is happening at the household level and control over broader community systems remains elusive. They also have shown that there is an inherent tension between taking a mainstream stance needed for governmental collaboration and local funding, and taking a radical stance necessary for transformational change that targets modes of consumption and mobility, or root political and economic drivers (Forrest and Wiek 2015). However, the city scale has been found to have opportunities to implement no-regrets strategies that address climate and provide multiple community benefits. More careful cost-benefit analysis and cost-effective planning strategies in routine planning at the local scale have shown promise to also address climate change impacts (Hallengatte and Corfee-Morlot 2011).

Urban Political Ecology

Frequently, questions about the equity and social justice dimensions of eco-district developments are raised. EcoBlocks and associated typologies of eco-districts, eco-cites, and eco-regions are often criticized for merely being an attempt to create an ecologically secure gated community, rather than contributing to a more collective notion of planetary security. The literature suggests several strategies to avoid the creation of premium ecological enclaves calling for the discussion of resource futures with users, balanced socio-technical responses, retrofitting the existing city (in addition to new builds), emphasizing questions about interdependencies (avoiding security for some), and encouraging debate about the new style of urbanism offered by the ecological city (Hodson and Marvin 2010).

Development History

The Oakland EcoBlock project focuses on a neighborhood block that developed as railroads crossed the United States and electrified transportation became commonplace. It was part of a prosperous city enabled by the "Age of the Trolley"—a time when an emerging middle class could begin to commute to employment centers and live beyond the city's original borders. The "extraordinary prosperity and vitality of most urban cores between 1880 and 1940 cannot be understood without reference to the streetcar system…by the turn of the century, a 'new city,' segregated by class and economic function and encompassing an area triple the size of the older, walking city has clearly emerged…[so that] by 1904 inventor Frank Sprague (known as the father of Electrical Traction) could reasonably claim: 'The electric railway has become the most potent factor in our modern life.'" (Jackson 1987). The prosperous city was also the consumptive city, consuming land, and with the advent of electrification, plumbing, and the automobile, water and energy.

The city of Oakland's origins date back to the middle of the nineteenth century, as Spanish and Mexican settlement gave way to American settlement and statehood. A chart of the Bay of San Pablo and part of the Bay of San Francisco from 1850 showed the current location of the project on land that was once identified as Contra Costa (the other coast) and part of the Rancho San Antonio owned by Vincente and Domingo Peralta. The Peralta Land Grant was given to Don Luis Maria Peralta, an officer in the Spanish army, by the last Spanish governor of California in 1820, and encompassed 44,800-acres (much of the East Bay) (Hornbeck 1978). The map from 1850 shows the alignment of the old road to Rancho San Pablo, which eventually reached the town of San Pablo. The road is shown in a similar location to today's principal north-south route, San Pablo Avenue (Rinngold 1852).

California became a state that same year, but it was the transcontinental railroad completed in 1869 that would usher in rapid changes to settlement patterns. The first continental rail road linked existing lines from the eastern U.S. rail network to the Oakland Long Warf on San Francisco Bay, with additional lines planned and constructed in subsequent years (WC 2018a). Both the Central Pacific and the Southern Pacific established some of their largest rail yards and servicing facilities in West Oakland, which continue to be a major local employer well into the twentieth century. Alongside economic growth from rail commerce in the late nineteenth century, Oakland was establishing itself as a deep-water maritime port and thriving shipyard, exporting vast quantities of raw materials from California and the Northwestern hinterland (WC 2018b).

By 1872, the neighborhood around the Oakland EcoBlock included the projected alignment of the Central Pacific railroad which ran to the west and roughly parallel to San Pablo Avenue, along the Bay's edge. The tract owned by Beaudry & Co. was north of the race course, between the projected alignment of the Central Pacific railroad and San Pablo Avenue (Allardt 1872). Land development began to accelerate. New infrastructure was proposed at the same time the State of California prepared a sale map to auction off the Bay's shallow tidelands. Subsequent maps reveal a process of bay fill and land creation that moved the edge of the Bay to the west of the proposed railroad alignment.

The Public Land Survey System, instituted in the State of California in 1951, was being used to measure and sell the water lots. In contrast, the Beaudry & Co. tract was a subdivision of the original land grant. It reflected changes brought about by the 1951 U.S. Federal Land Act that required Spanish and Mexican land holders to prove their land titles in court. Litigation lasted years, and squatters overran the land; in some cases, even selling the land belonging to the original owner. Rancheros often quickly subdivided the land and sold it to new settlers. By 1853, both Peralta brothers had sold most of their holdings to squatter-investors and in the 1860s newspaper advertisements shifted from offering prime agricultural land to advertising tracts suitable for subdivision (Pitt and Gutierrez 1999; Winsted 2015).

By 1876, a second Berkeley Branch of the Pacific Northern Railway (in addition to the Central Pacific alignment along the Bay) was visible, curving to the east and positioned along the southern edge of the tract containing the Oakland EcoBlock. Two railway stations serviced tract No. 41, identified as the L. M. Beaudry landholding. One railroad station was shown at Montague Street, serving the western edge of the tract, and a second at the intersection of Kierney Street and San Pablo Avenue, serving the eastern edge of the tract (King 1876).

In 1878, a successful German-born, San Francisco businessman, Charles Alexander Klinkner (1852–1893), paid $100 for a 14-acre tract of land between Oakland and Berkeley that ran parallel, and east of, San Pablo Avenue, near the Central Pacific's railroad station at San Pablo and Stanford Avenues. Klinkner set about creating a little town which he called "Klinknerville" (founded in 1885), and eventually induced the railroad to extend its line into Klinknerville. The *Oakland Sentinel* called Klinknerville a "Charming rural retreat in the country, but in sight of the city." Klinkner built a large, gothic-style commercial building and community center with a clock tower at 5832 San Pablo Avenue called “Klinkner Hall,” as well as a baseball field (the home of the Oakland Oaks, the city’s professional baseball team in the early 1900s), the fine Del Monte hotel, and 75 “upscale” houses for a residential community, each selling between $3,000 and $5,000. A Klinknerville post office was established in 1887 (Philips 2012).

In 1888, the town of Klinknerville was changed to “Golden Gate” (for the beautiful views, now obscured, of the cleft in the coastline providing views to the Pacific Ocean across the San Francisco Bay). In 1896, the city of Emeryville was incorporated and in 1897, little Golden Gate (an area also identified as the village of Temescal) voted to join Oakland to access public services, including schools and police [WC 2018c). In 1888, the original L. M. Beaudry tract was visible, and more than one-half of it was located in the new community of Emeryville, with the remaining portion in Oakland. Soon after the incorporations and annexation, the Klinkner name quickly vanished from the area, and Klinkner Avenue was changed to 59th Street (Henkenius 1888).

By 1906, the present-day site of Oakland EcoBlock (again to the north and west of the race track) was shown as being approximately two-and-one-half miles away from the Southern Pacific railroad pier to the City of San Francisco. Centering on the port shows the proximity of the neighborhood to a central point of trade, and suggests that transportation nodes were of greater importance than downtown at the time. Electric roads extended throughout the area, and San Pablo Avenue was electrified into downtown Oakland (Candrian 1906).

In the late 1890s and early 1900s, Oakland resident and mining magnate Francis "Borax" Smith (1846–1931), who made a fortune in his commercializing his namesake mineral, turned his investments to real estate and electric traction. Smith began to buy up and consolidate several streetcar lines across the east Bay until he operated a virtual electrified transportation monopoly, dubbed the “Key System,” the predecessor of today’s publicly owned AC Transit (WC 2017a).

By 1912, various light and heavy railways operated throughout Oakland, including the San Francisco-Oakland Terminal Railways; Western Pacific Railway; Southern Pacific Company and Operated Companies; Atchison, Topeka; and Santa Fe Railway, of which the San Francisco-Oakland Terminal Railway would be reorganized as the Key System Transit Company. At this time, transit service near the project site included west-east service on Stanford Avenue–Powell Street, with an additional Southern Pacific rail line visible through the center of the L. M. Beaudry tract, and north-south service along the length of San Pablo Avenue provided by the San Francisco-Oakland Terminal Railway (Realty Union 1912).

While a system of railroads operated in Oakland, automobiles were increasingly manufactured in the city. In 1916, Fageol Motors, a manufacturer of buses, trucks, and farm tractors opened a plant in Oakland. That same year General Motors (GM) built a major automobile factory in East Oakland, making Chevrolet cars and then GMC trucks until 1963, when it was moved south to Fremont. Then in 1922, W. C. Durant, the former President of GM, chose Oakland to build the Durant Motor Company factory. By 1929—the date when Chrysler also built its new plant in Oakland—the city was already known as the "Detroit of the West" (Botti 1998). The post-World War I economic boom benefited Oakland's strategic railroad and deep-water seaport status, and as the city's affluence grew in the 1920s, there was a rush to sell automobiles to the Californian masses. In Oakland, this process was accelerated thanks to the impressive clustering of mass-production automobile manufacturers in the city.

By 1935, the block and surrounding Golden Gate neighborhood were indicated by their present-day names. The bridge to San Francisco had been completed, energizing the use of automobiles over rail (Thomas Bros. 1935). Perhaps more important, with the rise of the massive and powerful automobile corporations, the Great American Streetcar Scandal (also known as the "General Motors streetcar conspiracy") influenced the demise of streetcars across America, with an epicenter in the city of Oakland (WC 2018d).

The scandal refers to convictions in relation to a program by GM and other major companies that conspired to purchase and then dismantle streetcar and electric train systems in many cities across the United States and to replace them with motor-powered bus routes. Between 1938 and 1950, National City Lines and Pacific City Lines—with investment from GM, Firestone Tire, Standard Oil of California, Phillips Petroleum, Mack Trucks, and the Federal Engineering Corporation—gained control of electric surface-traction systems in 45 cities, including St. Louis, Baltimore, Newark, Los Angeles, San Diego, and Oakland, converting many of them to bus operations in that period. Several of the companies involved were convicted in 1949 of conspiracy to monopolize interstate commerce in the sale of buses, fuel, and supplies to subsidiary companies, but were acquitted of conspiring to monopolize the ownership of these companies. Federal prosecutors argued that the deliberate destruction of streetcars was part of a larger strategy to push the United States into automobile dependency (WC 2017b).

The historical development of Oakland shows the progression of neighborhood block development in association with national and regional railroads and electrified streets. This neighborhood can be described as a typical American rail or streetcar suburb.

Throughout the United States blocks like this can be found in every major city, and today they are experiencing a renaissance as walkable neighborhoods are increasing in popularity. The Oakland EcoBlock provides a significant opportunity to contribute to the rebirth of the area, only reimagined as a place that will radically reduce climate change impacts and enhance community resiliency (Callaway et al. 2015).

Methodology

Utilizing the existing Oakland EcoBlock contact list, urban planners and architects Skidmore Owings and Merrill (SOM) identified 30 project team members to be interviewed over a three-month period (August–October). Eighteen interviews lasting between a half hour to one hour were completed with project team members. Eight interviews were conducted in person, and the other 10 were completed over the phone. The interviews were organized and undertaken to capture the following information:

- Document the legal, zoning, planning, and entitlement constraints and processes required by the city, state, and utility
- Describe the team's decision-making process for the legal framework
- Describe the team's decision-making process for the:
  - Deep energy efficiency retrofits
  - Electrical system
  - Water system
- Document the identification and analysis of innovative business models:
  - Utility-led model
  - Third-party developer
  - City-led model
  - Homeowner association
- Document the process of creating design development documents and specifications
- Document the process by which cost/benefit analysis, including critical assumptions and variables, are identified and chosen
- Document preparation of the instrumentation and monitoring plan.

Skidmore, Owings and Merrill developed a script (Appendix M) used to ask questions about these topics and administered standardized interviews to provide comparable information. The results were compiled into a comparative matrix of the answers provided by key team members. A discussion of the results is included in subsequent sections of this chapter.

Results

Narratives of the Oakland EcoBlock Project Elements

Oakland EcoBlock project team members provided responses on the following project topics:

- Constraints and Processes
- Community Engagement Process
- Legal Framework
- Energy Efficiency, Electrical, and Water
- Innovative Business Models
- Design Documents and Specifications

- Cost Benefit Analysis
- Instrumentation and Monitoring Plan

These topics are discussed below. Each section highlight lessons learned about the project process, revealing the complexity of a community-scale sustainability project.

Constraints and Processes

Project team members identified several legal constraints which the Oakland EcoBlock project would need to address for project success. For example, the legal regime for utility service is set at the state level and structured for regional-scale, not block-scale, service provision. The California Public Utilities Commission (CPUC) regulations are comprehensive and tailored for large-scale utilities, even though they are applied to any entity that provides energy to two or more persons. Respondents noted the current regulatory environment does not facilitate local or distributed generation at the scale of a block, where it is likely to serve between two and one-hundred individuals, and may not require the same type of regulatory oversight developed for a regional grid supplied by power plants.

Team members also noted several other legal limitations for energy and water systems. Sharing solar energy to multiple parties and across property lines, master metering, and on-site blackwater treatment are prohibited and barriers to allowing graywater reuse exist. It was unclear which interconnection with the utility would be optimal, but respondents noted that this was also an area likely to have legal constraints. Finally, it was unclear how ownership of shared elements, liability, and insurance would be legally structured and what mechanism would assure operations and maintenance of block-scale systems into the future.

In contrast to the significant legal constraints, respondents identified few zoning constraints for the project. Project team members noted that the land use will remain residential, avoiding any change in use that would trigger local review. The potential introduction of non-residential uses, such as the flywheel for energy storage or a living machine for water treatment, was permitted on an adjacent property zoned for light industrial/manufacturing use (but would be a concern for similar projects located in a neighborhood with only residential land uses permitted). Project team members pointed out the state-level regulation of utilities means that the local level is more often silent about local service provision, presenting few obstacles. However, respondents noted that local guidance to facilitate this type of project should be developed by engaging the California Governor’s Office of Planning and Research, setting state requirements for General Plans and Zoning, and addressing key aspects of the project such as ownership structure, operations and maintenance models, and limits to liability.

Project team members also believed planning and entitlement constraints were less of a barrier to achieving the project. They cited broad support from the City of Oakland and described a project approach that achieved feasibility by pursuing exceptions to existing planning and entitlements processes where needed. These responses suggest that the team approached the Oakland EcoBlock project as an opportunity to innovate and redefine planning and entitlement processes. Several project team members indicated that, although they believed that few planning and entitlement barriers existed, time and resources would be needed to address all concerns and obtain city approvals. An individual suggested that an Innovation District Overlay or Demonstration Zone, similar to those instituted in the communities of San Jose and Sacramento, might facilitate the project's success.

Project team members identified processes that both help and hinder planning for the Oakland EcoBlock, noting that the way these processes are addressed will determine the level of innovation possible. Responses indicated that state policy calling for reductions to greenhouse gas emissions and local policies supportive of sustainability are helpful to planning for the Oakland EcoBlock. The flexibility and supportiveness from local agencies such as the City of Oakland, East Bay Municipal Utility District, and Pacific Gas and Electric—all of whom provided staff time and data, attended meetings, helped characterize the existing systems, and participated in collaborative workshops—was also helpful. However, state regulatory processes for utilities hinder project planning, in that they enable a different scale and configuration of services. Finally, project team members noted that all public processes are constrained by limited public budgets and a lack of financial incentives that can hinder implementation despite robust planning and local support.

Community Engagement Processes

The project team indicated that a high level of interaction with the community was the highest priority for community engagement. Also important was the team's ability to address community questions, such as the project progress, when construction might be undertaken, or whether subsidies or cost share would be provided. Fewer respondents indicated that the community engagement process should prioritize providing a level of service or getting support from homeowners and tenants.

However, when asked how team members would evaluate the success of the community process, several individuals noted that support for the project, as exhibited by positive narratives at public meetings or owners and tenants electing to participate in the next phase of the project, would constitute success. Other indicators of success would include providing residents with information sufficient for decision making, or high levels of attendance at community meetings.

Project team members acknowledged that developing support and a positive public narrative requires a structured process with advance notice to the community, early in the project's planning phase. Several respondents expressed concern that the community process for this phase of the Oakland EcoBlock project should have taken place earlier and that it should have been more robust. Community contact was structured as academic research rather than community outreach.

Finally, some project team members felt it was important that the technical design of the project respond directly to community needs, while others believed it was most important to listen and understand concerns. Several respondents noted that integrating community comments directly can be tricky, acknowledging that professional judgements must be used to prioritize comments and identify appropriate responses. Respondents with these concerns suggested the emphasis should instead be on making sure all community concerns are addressed.

Legal Framework

There was little agreement among respondents when asked a question about which legal framework would facilitate the construction, maintenance, and operations of the project. The most common response was that a clear governance structure was needed, with a diversity of specific selected governance structures identified by individuals. Different respondents identified a cooperative, trust, community choice aggregation (CCA), utility, third-party developer, city, or a homeowner's association, of which it was believed that any structure could meet the project's needs. Several project team members indicated that they were not sure about the best legal framework, and several governance structures were still being discussed. Despite the diversity of answers, the question of how long-term operations and maintenance would be undertaken was a significant component of the responses. Several individual responses noted that a Community Facilities District (CFD) was an ideal mechanism to address the long-term funding challenge of operations and maintenance for small-scale infrastructure.

Energy Efficiency, Electrical, and Water Issues and Opportunities

The project team guided the technical elements of the Oakland EcoBlock though three primary methods with two key roles.

Respondents noted that most team members:

- provided data,
- assisted with identifying the optimal infrastructure design, and/or
- identified precedents, examples or processes that could serve as models.

Project team members also identified two unique roles:

- a project team facilitator that brought together academic and professional groups, and
- a community facilitator who was responsible for conveying project team information to the block residents.

Team members identified several critical decision-making points, with the most commonly identified as estimated costs relative to technology, implementation, and scalability. Respondents noted the tension between a research-driven project and the potential cost of implementation required for a demonstration project, acknowledging that there are many unknowns and elements that are difficult to quantify using traditional cost estimating methods. Other key critical decision-making points were identified including, community interaction, feedback and acceptance; ensuring reliability versus pursuing exceptional performance (net-zero); microgrid vs. no microgrid; grid interaction; all electric (direct current with no gas); and the ability to retrofit at scale. These answers describe key discussion points throughout the project process, such as developing an effective community outreach process; balancing interrelated sustainability priorities; supporting capital costs associated with infrastructure; commitments to wholesale electrification; and project transferability.

Issues

Project team members responded to several questions about the issues and opportunities associated with each technical element: deep energy efficiency retrofits and electrical and water approaches. They identified the most significant deep energy retrofit issue to be balancing the hard and soft costs of improving efficiency with the value of the improvements. Several noted that deep energy retrofits, such as adding insulation and high-performance windows within an existing home, may be disruptive, and other retrofits, such as a transition away from gas stoves to electric stoves may require owners to change behavior. Costs, as well as disruption and change, may act as barriers to achieving significant gains from energy efficiency retrofits. Several other concerns that were identified point to a complex mix of potential social, technical, and implementation issues. Specifically, respondents identified social concerns such as equitable benefits distribution and maintaining customer engagement. Others noted a limited choice in DC appliances and the public's lack of familiarity with central energy storage. Some respondents highlighted difficulties with regulatory approval, ease of installation, and limited tolerance for possible technical failure associated with developing technology.

Project team members responded that the most significant issue with the electrical system was technology choices, such as decisions around the use of specialized components; a two-circuit system including both alternating and direct current; specific connection to the grid and the ability to provide or draw energy; the capacity and capability of energy storage; and the ability to integrate electric vehicle charging. In addition, they noted that the electrical systems being considered are relatively new and are likely to evolve rapidly over the next two to three years. Many respondents also identified balancing costs and value as an important issue for the electrical system. Individuals pointed to the limited supply chain; capital costs of an alternate system of collection and redistribution; ongoing operations and maintenance needs; ensuring reliability without relying on the existing grid; and sufficient payback. Team members identified several other concerns as well, including permitting; responsibility for the new infrastructure; and disruption caused by through-roof penetrations and opening walls for key system connections.

When asked about the water system, project team members highlighted costs as the most important issue, particularly compared to the relatively low cost of water and the relatively high cost of water treatment and distribution infrastructure. Many respondents also highlighted the block-scale versus regional-scale approach as a critical issue, noting that scale efficiencies for energy and water varied based on the costs and configuration of each system, with early analysis suggesting that water efficiencies may be reached at scales greater than a single block. Other concerns regarding the water system included ensuring water quality and associated public comfort; costs not reflecting a condition of drought and shortage; disruption associated with plumbing upgrades (e.g., fixture replacement); and limited system understanding by the user group.

Opportunities

Project team members also were asked to identify opportunities associated with the deep energy efficiency retrofits, electrical, and water systems. For energy efficiency retrofits, reducing energy costs was the most common opportunity, with quality of life and comfort also identified by multiple respondents. One individual noted that they had found that, although saving money was important for residents, most users were persuaded to undertake energy efficiency retrofits on the bases of comfort (temperature), safety (fewer pests), health (improved indoor air-quality), and sound transmission (quieter). Individuals also noted an opportunity to address state greenhouse gas and carbon reduction goals, and the associated focus on achieving better performance resulting in resource conservation. Other opportunities identified included: access to rebates; independence; resilience; managing customer demand and associates benefits, such as controlling costs associated with infrastructure improvements; reducing the size and cost of storage; and enabling electric vehicle charging.

Respondents identified resilience and reliability as the primary opportunity of an improved electrical system. They noted that redundancy created by local energy production and independence from the grid during an emergency can be a direct benefit for residents (particularly in an earthquake-prone region). Leveraging local resources and access to renewable energy produced nearby, along with load management (for both use and securing preferential use rates) were also identified as important opportunities. Other noted benefits mirrored the key opportunities of energy efficiency retrofits—cost, reduced greenhouse gas (GHG) emissions and carbon, and quality of life—in addition to opportunities to demonstrate microgrid technology and enhance local buy-in.

Project team members responded that the key opportunity of the project's water system is to conserve water, which will, in turn, heighten resident's awareness of water as a resource. Several individuals indicated that visible treatment and purification could also raise awareness about the importance and challenges associated with maintaining water quality. A variety of other benefits were identified, including: showing how water use is linked to energy consumption; ecosystem benefits; and local water availability and scarcity.

Innovative Business Models

The project team was asked if they had guided the development of innovative business models, and if so, how. Most respondents answered that they had not assisted with identification and development of business models. The exceptions were individuals who felt they had contributed by building an understanding within the project team about the design and engineering landscape. A respondent described elements related to water re-use where they identified suppliers, described on-bill financing, structured agreements and financing, and methods to leverage capital. Also, several respondents contributed peripherally to cost estimation, identifying long-term costs and/or pricing system components.

When asked if their input had helped to identify and analyze alternative business models, more project team members noted they provided their expertise in the construction, technology, and electrical areas to evaluate proposed business models. Several project team members noted that they helped by brainstorming, identifying pitfalls to avoid, or pushing back on costs. One respondent described a process of identifying the optimal technical approach, raising questions, and considering deferred maintenance, anticipated cost increases, and changes to business models over time.

Team members were also asked to consider the cons and pros of several business models that might serve as an alternative to a typical utility structure. Specifically, respondents were asked to consider a city-led model—as well as the possibility of other models such as a utility, third-party developer, or homeowner-led model. Project team members identified a lack of municipal capacity and budgetary limits as the biggest drawback to a city-led business model. Respondents also expressed concerns about a city’s ability and/or willingness to take on the responsibility and associated liability of these critical functions. Several did not believe the city would have the appetite or ability to provide the same level of service that is currently provided by a utility district or electric company. Several other cons of a city-led business model that were identified included: general distrust of government; a lack of assured funding for continued operation and maintenance; limitations on increased taxation; and the potential for a jurisdiction to be too small. On the pros side, project team members noted the city’s existing governance structure already engages with codes and regulations and has authority over public rights-of-way. In addition, some respondents noted that the city shows interest in alternatives that the utility is slow to consider.

Within this discussion, project team members also expressed a diversity of opinions about the other possible business models of the utility, third-party developer, or homeowner-led association. While some respondents noted that the utility has an enabling legislation, a corporate organization, energy knowledge, and technical expertise, they may be too profit-focused, with little incentive to take on a more equity-driven model that could be offered by a municipality. Project team members noted that a third-party developer-led model could provide competent technical management, but that there is no clear company structure or business incentive. Individuals considered the homeowner-led model attractive because it promoted grassroots involvement and community commitment, but were more warry of this structure because it relied too much on volunteer labor, lacked technical expertise, and was often perceived as parochial and/or overly restrictive.

Finally, team members were asked if there were other models or alternative structures that might be worth investigating. The majority answered no, they did not know of others or had not been involved in discussions; however, a few other structures were identified. These included a CFD; a yet-to-be-defined hybrid structure; a cooperative model; or a regional nonprofit (or for-profit) third-party organization. A couple of individuals described radical restructuring approaches which they believed were not realistic, but highlighted some of the difficulty of innovation in this area. Specifically, one individual suggested that the University of California purchase of all land and lease it back to residents to create a block-scale laboratory, and another noted that without removing property rights and eliminating taxation of land it may not be possible to overcome key drivers of current models.

Design Documents and Specifications

The technical teams focused on electricity and water noted that they anticipated developing concept-level design, narratives, and specifications, and at the time of the survey indicated that this work was currently in preliminary stages. Other project participants noted that they would not be developing these materials, but would need them to complete their analysis of project pros and cons.

Most project team members indicated that the primary elements to describe in design documents should be details of the physical infrastructure. Respondents also noted that design documents may include legal requirements and approach, installation, testing requirements, quantitative performance characteristics, scope of alternatives, modifications to existing utilities, maintenance requirements, and homeowner responsibilities. Project team members provided little distinction between design documents and specifications even when subsequently asked which were the most important elements to specify. Although specifications are more commonly understood as a detailed description of the design, materials, and the standard of workmanship, responses instead tended to include a broad array of project elements, such as costs, best practices, goals and benefits, lessons learned, and comparable programs.

Cost/Benefit

When asked what costs should be considered, team members most often discussed hard costs, specifically identifying building construction components for energy efficiency, photovoltaic equipment, electric vehicle charging, electrical conduit, hardware, and batteries. Several other respondents identified soft costs, such as design of the electrical system, water concepts, and alternative designs. Individuals also identified operations and maintenance as an important project cost to be considered and noted that resident transactional costs, such as hours present at home and detailed conversations with contractors can be substantial. Other noted costs ranged from loss of revenue (fewer utility customers), homeowner property limitations and/or community held property, public staff time for processes and reporting, review of permitting standards and legal requirements, and experimentation associated with piloting.

Project team member responses commonly identified five key benefits of the project:

- Greater sustainability and resilience
- Greenhouse gas emission and carbon reduction
- Scale efficiencies and more effective use of resources
- Reduction in utility bills and associated cost control
- Rapid technology development associated with proof of concept

These five benefits were consistently mentioned by a diversity of individuals, suggesting a more unified concept of the project's potential despite the team members' diverse viewpoints. Several other benefits identified included modernization, greater reliability, improved air quality, access to direct-current power, local control, faster deployment, social benefits associated with collective action, better living, and doing the right thing.

Project team members were asked to not only identify key assumptions when considering costs and benefits, but also discuss why they were important. The most common response was to assume that capital, operations and maintenance, and full lifecycle costs must all be considered. Individuals noted that calculations too often omit items that give an inaccurate picture of the full cost and/or value of project elements. Other respondents noted it is likely safe to assume that resident project improvements will go beyond solely cost savings because drivers such as societal benefits and resource conservation will be valued by residents, and that the benefits (e.g., sense of well-being for upholding environmental values) may be difficult to quantify. In addition, project team members believed that assumptions that energy and water rates will rise over time and technology costs will fall with greater use must be integrated into estimations, and that this variability will require a dynamic understanding of project costs and benefits. An individual noted that it may be a mistake to use industry standards and traditional business metrics, since they may not account for uncertainties inherent in a demonstration project and may not reflect motivations for participating.

Instrumentation and Monitoring Plan

Project team members were asked if and how they had assisted with the instrumentation plan and uniformly indicated that they had not assisted. An individual noted that the plan had not been completed yet and it would be developed as part of the technical team's recommendation.

Discussion

The analysis of the narratives emerging from the interviews with specific project team members revealed high levels of complexity between technical/utility/research elements and legal/political/community elements. The potential to promote a change in resource use and energy production at the block scale in an existing community remains experimental and challenging.

The planning process provided additional evidence that community-scale sustainability projects with aspirations of transforming cities require a consistent theoretical basis and attention to data development. The Oakland EcoBlock prioritized water and energy systems, but is silent on common ecological city variables such as waste, mixed-uses, or compact/high-density settlement patterns that potentially have significant effects on the consumption-based demand of a city block (Bayulken and Huisingh 2015; Thomson 2015). In addition, project team members acknowledged that a retrofit project would include pre-conditions and unknowns that effect both data development, and in turn, cost estimation, which is a critical decision-making factor in the planning process. Upgrades and installation necessary for each house would be highly variable, as maintenance and improvements have taken place over the lifespan of each home (+/- 100 years in some cases).

The interview results suggest that deploying the Oakland EcoBlock and scaling up the approach will be affected by factors identified in other research; specifically, the success to which the team can secure external support, develop generalizable approaches, and create compelling narratives (Ruggiero et al. 2018). First, it is necessary to identify who should support similar projects into the future to supplement limited state dollars and build external support, including resources, policy, and funding. Second, translating specific project experience into generalizable approaches that move beyond the specific Oakland EcoBlock case (i.e., policy guides and business models) is important. Finally, it will be essential to create a powerful narrative around the Oakland EcoBlock experience as a political device to further promote additional efforts using this same approach. Narratives are also needed for community-based social marketing already used by cooperatives to effectively reduce barriers to the adoption of renewable energy (Viardot 2013).

The results show that the Oakland EcoBlock project team was aware of the effects of influential project stakeholders that could be identified as working at the macro (government), intercommunity (intermediary organizations), and intracommunity (local champions) levels (Ruggerio et al. 2014). The state has defined climate goals and is providing the grant funding to undertake the study. Both the University of California, Berkeley, and the City of Oakland act as intermediary organizations, providing advice and guidance about research and political processes. The university project manager assembled academic and practice project partners, and a community member rallied neighbors to attend community meetings, each acting as local champions. One project team member noted specifically, "*Projects like this need a champion. The success is only because of Tony's [the university's project manager] pursuit, passion, vision and commitment. This is needed to bring together the results of the funded project.*"

The study supports findings that determining the right scale for a community sustainability project is specifically linked to planning, modeling, simulating, and demonstrating a specific project. District-scale zero energy projects present unique opportunities for renewable energy and energy efficiency, as well as other system efficiencies and conservation gains (Polly et al. 2016). The Oakland EcoBlock showed that the systems of water and energy are both likely to make gains at the block scale, with optimization for energy possible at the scale of a single block and water possible at a scale closer to sixteen blocks. This work resulted in the identification and description of economic drivers, retrofit program principles, and block-scale system design principles. The effort also allows for enhancement to modeling platforms and protocols, similar to the National Renewable Energy Laboratory's (NREL) partnership on two new district projects in Denver: The National Western Center and the Sun Valley Neighborhood (see the case studies below).

Although this study has described the planning process for a specific community-scale residential retrofit effort, the narratives emerging from the interviews revealed that future research should address how to prioritize community outreach earlier in the research and technical planning phases and how to improve data collection methods for a residential retrofit dependent upon current built conditions.

Conclusion

This chapter is aimed at understanding a project team's process for a community sustainability project, one that develops and documents an optimum design for implementation, to transform a neighborhood (and eventually a city) from a high energy and water dependency model to the lowest possible. It identifies the factors that allowed the project team to envision a block-scale, residential retrofit project to address today's challenges of resource scarcity, greenhouse gas emissions, and enhanced resilience.

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) despite a common understanding of benefits, a variety of disparate approaches must be used to verify benefits through implementation, measurement, and communication.

The study makes two important contributions. It thoroughly documents the project team's process for the Oakland EcoBlock to unlock the transformative potential of a community scale sustainability project. It also describes key factors in decision making (identifying the key constraints, concerns, and opportunities of the project) to understand ways in which similar efforts can be undertaken to achieve maximum energy efficiency, renewable energy production, water conservation, stormwater capture, and localized wastewater treatment to reduce use and capture flows.

For street-car suburbs throughout American cities, the design and implementation plan for the Oakland EcoBlock is encouraging. A plan to reduce the energy and water intensity of neighborhoods has the potential to address some of today's most dire needs. However, to realize this positive transformation, teams will need to develop new legal and governance structures along with robust community processes; identify and create revenue sources for demonstration projects and the associated emerging markets for technology; and continue to implement, document, and communicate the benefits of this residential retrofit (and new build) community-scale sustainability projects.

Comparable Case Studies (Projects)

Table 10-2 summarizes 10 case studies of comparable projects. The team examined three case studies (Regen Villages, Bayview GLEN Snap, and Sun Valley EcoDistrict) for their similarities with the goals and aims of the Oakland EcoBlock project, and an additional three cases (UC Berkeley Global Campus, ParkMerced, India Basin) are profiled because they are district-scale developments in the Bay Area with strong environmental goals and aims (Figure 10-4 and Figure 10-5). In addition, four cases of interest (Smart City Shioashya, N Street Co-housing, Hydebygade Block, Transition Zero) were included.

Table 10-2: Case Studies of Projects Comparable to the Oakland EcoBlock

Name	Location	Program Type	Construct Type	Site Area (acres)	Dwelling Units	Date
Regen Villages	Almere, Netherlands	New Town, Residential	New	3.9	25 Pilot Homes	2016 Ongoing
Bayview Glen SNAP	Toronto and Region, Canada	Urban Renewal, Residential	Retrofit	Varies	Varies	2016 Ongoing
Sun Valley EcoDistrct	Denver, CO, USA	Mixed-Use, Residential	Retrofit & New Construction	100.0	1,083	Ongoing
UC Berkeley Global Campus	Richmond, CA, USA	Research Campus	New Construction	134.0	0	Vision Plan 2016
ParkMerced	San Francisco, CA, USA	Mixed Use, Residential	Retrofit & New Construction	152.0	3,221	Vision Plan 2012
India Basin	San Francisco, CA, USA	Mixed-use, Residential	New Construction	23.0	1240	Concept Plan 2018
Smart City Shioashya	Hyogo, Japan	Residential	New Construction	29.7	500	Launch 2012
N Street Co-housing	Davis, CA, USA	Residential	Retrofit & New Construction	3.0	19	1999
Hedebygade Block	Copenhagen, Denmark	Residential	Retrofit	35.0	350	1996
Transition Zero	Nottingham, UK	Residential	Retrofit	10	9	2017

Source: Skidmore, Owings & Merrill, LLP

Regen Villages, Almere, Netherlands

Regen Villages is an off-grid integrated, regenerative, resilient eco-village that can power and feed self-reliant families around the world. Each completed village will house approximately 100 families on about 50 acres (1 family/2 acres). Agreements to develop Regen Villages include Sweden, Denmark, Norway, Germany, and Belgium.

Web Address: http://www.regenvillages.com/

Bayview Glen SNAP, Toronto and Region, Canada

Bayview Glen SNAP is an innovative model for sustainable urban renewal in older existing neighborhoods. Each neighborhood plan contains measurable outcomes that help make the business case for implementation. Plans include strategies to achieve stormwater targets, identify stormwater re-use potential, grow an urban forest and increase natural cover, provide eco-services, measure water and energy savings, and characterize other social co-benefits.

Web Address: https://trca.ca/wp-content/uploads/2016/10/SNAP-Summary2014_SinglePg_WEB.pdf

Sun Valley EcoDistrict, Denver, Colorado

The Sun Valley EcoDistrict is a neighborhood redevelopment that includes existing public housing, new mixed-income housing, a 30,000 gross square feet multi-use office building, and a mixed-use transit station stop for the Decatur-Federal light rail station. The anticipated outcomes include open space watershed restoration, 15 to 20 percent energy reduction through district energy and water, and place making by prioritizing an attractive public realm and economic opportunity.

Web Address: http://www.sved.org/

University of California, Berkeley Global Campus, Richmond, California

The UC Berkeley Global Campus is a joint effort by UC Berkeley and the Lawrence Berkeley National Laboratory envisioned for the 135-acre UC Berkeley Field Station in the City of Richmond. The proposed electrical system is an AC/DC hybrid system configured as a 1000 V DC site distribution layered onto the 12.47 kV AC System. The DC generation plan includes natural gas generators, PV and battery storage and DC distribution, with radial DC feeders to each building, to serve loads such as lighting, telecommunications, servers, DC motors, and computers.

The proposed wastewater and recycled water system includes on-site wastewater conveyance with a gravity system and the option to pump the regatta property to a sewage treatment plant dependent on water balance. An on-site wastewater treatment plant is planned with first phase build to minimize the impact fee ($5/gallon one-time impact fee to City of Richmond). Recycled water will be used for toilets, irrigation, and cooling, and the winter supply is likely to be greater than the demand, potentially offering an export opportunity. Storage will include a minimum surge storage and elevated campanile storage. Additional tanks are proposed for thermal storage, to add resiliency. Finally, resident use times and water quality considerations will allow for a slow drip return through the proposed sewage treatment plant.

Web Address: https://chancellor.berkeley.edu/sites/default/files/BGCRB-1sheetDec2014.pdf

ParkMerced, San Francisco, California

ParkMerced set sustainability goals across all resource groups, including a 60 percent carbon reduction, 56 percent energy use reduction from the grid, 60 percent potable water consumption reduction, 60 percent wastewater reduction, and 100 percent of stormwater handled on site. Green infrastructure elements include a district energy and water loop, solar-ready rooftops, micro power grids, wind turbines, air-source heat pump, green food chain, and water recycling. The hydrological approach includes bio-swales and a bio-gutter, cisterns, and a stream corridor. The open space strategy provides hedgerows and bio-swales, community gardens, neighborhood gathering spaces, a green connector, a recreation and active plan, and an organic farm and stream corridor.

Web Address: https://parkmercedvision.com/

India Basin, San Francisco, California

India Basin is a mixed-use residential development that includes a water, energy, and environmental strategy. The project will treat 100 percent of stormwater and a portion of the wastewater on site and include efficient plumbing fixtures. The plan includes integrated ecological corridors, including green and solar-ready roofs. A strategy to achieve a zero-net energy public realm includes a DC micro-grid in association with DC parking and site lighting, battery storage, and electric-vehicle charging. The buildings will be predominantly electric with high-efficiency systems and high-performance building envelopes. The project is designed as an active site with a large park, bikeway, bay trail, and access to water recreation. Finally, India Basin includes a living shoreline for coastal adaptation.

Web Address: http://indiabasinsf.com/

Additional Projects of Interest

- Smart City Shioashya, Hyogo, Japan, includes 117 homes that utilize Japan's first microgrid. Web Address: http://news.panasonic.com/global/topics/2017/50883.html
- N Street Co-Housing, Davis, California, United States, is a traditional mid-1950s subdivision that has transformed into a co-housing community. Web Address: http://nstreetcohousing.org/
- Hedebygade Block, Copenhagen, Denmark is block renovation that became an urban ecological demonstration project that integrates high-technology products and fosters an international exchange of knowledge. Web Address: http://www.cardiff.ac.uk/archi/research/cost8/case/holistic/denmark-block.PDF
- Transition Zero is stimulating deep energy efficiency retrofits in social (public) housing by reducing retrofit time to one week, using both standardized procedures and prefabricated modules. Web Address: http://transition-zero.eu/

Additional Programs and Organizations of Interest

- Energiesprong Program focuses on whole-house refurbishment, a new build standard, and a funding approach to create desirable, comfortable, and affordable homes for everyone. The program is run by an independent market development team that focuses on comfortable, super-energy-efficient retrofits (and new build) with guaranteed performance, as well as new financing approaches and improving government regulations to support these solutions. The program's mission is to scale this approach to other markets. Web Address: http://energiesprong.eu/
- Resilient Neighborhoods Program organizes climate action teams that reduce household carbon footprints and enhance emergency preparedness. Individuals join a team and use their computer and utility bills to reduce carbon dioxide pollution across a neighborhood. Web Address: http://www.resilientneighborhoods.org/
- Open Path Investment Program – Urban Village organizes apartment communities by designing a gathering room, facilitation, and developing community-inspired programs that incorporate sustainable practices (yoga, community gardens, dog park, etc.). Using these methods, the program seeks to transform ordinary apartment spaces into thriving communities. Web Address: https://openpathinvestments.com/urban-village/
- Energy Foundation supports education and analysis to promote policy solutions that advance renewable energy and energy efficiency in the U.S. and China. Web Address: https://www.ef.org/
- Energyville is focused on becoming one of the top five European institutes in innovative energy research. Web Address: http://www.energyville.be/en/about-energyville/

Figure 10-4 shows examples of the Oakland EcoBlock and Figure 10-5 shows the size and scale of the example case studies.

Figure 10-4: The Oakland EcoBlock and Six Other Example Case Studies

OEB PARKMERCED INDIA BASIN UC BERKELEY GLOBAL CAMPUS REGEN VILLAGES SUN VALLEY ECO-DISTRICT BAYVIEW GLEN SNAP

Oakland EcoBlock compared to Bay Area example projects and global district-scale retrofit projects
Credit: Skidmore, Owings & Merrill, LLP

Figure 10-5: Size and Scale of the Example Case Studies

Case Study projects described by size and scale.

Credit: Skidmore, Owings & Merrill, LLP

CHAPTER 11: Outreach Plan

Abstract

The Oakland EcoBlock's ambitious goals have the potential to chart a new course for aging urban neighborhoods throughout California. But a neighborhood is not only comprised of physical space—it relies on people to make it sustainable and vibrant. Engagement of property owners and existing residents in all future EcoBlock or EcoDistrict planning, design, and implementation will be essential. And, given the scope of changes that EcoDistrict designs suggest for residential communities, stakeholder engagement will take significant time and resources until this type of development (and approach to living) is considered commonplace in California.

Additional study should be conducted to better understand resident and property owner barriers to participation, in efforts to streamline and improve the overall engagement process for stakeholders and increase the viability of this development type. Future EcoBlock development efforts should acknowledge the significant investment of time and resources necessary to overcome barriers to engagement. Future assessments of EcoBlock implementation potential should consider stakeholder engagement risks alongside design feasibility.

Social Sciences Team

The Social Sciences team was comprised of outreach and research members. Community engagement specialists (Outreach team) developed the outreach strategy described as follows. The graduate student researcher conducted in-depth interviews with residents and property owners (IRB Protocol ID 2016-10-9271) to inform the outreach strategy and assessment of project feasibility. Findings from this research are included in the "Resident Interviews" section below.

Oakland Pilot Outreach Activities

The project team selected a community block within the Golden Gate Neighborhood in Oakland, California, as the subject of the feasibility study. The Outreach team developed and implemented an outreach strategy for the block. The project was characterized in two phases to the block residents: the first being a feasibility study, and the second, dependent on funding, being the implementation of the feasibility study recommendations. The following summarizes the project team's outreach efforts. The information gathered from the block is reflected in the final outreach recommendation for EcoBlock implementation across California.

Background

Prior to the start of the project, Anthony Nahas (project manager) spoke with residents of various neighborhood blocks in the East Bay. Ultimately, the block in Golden Gate

Neighborhood in Oakland showed the most promise and interest in the project. Some information gathered during the initial engagement was provided to the Outreach team to inform the development of the outreach strategy.

Outreach and Engagement Strategy

The Oakland EcoBlock is a complex and groundbreaking project that requires stakeholders to participate in changes to their homes and neighborhood that will significantly impact their lives. This impact will go beyond what a traditional neighborhood planning process would entail. Because of the degree of potential impact to stakeholders, the focus on Phase 1 engagement was to understand stakeholder interests, perspectives, and concerns, and to identify a robust engagement process to implement in Phase 2.

Objectives for Stakeholder Engagement in Phase 1

The initial objectives for stakeholder engagement were to gather input on interests and concerns, and to conduct targeted engagement around design options. These included the following:

- Understand resident and property owner interests, concerns, and aspirations as they relate to participation in the creation of an EcoBlock.
- Understand what information is most essential to the resident decision-making process about the EcoBlock, and convey this information in a way that all residents and property owners can comprehend and evaluate it.
- Identify a process by which those most affected by the EcoBlock concept are involved appropriately in its design and implementation.
- Identify a process for resident participation in ongoing design and decision-making for the EcoBlock, and develop a broader roadmap for stakeholder participation in EcoBlock implementation.

Objectives for Stakeholder Engagement in Phase 2

Phase 2 stakeholder engagement objectives were focused on providing information and updating residents on the implementation of the proposed recommendations from Phase 1. These included the following:

- Convey complex information about project options and trade-offs in a way that all residents and property owners can understand and evaluate
- Implement the roadmap for each stakeholder constituency's participation during EcoBlock implementation

Desired Outcomes for Stakeholder Engagement

Through this targeted engagement, the team sought the following outcomes:

- Residents and external stakeholders understand their role and related opportunities for involvement in the decision-making process.
- Residents understand the trade-offs involved in design decisions and have the tools they need to evaluate those trade-offs.

- Residents understand the opportunities presented by the EcoBlock project.
- Residents converge around a preferred alternative for the design of the EcoBlock.
- All stakeholders understand the intent of the EcoBlock project and its process.

It is important to note that the stakeholder outreach and engagement strategy was resident focused. An additional and pivotal stakeholder in the creation of an EcoBlock were the utilities that provide residents with energy and water. In this case, Pacific Gas and Electric and East Bay Municipal Utility District acted as quasi project members, providing the team with details of infrastructure on the block and expertise with existing systems to inform design decisions. How utilities should be engaged in an EcoBlock is discussed later in this chapter.

Timeline of Engagement with the Oakland EcoBlock

In early 2015, the planning area was identified through the project manager's personal connections. After some initial conversations with groups of residents who were familiar with one another, the project manager concluded that the block would be a good candidate for the pilot design, and also introduced project leadership to some of the residents. Some informal outreach and data collection began in the summer of 2015, in preparation for the formal application to the EPIC grant that funded this work. The project manager continued to stay in touch with some residents to keep them apprised of the project progress.

Formal outreach began with "meet and greets" with homeowners on June 3, 5, and 7, 2017. Focus groups were conducted on July 11, 12, 18, and 19. Finally, the team conducted a charrette on August 12. Table 11-1 lists the various outreach activities the project team held to solicit input from block residents.

In addition to these community outreach efforts, all planning area residents and property owners were invited to participate in an in-depth interview, discussed in the "Resident Interview" section.

Table 11-1: Outreach Meetings

Outreach Activity	Stakeholders Involved	Goal	Timing of Activity
Meet and Greet	18 total residents attended three separate but identical meetings.	• Provide project background and expected outreach calendar • Introduce block residents to the Social Sciences team • Gather residents' initial thoughts and concerns about the EcoBlock • Gather contact information and preferred timeslots for the energy interview	June 3, 5, and 7, 2017
Focus Groups	16 total residents attended four separate but identical meetings.	• Share general information about the EcoBlock • Gather resident input on needs and aspirations related to how they live in their homes/neighborhood • Gather information on resident preferences relative to elements of water and wastewater (WW) systems, electrical systems, and electric vehicles to inform design options or alternatives • Distribute and explain Utility API[41] release forms	July 11, 12, 18, and 19, 2017
Charrette	6 residents attended one spatial planning focused meeting.	• Share options or alternatives for EcoBlock water, wastewater, and electrical systems design • Energy Systems: Reliable DC, Reliable AC+DC, Reliable AC, ARDA Power Inc. DC Microgrid • Water Systems: No Central WW, With Central WW • Wastewater: Limited Street Improvements, Full Street Redesign • Convey how resident input has been incorporated into the options, and where there are gaps • Gather input on preferences for elements of the design(s) to aid in the selection of a preferred alternative • Gather input on general preferences for management of block resources	August 12, 2017

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[41] Utility API is a third-party application that allows residents to provide permission to utilities to release information related to their utility use. Permissions were gathered through Utility API by the Outreach team for use by the Energy team.

Source: UC Berkeley

For each outreach meeting held, the project team developed and used various tools and exercises to solicit detailed input from block residents around various aspects of the project.

Table 11-2 summarizes these tools and when the project team used them. All tools were supplied to residents in hard copy, both through canvassing and electronically, to residents who provided their email address. All outreach materials are compiled into Appendix N.

Table 11-2: Oakland Pilot Engagement Tools

Tool	Purpose	Meeting
Electric Systems Design Board and Workbook	Provide general information, and gather input on design examples of possible electrical infrastructure for the block and individual retrofits to block residents	July Focus Groups; August Charrette
Water Systems Design Board and Workbook	Provide general information and gather input on design examples of water infrastructure on the block and individual retrofits for block residents	July Focus Groups; August Charrette
"What is an EcoBlock?" Board and Workbook	Provide block residents with general background information of the project and contact information of project staff	July Focus Groups; August Charrette
Governance Workbook	Gather input on preferences around how residents would like the EcoBlock to be governed.	August Charrette

Source: UC Berkeley

All tools were designed in consideration of the fact that the development of an EcoBlock is potentially disruptive to the residents. The use of display boards and handouts to support conversations was intended to encourage discussion with project members and residents regarding their interests and concerns. Additional details about the tools and their use is provided below.

Electric Systems and Water Systems Design Boards and Workbooks: The design boards asked various questions regarding energy efficiencies and water use and management on a hypothetical EcoBlock. Possible design elements that could address the various questions were listed and their purposes were explained. Resident feedback regarding the displayed design elements was gathered.

During the focus groups project members would present the boards to residents and would either lead a discussion with the group or ask residents to provide feedback individually. The design boards were displayed during the August charrette to allow residents whom were not able to attend the focus groups to provide feedback.

"What is an EcoBlock?" Board and Workbook: Typically, a project fact sheet is developed to provide background information to stakeholders. Because of the unique nature of the EcoBlock project, the Outreach team developed a board, and eventually a workbook, to provide background information. The board specifically addressed what an EcoBlock is, why it should be studied, length of the project, how residents could participate, and how they could receive more information.

Governance Workbook: The Governance Workbook posed various questions regarding resident's comfort and preferences in the management of the EcoBlock. Questions included what role they play on the block, how involved they would like to be, how costs should be incurred, preference of a third-party management entity and its characteristics, and the importance and allocation of benefits. The document provided multiple, and often detailed, answers to the questions, at times utilizing a sliding scale to indicate preference.

The Governance Workbook also included questions regarding energy and water management on the hypothetical EcoBlock. The project team used the feedback from the electric and water systems design boards to develop exercises that provided more tangible feedback. Rather than provided feedback on single design element, residents provided feedback on a sliding scale, indicating their preference on combinations of design elements most likely used.

Residents whom attended the August charrette received the Governance Workbook. It was later distributed during canvassing efforts and via email to residents whom did not attend.

Resident Feedback

Generally, block residents supported the EcoBlock project from a design standpoint only, providing a few caveats for their support such as keeping some gas appliances (stove and dryer) and no blackwater recycling on the block. Most concerns voiced involved the governance of block resources, funding, and how much control their neighbors had on their action. Below are the common themes and frequently asked questions from block residents at each meeting.

Meet and Greet

Residents provided very general feedback regarding preferences on scheduling and notification and voiced concern over the gas appliance and blackwater recycling issues. The residents also preferred having a data-driven and provable approach to the design process. The following questions were received:

- What has changed since the last year?
- How do property sales affect the project?
- Are renters allowed to participate, if so, how?
- Is there a minimum amount of residents needed to participate?

Focus Groups

During the focus groups, residents participated in an exercise that posed two questions: (1) what do you like about your block now, and (2) what do you wish to change? Block residents enjoy the greenery, location, quietness, safety, parking, and familiarity of the block. Changes residents wanted to see were varied, and included introduction of public art, an increase in transportation access, a bike lane, sidewalk improvements, community space or community activities, improved safety, and water infrastructure.

For the second half of each meeting, project staff introduced energy and water design boards followed by a lightly facilitated question and answer session. Residents were then asked to provide feedback on various water and energy design examples that could be implemented on the block. Generally, residents expressed excitement for the design elements displayed for both water and energy. Some residents expressed concern for reclamation and treatment of wastewater on the block, as well as impacts during construction for residents who work at home. Two common and reoccurring questions asked during the four focus groups were how block resources would be managed and what the final design of the block would look like.

For additional details, including common themes and frequently asked questions, please see Appendix N.

August Charrette

Based on small attendance numbers, an "office hours" approach was taken for the August charrette, allowing attendees to talk to project staff one-on-one while reviewing a large aerial photo of the block. A PowerPoint presentation was available for attendees, outlining the scope of the EcoBlock project, including feedback from community meetings, the design process, and next steps. After the presentation, attendees were asked to provide written feedback by filling out water and governance workbook handouts that were distributed during the charrette.

Attendees' concerns included how many residents are required to make an EcoBlock, details concerning the implementation and construction on individual houses, how the project is funded, and the funding necessary to implement the project. For a full list of questions, please see Appendix N.

Some attendees returned completed water and governance workbooks at the end of the meeting. The governance workbook posed general questions regarding residents' comfort with varying levels of participation in the governance of the EcoBlock, how fees would be calculated, preferences on outside management and possible ownership, and preferences on energy usage. Generally, respondents wanted to be very involved in governing the block and would be willing to pay a monthly or regular fee, bill, or equivalent increase in property taxes for operations and maintenance if the cost were covered by savings on their utility bill. When asked about management of EcoBlock systems, respondents were not comfortable with a local government agency or entity taking on that role, and prioritized utility certification over government certification, nonprofit, and for-profit entities. Responses regarding energy usage and electrical vehicle preferences varied, but all respondents were willing to select direct current compatible appliances, efficient electric space-heating and water-heating units, electric storage at their house, and solar panels on their house.

The water workbook asked preferences on how to make homes more water efficient, wastewater management, and how to green the streets and improve stormwater management. Respondents preferred native plants, efficient irrigation systems, and water recycling on the block to improve home water efficiency. All respondents supported wastewater treatment and recycling serving the entire block, while their views differed on how to green the streets and improve stormwater management.

Canvassing Efforts

In addition to the activities discussed above, the Outreach team periodically canvassed block residents. The purpose of the canvassing efforts was primarily to collect authorizations from residents to release their utility data. The project team used various methods, including door-to-door canvassing, office hours, and cash incentives to collect the information. Nineteen residents provided utility data to the project team.

Common Themes

The engagement and outreach process was primarily focused on block residents during Phase 1 of the EcoBlock project. It is important to note that though block residents are a primary and important stakeholder in the process, there are other stakeholders in designing an EcoBlock. For a more detailed review of stakeholders when developing an EcoBlock, please see the Outreach and Engagement section below.

Resident Interviews

Twenty-four resident interviews were conducted between June and November 2017. These interviews covered three topic areas: perceptions of potential project benefits and drawbacks, personal history and experiences in the neighborhood, and relationships with neighbors. A paper questionnaire was also distributed, which included questions about energy, water, and transportation use habits. These meetings lasted 1.5–2 hours, and respondents were given $50.00 for their participation. With permission, interviews were audio-recorded in all but two cases. Interviews were conducted with both single residents and couples.

Residents were recruited for meetings at the Meet and Greets described above, as well as through mailed letters (addresses were obtained from the Alameda County Parcel Assessor's database). Absentee property owners were also contacted via mail at addresses listed on the parcel assessor's database, but no responses were received.

Project Benefits

Superficially, perceptions of potential project benefits were broadly consistent. For almost all, the thought of living in more ecologically sustainable, well-maintained, and energy- and water-efficient homes was very appealing. For tenants who had negative experiences with landlords over maintenance requests—leaking plumbing, broken heating, flooding sewage—the EcoBlock project meant hope for more livable housing.

Likewise, for owners who saw need for improvement in city infrastructure, the EcoBlock meant hope for a more livable and green city, and a substantial potential return on their housing investment. A few residents described this as an obvious "boon" to property owners on the block.

An increased sense of community was chief among the potential benefits cited. For some respondents, the EcoBlock outreach meetings themselves were the first time they had spoken with or met some of their neighbors. Residents also registered a sense of hopefulness about community-scale solutions in light of frustration with national politics. However, this optimism about community involvement and cohesion was tempered by disenchanting experiences in homeowners' association politics, community garden management, and inefficiencies or suspected corruption in local government. Still, some saw the work of planning participation, and establishing and engaging in governance systems for ongoing maintenance, itself constituting a worthy form of public service.

Global environmental concerns figured into some residents' perceptions of benefits. Some resident respondents saw themselves as having exercised all potential avenues for behaving in a sustainably (such as buying organic food, recycling, bicycling, taking public transit) and felt frustrated by what remained out of their control (such as utility decisions about energy procurement, national politics, environmental policy, and wasteful industry practices). In this sense, the EcoBlock project could be environmentally empowering. Some residents directly mentioned the merits of "testing the case" of an ecologically sustainable urban city block, and were eager to participate in support of the project.

Project Drawbacks

Residents' sense of project drawbacks varied widely: from seeing few to no drawbacks at all, to being unable to speculate, to seeing such substantial drawbacks as to be opposed to the effort entirely.

One resident raised conversion to electric stoves as non-negotiable point—she would refuse to participate in the project altogether if it meant losing access to gas cooking. Others saw it as a fair trade-off to make in exchange for new appliances and a more ecological lifestyle.

Some raised concern over blackwater harvesting and treatment in connection to physical and spiritual health. Blackwater harvesting would involve tapping into the block's shared sewage line and diverting wastes for onsite treatment for outdoor use. They worried that medications and other insoluble wastes would make their way into food grown onsite.

A few residents discussed a recent campaign against a new cell tower that had been planned for installation on a local building. Concern over EMFs (electromagnetic fields) and their effects on health motivated the successful opposition campaign, and some residents also expressed concern over EMFs from electric vehicles.

Concerns over changes to property values arose in a few different ways. For tenants, potential rent increases were top of mind. Depending on their relationship and level of trust with their landlord, some anticipated that landlords might try to justify a rent increase after upgrades were complete. Owners, on the other hand, did not raise concerns about property values, except concern that the project could trigger reassessment and increased property taxes.

Some residents also expected the EcoBlock retrofit to attract attention to the neighborhood. One saw the prospect of media attention in a positive light. Others worried about increased traffic, exacerbated parking issues, or even heightened crime if the quality of the neighborhood increased dramatically relative to neighboring blocks. Similarly, a few cited some measure of concern over adjacent blocks becoming jealous; or disappointment that their neighbors across the street would not be included.

The concept of the “block” in the context of the project also drew some criticism. Many residents, when asked to describe their social connections in the neighborhood, included acquaintances from areas not included in the planning effort, since their social connections were stronger with neighbors on the opposite side of their street.

Neighborhood Relationships and EcoBlock Governance

Enthusiasm for a more community-minded neighborhood was tempered by wariness about loss of privacy, loss of physical and even emotional boundaries with neighbors, and exposure to risk and invasion from strangers. One interviewee recounted once living in a community that had removed fences and a shared backyard. They emphasized that this worked because they had a shared spirituality and value system. Many interviewees saw “shared values” as essential to a successful EcoBlock. Others felt more confident that the right legal structures and monitoring and control technologies would ensure that the EcoBlock could function properly regardless of differing beliefs and social relationships.

The majority of residents felt comfortable with a shared utility metering system, as long as there were assurances that all residents would continue to pay their fair share, and that no bad actors would manipulate the system. But the installation process, and that of the project approvals in general, raised concern among tenants who had challenging relationships with their landlords or property owners.

Challenges

The first phase of the project being a feasibility study caused confusion for block residents when they were approached for their input on design and governance options. The project team did not define what role block residents had in the process, which added to their confusion. However, even if the project team had defined resident’s roles, a paradox still exists in requesting input on design features during a feasibility study for community development.

A major challenge throughout the outreach process was encouraging block residents to participate. Typically, in a collaborative process stakeholders have factors, or needs, that drive them to participate in the process. For the Oakland EcoBlock pilot project, no obvious drivers provoke block residents to participate. The block residents who participated primarily were sustainability advocates who were personally invested in the success of the EcoBlock because of their own beliefs. In an attempt to leverage their participation, the project team often requested the sustainability-minded residents to invite their neighbors to meetings, which had mixed results.

Another challenge the project team encountered was “meeting fatigue” for block residents. Meeting fatigue occurs when individuals must participate in multiple meetings and typically multiple processes. This challenge affected a large apartment building that had just been segmented into condominiums and sold to individual buyers whom were unaware of various issues the building had. The Outreach team tried to reduce the outreach to the apartment residents by primarily interacting with the homeowners association (HOA) for the apartment building as a “key communicator” that could interact less formally with the apartment residents.

Some challenges the project team faced were caused by a compressed outreach schedule that prevented the Social Sciences team from conducting a stakeholder assessment for block residents. During Phase 2 of the project, the following is recommended:

- Conduct a stakeholder assessment to identify preferred outreach methods.
- Establish a block advisory group that meets periodically with project team members and provides detailed input.
- Provide meeting notifications to residents earlier.

Outreach and Engagement History and Best Practices

The Practice of Public Involvement and Stakeholder Engagement over Time

The evolution of stakeholder engagement as a professional practice and area of academic inquiry has occurred relatively recently. Early twentieth-century land use planning efforts encouraged a limited amount of citizen involvement through statutory requirements in zoning, for example, the Standard Zoning Enabling Act of 1926 by the U.S. Department of Commerce, which required public notice and access to hearings. Around the same time, the Federal Administrative Procedure Act set rules for public comment, helping set the stage for further public involvement (Beierle and Cayford 2002, 3)

By the mid-twentieth century, planning and zoning commissions, public newspaper notices, and public meetings had become common tools for local governments. By the 1960s, President Johnson’s Great Society program had created the Office of Economic Opportunity (OEO), which required that its social programs be “developed and conducted with the maximum feasible participation of the residents of the area.” (Beierele and Cayford 2002; Goodspeed 2008).

In this climate of cultural and urban change of the 1960s and 1970s, the influential theory of public participation was proposed in an article by Sherry Arnstein (1969). Professional land use planners became increasingly interested in public participation in the decades that followed, aided by federal investment in multiparty stakeholder negotiation in federal projects. The field grew, such that by the 1980s and 1990s, professionals working in the fields of planning, architecture, engineering, and natural resource management could expect to encounter public participation as a regular component of most projects.

As noted by James Creighton (1998), “During the 1970s, a number of people worried that environmental conflicts were so antagonistic that they were not productive for anyone. From this concern came the idea to use the techniques—particularly mediation—that had worked in labor/management negotiations and apply them to resource decisions.”

In the 1980s, “integrated” or “interest-based bargaining” emerged as a solution to regulatory and resource conflicts, applying a mutual gains approach to negotiation. This approach seeks to generate a range of options that emphasize party’s interests, rather than their preexisting positions. Participates are seen as collaborative problem solvers rather than opposed parties (Fisher and Ury 1981).

In 1990, the International Association for Public Participation (IAP2)[42] was founded in response to the global interest in public participation. The organization grew quickly with the current mission to advance and extend the practice of public participation. While the rationale behind conducting public or stakeholder engagement may vary by project type and location, in general, IAP2’s core values for the practice of public participation summarize the importance of engagement as a tool:

- Public participation is based on the belief that those who are affected by a decision have a right to be involved in the decision-making process.
- Public participation includes the promise that the public’s contribution will influence the decision.
- Public participation promotes sustainable decisions by recognizing and communicating the needs and interests of all participants, including decision makers.
- Public participation seeks out and facilitates the involvement of those potentially affected by or interested in a decision.
- Public participation seeks input from participants in designing how they participate.

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[42] International Association for Public Participation. www.iap2.org.

- Public participation provides participants with the information they need to participate in a meaningful way.
- Public participation communicates to participants how their input affected the decision.

Overview of Best Practices

Best practices in stakeholder engagement and public involvement now seek to achieve durable decisions though the application of these values and the lessons of a mutual gains approach to negotiation. Additional components of best practices in stakeholder engagement include the following:

- **Preparation for productive engagement.** While effective facilitation is essential for successful meetings, thoughtful preparation and detailed follow-up are also critical. Meeting goals and intended outcomes should be clearly identified, with agendas developed to help achieve those outcomes. Meeting facilitation plans should also be used to outline the choreography and sequencing of the meetings and to achieve intended outcomes.
- **Engagement to the situation.** An extensive toolkit of best practices exists to facilitate and manage meetings and other engagement processes to ensure there is open, creative dialogue. Facilitators can design meetings to achieve specific goals (e.g., brainstorm, prioritize, make decisions), and can transition between techniques as the need arises. Diverse groups often require creative problem-solving and navigation of group dynamics through the collaborative process. Engagement approaches may vary by stakeholder type, geographic location, and subject matter type, and should reflect the resources available.
- **Focus discussions on interests rather than positions.** Stakeholders should be engaged at the level of interests rather than positions, and be shown that joint problem-solving is a productive way forward.
- **Maintain neutrality.** Neutral, third-party party participation in meetings and processes helps to reduce the emphasis on stakeholder positions. This neutrality helps to ensure that engagement is inclusive, informative, respectful, meaningful, and mutually beneficial.
- **Ensure information and participation opportunities are easily accessible.** A variety of methods should be used to ensure that project information is accessible, and that opportunities for stakeholders to provide input are convenient. This may mean using digital communication and engagement techniques, multi-language approaches, or other methods to reach all interested stakeholders.

Risks and Misalignments in Public Participation

While public participation in urban development is typically perceived as beneficial to the projects and their sponsors or local governments, there is some research that argues that public participation may not be beneficial if the process is not alignment with the participants' needs (Cohen 2015). Misalignments can occur at the process level, can be cultural or socioeconomic, or can result from historic low levels of participant trust or civic engagement. Mitigation strategies exist to help correct misalignments in public participation processes. As outlined by Cohen (2015, 44–50), those which are of particular relevance to the Oakland EcoBlock situation include the following:

- Researching community needs and assets before designing the process
- Keeping events short
- Providing resources to participants
- Include community members in positions of leadership
- Evaluate participatory processes in real time
- Present the entire process
- Interview participants before designing the process
- Preselect feasible options to facilitate deliberation of options

A Recommended Approach to Stakeholder Engagement

Situational or Stakeholder Assessment

A comprehensive stakeholder engagement process begins with an assessment of stakeholder interests. Often called a “situational assessment,” this exercise helps to identify and separate interests from positions. This effort also defines the realm of stakeholders for any given project, and clearly identifies the need to either expand the outreach to address all identified stakeholders or to right-size the approach to ensure proportional engagement.

This step should also identify the historical context and current issues coloring the landscape in which the project or engagement process exists, and lead to a better understanding of whether residual conflicts exist between engaged parties, such as a historic lack of trust between a disadvantaged community and a local government.

Engagement Strategy Design

The next step in the process is to apply best practices and lessons learned to the findings of the situational and stakeholder assessment, to design an appropriate engagement strategy.

The engagement strategy then serves as a roadmap for stakeholder engagement, enabling all project team members to discuss and understand their roles and how engagement timelines correspond to overall project timelines.

The core of the engagement strategy must also articulate the desired outcomes of the process, such that all participants recognize:

- What is the decision to be made?
- Who will make the decision?
- Who will influence the decision, and to what degree?
- What will define success for the engagement process?

Engagement Strategy Implementation

The final step in the process is to implement the strategy that has been developed. It is important, throughout implementation, to be cognizant of the tools and techniques that are utilized and whether they are achieving the desired outcome. A mid-process evaluation of the strategy's effectiveness is recommended, in the event that it should be revised to better address evolving project information, political or cultural situations, or new information about stakeholder interests.

Engaging California Communities about EcoBlocks

California's diverse sociodemographic and political landscapes mean that communications and engagement approaches can vary broadly by geography, particularly when focusing on climate change, adaptation, and resiliency. In addressing these issues with various California communities, communications should address the issues of greatest concern to each stakeholder group.

Identifying how to address the interests of individual stakeholder groups should be undertaken in service of collaborative decision making, rather than marketing. This differentiation is significant. Stakeholder engagement efforts should focus on communicating factual information about the project and decision to be made, rather than attempting to "sell" the project to influence the decision. It is paramount that project team members acting as intermediaries between stakeholders and the project or decision-making body retain their neutrality throughout the process and are continually seen by both sides as "honest brokers."

Working with Different Community Profiles

A decade ago, discussions of climate change often began with doom and gloom scenarios. Cities and community leaders have now changed their approach to focus instead on the "co-benefits" of climate change mitigation and adaptation. Put another way, mitigating climate change on a local level involves the implementation of a number of discrete actions: install solar panels, increase permeable pavement, encourage kids to ride bikes to school, and so forth. Taken individually, these actions can be far more understandable, and even palatable, to community members than the amorphous, frightening and seemingly insurmountable charge of stopping or slowing climate change.

For example, in communities where government is perceived as untrustworthy and wasteful, the concept of self-reliance through distributed energy generation or microgrid may be compelling to community members. In the nonprofit sector, organizations are working to identify effective messaging and communications approaches that are accessible and engaging for a broad number of Americans. Good guidance on messaging and language can be found from the Local Government Commission.[43]

While the shift from talking about sustainability in broad strokes to talking about specific improvements has occurred, there is room to improve and customize the way information is shared and community interests are addressed.

For this reason, it is important to understand what each community values or is concerned about prior to engaging around technical subject matter. In the case of the Oakland EcoBlock, distinct constituencies within the block may perceive messages on sustainability improvements differently. Furthermore, with future state policy direction emphasizing the importance of funding improvements in disadvantaged communities, stakeholder engagement approaches should take into consideration the particular needs of these communities in their design.

Additional Factors for Success for the Oakland EcoBlock

During the course of this project, three additional factors for success were identified. These factors are consistent with best practices in stakeholder engagement and conflict resolution, and are summarized as follows.

Is engagement proportional to the impact a party will have on a decision?

Underlying each engagement process is the concept of return on investment. If stakeholders are asked to volunteer a significant amount of time to participate in the process, they develop an expectation of ownership over the decision. This can be a benefit in instances where the desired outcome is capacity building or encouraging implementation action *and* the participants will have a significant role in the decision-making process. However, if the participants will not have a significant role *and* they are asked to significantly contribute, there is a disproportionate burden placed on the stakeholder participants.

In the case of the Oakland EcoBlock, tenants were asked to engage in all aspects of outreach related to the design of the EcoBlock. While there appeared a significant amount of enthusiasm from some tenants about the project, there existed little opportunity for them, at the ultimate decision point (whether or not to become and EcoBlock) to influence the decision. This disproportionate engagement has the potential to result in apathy or even disillusionment on the part of those engaged in this manner.

Recommendation for EcoBlocks: Ensure engagement opportunities and requests for stakeholder attention are proportional to the impacts stakeholders can eventually have on the decision.

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[43] Local Government Commission. www.lgc.org

Do the parties engaged have the information they need to make a decision?

In any engagement process with highly technical information there is a concern that cursory decisions are made by stakeholders who may not have the benefit of subject matter expertise, thus compromising their ability to accurately weigh trade-offs. The result is often a decision that is not durable (in other words, where a party can go back and say “I didn’t understand and therefore I’d now like to make a different choice”). Additionally, some stakeholders may refrain from deciding at all, for lack of adequate information.

In the instance of the Oakland EcoBlock, stakeholders who were being asked to share their overall attitude toward the EcoBlock were frequently unable to provide a definitive response. Rather, the position of “wait and see” was common, as stakeholder participants demonstrated general interest in the project, but wanted to know “what the deal would be” before they could express support or opposition.

Recommendation for EcoBlocks: Ensure stakeholders information needs are identified early and then addressed in a timely manner, to help prevent engagement fatigue and encourage trust building.

Do stakeholders perceive a benefit from their participation in the engagement process?

A successful negotiation process will only occur when parties have a reason to come to the table and deliberate. When applying this to public involvement or stakeholder engagement, the convening party must ask themselves whether the stakeholders being asked to engage have a reason to engage. In many government-led engagement processes, this is actually a negative motivation, or threat: for example, a development project that residents perceive to impact traffic or bring undesirable uses to their neighborhood. It can also be a positive motivation, or benefit: for example, when a plan is developed to rehabilitate a community resource like a park or library, and residents are asked to provide input that will be incorporated into the design.

In the instance of the Oakland EcoBlock, participation rates were depressed by the lack of specific perceived benefit or threat to residents. Because the first phase of the project is a “study” without guarantee of direct benefit (or, in an alternative interpretation, threat), residents who were happy with the status quo on the block had little incentive to attend meetings, take surveys, or generally engage with the project team.

Recommendation for EcoBlocks: Ensure that stakeholders are engaged at the appropriate time and with the appropriate information. Assess the situation before designing an engagement program in order to determine most productive scope and schedule for engagement.

Next Steps in Oakland EcoBlock Stakeholder Engagement

The engagement strategy for the Oakland EcoBlock going forward must address the following questions:

> **What is the decision to be made?** The decision to be made is whether or not to implement the Oakland EcoBlock at the current study location.
>
> **Who will make the decision?** Ultimately, the decision will need to be made by individual property owners at the current study location.
>
> **Who will influence the decision, and to what degree?** The California Energy Commission and other potential funders will influence the decision to the degree that the funding they provide may or may not enable a suite of improvements (the existing EcoBlock designs as outlined in the Master Plan) to the natural and built environment at the current study location.
>
> **What will define success for the engagement process?** Success should be judged by whether or not the individual property owners have the information they need (and any tools to evaluate it) to make a decision about whether or not to participate.

Options and Recommendations for Next Steps

Given the decision-making process outlined above, the engagement work could advance in several directions.

Stakeholder-Led Process (Recommended Option)

A number of highly enthusiastic residents of the block could be recruited to continue an engagement process into the next phase of design work. The benefits of recruiting stakeholders to play a larger role include:

- Greater ownership of the project and benefit of capacity building for future resident or property owner management of shared EcoBlock resources.
- Potential for more broad engagement block-wide, as neighbors are generally perceived as being more trustworthy than outsiders initiating engagement efforts.
- Potential to reduce cost of engagement efforts, through increased volunteer participation.

Project Team-Led Process with Additional Information

The project team could continue to lead engagement with EcoBlock residents. At this juncture, a project team-led process could also shift to greater engagement of a smaller group of residents in a steering committee format, to better proportion the engagement requests to the level of desired stakeholder participation.

The next steps in a project team-led process would need to include the presentation of cost estimates and preferred governance and finance models to stakeholders in a manner that is legible and allows them to adequately weigh trade-offs and provide feedback.

Contest for Motivated Communities

The origin of the current EcoBlock study area has been a point of interest for residents—and a common first question at project meetings. While some residents are enthusiastic, others have reacted with the sentiment "why us?" In studies of other eco-districts abroad, it has been observed that a factor of success may actually be a preexisting community network that is a proponent of this type of change. It has been suggested by various team members that it may be feasible to broadcast a call for projects and conduct a citywide competition for EcoBlock development, thus requiring that neighbors come together prior to EcoBlock design to agree on the concept, rather than asking for their input on the design and then asking for their agreement with the concept. The potential for this as a successful approach is supported by existing research (Bayulken and Huisingh 2015, 161) that notes the stronger form of eco-town development process to have a decentralized governance model with bottom-up decision making at the very beginning phases. While the Oakland EcoBlock process thus far made every effort to involve residents in the initial design phases, they were not adequately involved in the project's inception, leading to a challenging environment for engagement and implementation.

A contest does appear to be a viable approach to implementation. However, for the existing Oakland EcoBlock location, it raises the issue of having asked for a significant level of participation from the current study area residents, who have an expectation that their block will take priority when seeing additional funding.

Other Future Considerations

Stakeholder Engagement and Implementation

The need for stakeholder engagement does not stop at EcoBlock implementation. It should be assumed that continued successful operation and maintenance of shared facilities will greatly benefit from a robust culture of neighborhood engagement from residents (Bayulken and Huisingh 2015, 160). The next steps in stakeholder engagement should consider how processes or organizations being established in the present time can help sustain engagement over time.

Community Cohesion and Existing Community Networks

Additionally, future EcoBlock development projects should consider the possibility of leveraging existing community networks, such as homeowners associations, that could more easily enter into the type of governance agreements that an EcoBlock would require. Given the significance of the resident and property owner in the implementation and long-term operations of an EcoBlock development, faster adoption rates might result if the question of community ability for self-governance were among the initial selection criteria.

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CHAPTER 11

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ACRONYMS AND ABBREVIATIONS

AB	Assembly Bill
ABAG	Association of Bay Area Governments
AC	alternating current
ACEEE	American Council for an Energy-Efficient Economy
API	Application Programming Interface
APS	Advanced power strips
ASHRAE	American Society of Heating and Air-Conditioning Engineers
CCA	community choice aggregation
CC&Rs	covenants, conditions, and restrictions
CEQA	California Environmental Quality Act
CFD	Community Facilities District
CLT	community land trust
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
CPR	Critical Project Review
CPUC	California Public Utilities Commission
DC	direct current
DERs	distributed energy resources
DER-CAM	Distributed Energy Resources Customer Adoption Model
DHW	Domestic Hot Water
DMF	Decision-Making Framework
DOE	U.S. Department of Energy
DPR	direct potable reuse
EBCE	East Bay Community Energy
EBMUD	East Bay Municipal Utility District
EE	energy efficiency
EIFD	enhanced infrastructure financing district
EPA	U.S. Environmental Protection Agency
EV	electric vehicle
EVSEs	electric vehicle supply equipment
GHG	greenhouse gas
gpcd	gallons per person per day (gallons per capita daily)
GWh	gigawatt-hour
GWP	global warming potential
HERO	Home Energy Renovation Opportunity
HESaver	Home Energy Saver Professional website
HHW	Heating Hot Water
HOA	Homeowners Association
HPWH	heat pump water heater
IOU	Investor-Owned Utility
JPA	joint powers authorities
kg	kilogram
kW	kilowatt
kWh	kilowatt-hour

LBNL	Lawrence Berkeley National Laboratory
LED	light-emitting diode
LMP	locational marginal prices
MEL	Miscellaneous Electrical Load
MLS	Multiple Listing Service
MOL	maximum outage length
MPC	model-predictive control
MWh	megawatt-hour
NEM	net energy metering
NPV	net present value
NP	non-potable
OEB	Oakland EcoBlock
O&M	operations and maintenance
P3	public-private partnership
PACE	Property Assessed Clean Energy
PFA	public financing authority
PG&E	Pacific Gas and Electric
PV	photovoltaic
ROM	rough order of magnitude
ROW	right-of-way
RWH	rainwater harvesting
SB	Senate Bill
SPV	Special Purpose Vehicle
SOC	state-of-charge
TOU	time-of-use
UL	Underwriters Laboratories
V	volt
V2G	vehicle to grid
VOC	volatile organic compound
VMT	vehicle miles traveled
W	watt
WRCOG	Western Riverside Council of Governments
ZNE	Zero Net Energy

APPENDICES

These appendices are published in a separate document CEC-500-2019-043-APA-N

Appendix A: EcoBlock Report Author Contact Information

Appendix B: Map Analysis

Appendix C: Home Energy Saver Single Family Batch Run Input Values

Appendix D: The Oakland Eco-Block Project: A General Survey and Assessment of Proposed Building Materials and Their Constituent Chemicals proposed by the Water and Energy Sub-groups

Appendix E: Ecoblock Oakland Base Scheme Based on Review and Analysis of Concept Stage Documents

Appendix F: Lifecycle Assessment Report

Appendix G: Grid Impacts On EcoBlock Scaling Report

Appendix H: EcoBlock Water Systems

Appendix I: Decision-Making Framework

Appendix J: Types of Costs, Savings, and Revenue

Appendix K: Additional Ownership and Organizational Models

Appendix L: Green Bonds Report Commissioned by Oakland EcoBlock Project

Appendix M: Case Study Interview

Appendix N: Outreach Materials