CALIFORNIA ENERGY COMMISSION

ENERGY RESEARCH AND DEVELOPMENT DIVISION

FINAL PROJECT REPORT

Mutual Housing at Fairview Terrace—Affordable Mixed-Use Housing Development

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PREFACE

The California Energy Commission's (CEC) 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 EPIC Program is funded by California utility customers under the auspices of the California Public Utilities Commission. The CEC and the state's three largest investor-owned utilities—Pacific Gas and Electric Company, San Diego Gas and 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 CEC 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.

For more information about the Energy Research and Development Division, please visit the CEC's research website (www.energy.ca.gov/research/) or contact the Energy Research and Development Division at ERDD@energy.ca.gov.

ABSTRACT

The world is a sacred place. Everyone has a duty to sustain Earth's crucial infrastructures by ensuring all parts are attended to equitably. The things that humans build and create have a large impact on the network of fragile natural ecosystems. With this in mind, the design team for the Mutual Housing at Fairview Terrace Project strove to achieve new practices for sustainable building design. These practices exceed current standards as a solution to the Next Electric Program Investment Charge Challenge competition.

Located in Stockton, California, the 62,568-square-foot Mutual Housing at Fairview Terrace Project is a 100-percent affordable, all-electric senior housing project with an adjoining tenant office space for Stocktonians Taking Action to Neutralize Drugs, a local nonprofit community organization that provides services to the South Stockton neighborhood.

The Mutual Housing at Fairview Terrace Project will both provide the community in Stockton with critically needed services and implement emerging technologies to provide this disadvantaged neighborhood with access to a sustainable, energy-efficient building. The robust community outreach and research completed led to a development design that includes a 76-unit facility with one-bedroom, two-bedroom, and studio residences; a services and management office; indoor and outdoor bicycle storage; tenant space; a resilient cooling center; community kitchen; courtyard; shared gathering space; urban agriculture; electric vehicle charging; meandering outdoor walkways; community art; a place to learn; and outdoor recreation. By considering the history of this place, the team was able to foster a design that is a catalyst for progress.

Keywords: EPIC, affordable, housing, Stockton, all-electric, sustainable, outreach, resilient, mixed-use, development, building, emerging technologies, disadvantaged, energy efficient, zero net energy, carbon, community

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Executive Summary

Background

The need for affordable housing throughout California is critical. There is no greater need than in Stockton: one of the state's poorest communities. Nearly 16 percent of its 320,000 residents live in poverty—higher than the 12.2 percent state average.[1] Per the City's Housing Element, 64 percent of Stockton's 20,000 senior renter households experience housing-cost burden.[2]

Additionally, climate change has caused an increase in the frequency of extreme weather events that dramatically impacts the main energy grid. The emergency preparedness and resiliency of residential communities in Stockton to respond to these extreme events is currently either inadequate or missing.

To address these severe challenges facing California communities such as Stockton, an improved approach to mixed-use affordable housing is needed. This challenge presents a unique opportunity to pair need with innovation.

Project Purpose and Approach

The project team, led by Mutual Housing California (Mutual Housing), designed the Mutual Housing at Fairview Terrace Project as an all-electric 55+ Senior Affordable Housing and Mixed-Use Development. The development design includes 76 residential units, a courtyard, a local nonprofit office space, urban agriculture, and a community cooling center.

The Mutual Housing at Fairview Terrace Project will include advanced technologies such as a microgrid with energy management software, solar photovoltaics, battery energy storage system, bidirectional electric vehicle charging, connection to transactive energy markets, demand response, and sensors and automatic controls. Other innovations include vampire switch technology to manage plug loads, vertical photovoltaics, and thermobimetal (a laminate of two different metals with different temperatures coefficients used for building facades or shading systems) shading. The introduction of these advanced technologies will underscore their potential to reduce living expenses for residents and operating expenses for owners. Their effectiveness will serve as a catalyst for their adoption in the affordable housing industry.

At the start of the design process the team developed a design brief that is an aspirational defining vision for the project to create a link between the "why" and the "what":

"We approach this place with **cautious anticipation**; a place that **links** our past to our future, reminding us of where we came from. This place is a part of the woven landscape and urban fabric that **reconnects** us to the agriculture, nature, and **resilient** community. A catalyst for progress with the comfort of **home**."

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[1] U.S. Census Bureau. n.d. *QuickFacts: Stockton City, California*. Retrieved on January 16, 2024 from: https://www.census.gov/quickfacts/fact/table/stocktoncitycalifornia/PST045223.

[2] Placeworks. 2023. *City of Stockton 2023-2031 Housing Element*. Available at http://www.ci.stockton.ca.us/files/Revised_Draft_Housing_Element_June_2023.pdf.

Key Results

Performance: The proposed design has 15 percent better time dependent valuation efficiency and 17 percent lower operational carbon emissions as compared to a Title 24-2022 Part 6 standard design before considering photovoltaics and battery. The proposed solar photovoltaics kilowatt direct current size is 2.5 times larger and battery kilowatt hour size is 8 times larger than required by the code, making the building an all-electric net-positive energy and net-zero (operational) carbon project.

Load Shifting: To shift building load off the power grid during peak grid demand times, the design incorporates a battery energy storage system large enough to store excess solar photovoltaic generation during the day and discharge the stored energy during the 4:00 p.m. to 9:00 p.m. hours. This size also allows for the building to draw little to no power from the grid during the months of May through July.

Resiliency: In the event of a grid outage, the microgrid can support all Tier 1 and Tier 2 critical loads (Francescato, 2019).[3] This includes supporting the community room to operate as an emergency shelter and cooling center during outages and extreme events.

Operational Savings: Lifecycle costs savings through energy bill reductions are realized in part due to the first cost premiums for both residents and the owner. In other words, the higher upfront investment during construction results in significantly higher lifecycle cost savings during operations. Both the owner and residents will essentially see their energy bills reduced to zero. The lifecycle costs for residents and owner are based on a 30-year building life. The lifecycle cost analysis resulted in a large negative net present value that essentially offsets the first cost premium to meet Electric Program Investment Charge goals. The lifecycle cost analysis also resulted in operational cost savings compared to a minimally compliant Title 24 design.

Equity: All of the units are affordable. The targeted income level is 30 to 60 percent of the area median income. The means to ensure long-term affordability include income verification of tenants in addition to a 55-year regulatory agreement with the state. Mutual Housing California will also target an average affordability of 50 percent area median income or lower, making the development deeply affordable. The design and proposed density are a result of considering the priorities of both the local community and the city of Stockton. In addition, the local nonprofit community organization Stocktonians Taking Action to Neutralize Drugs will occupy the mixed-use office space, providing services to the community such as food distribution events and violence prevention outreach. The community will also be affirmatively marketed to minority and disadvantaged groups through an official marketing plan before lease-up. The project team implemented the Social Economic Environmental Design Network certification process to create a robust community outreach process. This was used in each phase of the design to ensure that there was continued community engagement. Elements of the design that incorporate the outreach results include increased site lighting and safe walkways, a green screen to grow urban agriculture for resident and neighborhood use,

[3] Tier 1 = Critical load, usually 10 percent of total load: life-sustaining or crucial to keep operational during a grid outage; Tier 2 = Priority load, usually 15 percent: Important but not absolutely crucial to keep operational during an outage; Tier 3 = Discretionary load, usually 75 percent: remainder of the total load.

community gardening, bike storage, vibrant interiors with wayfinding features, interior biophilic elements with connection to nature, a community-driven mural wall, and rainwater cisterns for irrigation.

Knowledge Transfer and Next Steps

To ensure the broader adoption of emerging energy technologies and advanced architectural, design, and construction practices, the design team employed a comprehensive community and client engagement process. This process was not only intended for the successful implementation of the technology, but also for the education and engagement of the various stakeholders involved. This educational approach promoted the use of advanced technologies and fostered trust among the community members, utilities, and workers involved. This collaborative approach will help catalyze broader technological adoption for sustainable energy management.

Currently, the team is developing media packages and media targets, which will be shared before the project finishes construction. The project is currently a registered project with International Living Future's Zero Energy Certification and is designed to achieve these results. The project team plans to complete this certification in the build phase and present the constructed building as a case study for future projects.

Please view the project video, available at https://www.youtube.com/watch?v=wgSqgZnozkY. Figure 1 provides a rendering of a mural wall at the Fairview Terrace in Stockton.

Figure 1: Mural Wall

Source: Architectural Nexus, 2023

CHAPTER 1: Introduction

The need for affordable housing throughout California is critical. There is no greater need than in Stockton: one of the state's poorest communities. Nearly 16 percent of its 320,000 residents live in poverty—higher than the 12.2 percent state average. Per the City's Housing Element, 64 percent of Stockton's 20,000 senior renter households experience housing-cost burden.

This challenge presents a unique opportunity to pair need with innovation. Building systems are typically static binary systems; in simple terms, they are either "on" or "off." When a tenant feels hot, they adjust the thermostat and the heating, ventilation, and air conditioning (HVAC) system switches from off to on. Many variables, including human behavior can influence how much energy is used. Energy use, often priced on a sliding scale based on demand, has a high demand load during specific times during the day, typically between the hours of 4 p.m. to 9 p.m. Individuals also have unique, yet predictable routines and energy use patterns. These patterns are established at both the individual and community level and are not yet factored into refining the efficiency of energy use of individual tenants. Today, sustainably generated power is often not stored on site. Much of this energy is gathered through photovoltaic (PV) cells and is collected during daylight hours. Any excess is pushed back to the main electrical grid. When energy storage is included onsite, there is an opportunity for efficiency through communication between the main grid and the local microgrid that remains untapped. Additionally, climate change has caused an increase in the frequency of extreme weather events that dramatically impacts the main energy grid. The emergency preparedness and resiliency of residential communities in Stockton to respond to these extreme events is currently either inadequate or missing.

To address these severe challenges facing California communities, an improved approach to mixed-use affordable housing is needed.

The Mutual Housing at Fairview Terrace Project is designed as an all-electric, 55+ senior affordable housing and mixed-use development. The development includes 76 residential units, a courtyard, a local nonresidential community nonprofit office space, urban agriculture, and a community cooling center. This report details the significant design features that contribute to this highly sustainable, energy-efficient, net-positive energy development.

Mutual Housing California proposes to design and build the Mutual Housing at Fairview Terrace Project in collaboration with the city of Stockton and Stocktonians Taking Action to Neutralize Drugs (STAND). This project holds much promise in terms of providing healthy, affordable, and supportive housing to seniors in south Stockton, a historically disadvantaged community.

The Mutual Housing at Fairview Terrace Project will include advanced technologies such as a microgrid with energy management software, solar PV structures, battery energy storage system (BESS), bidirectional electric vehicle (EV) charging, connection to transactive energy markets, demand response, and sensors and automatic controls. Other innovations include vampire switch technology to manage plug loads, vertical photovoltaics, and thermobimetal (a laminate of two different metals with different temperatures coefficients used for building facades or shading systems) shading. The introduction of these advanced technologies will underscore their potential to reduce living expenses for residents and operating expenses for owners. Their effectiveness will serve as a catalyst for their adoption in the affordable housing industry (Figure 2, Figure 3 and Figure 4).

At the start of the design process, the team developed a design brief that is an aspirational defining vision for the project to create a link between the "why" and the "what":

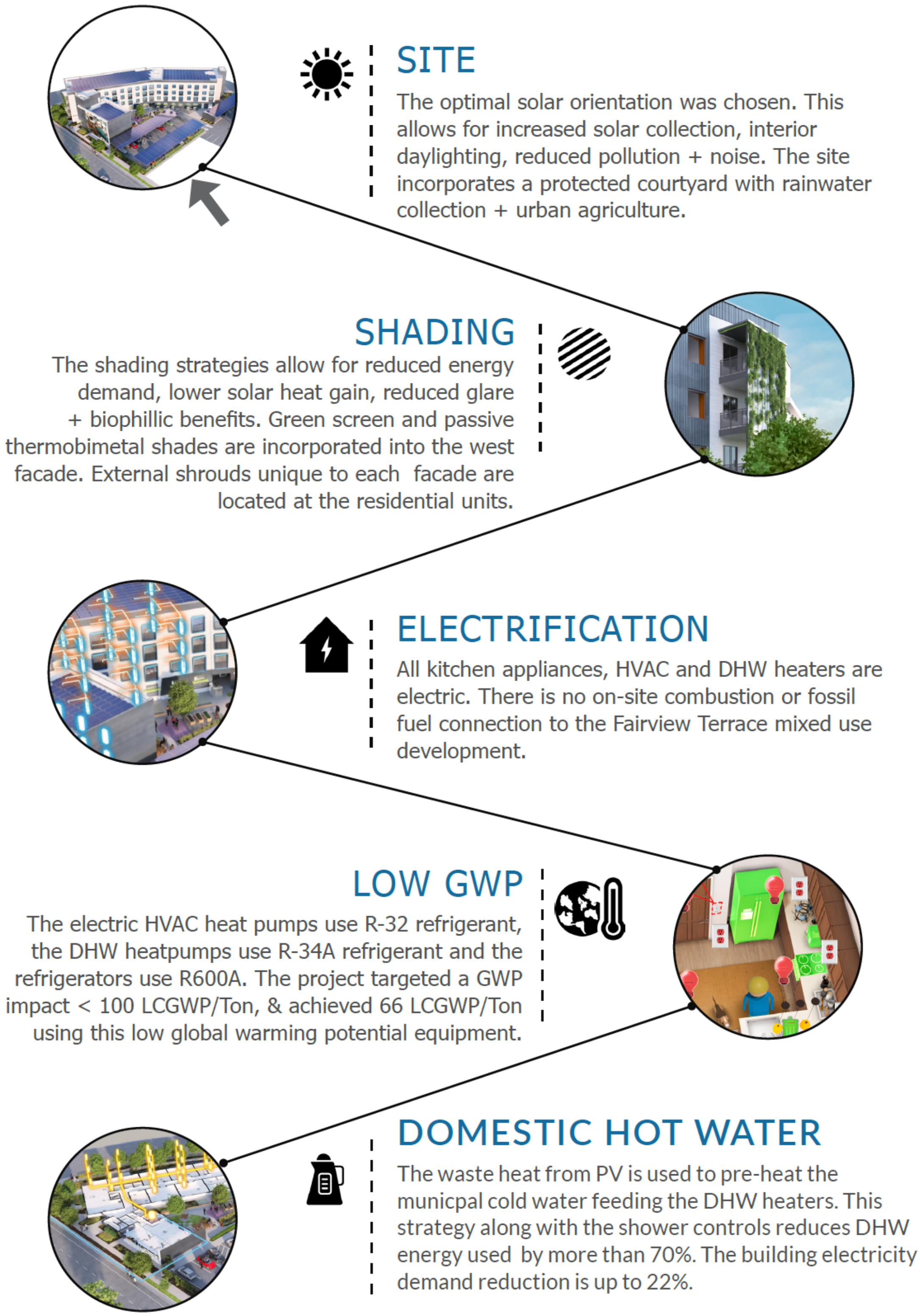
"We approach this place with **cautious anticipation**; a place that **links** our past to our future, reminding us of where we came from. This place is a part of the woven landscape and urban fabric that **reconnects** us to the agriculture, nature, and **resilient** community. A catalyst for progress with the comfort of **home**."

Please view the project video, available at https://www.youtube.com/watch?v=wgSqgZnozkY.

Figure 2: Building Entry

Source: Architectural Nexus, 2023

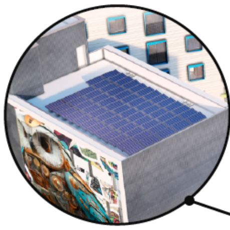
Figure 3: Design Strategies



GWP: Global warming potential; LCGWP: Lifecycle Direct Global Warming Potential; DHW: Domestic hot water

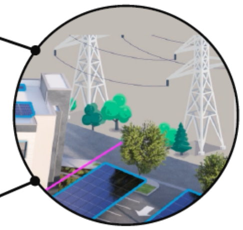
Source: Architectural Nexus, 2023

Figure 4: Design Strategies



MICROGRID

The project utilizes 316.8 kW_{dc} PV system through a combination of Rooftop+Carport+BIPV to exceed net zero energy goals. A battery system of 600kWh/150kW will be utilized for resiliency and demand flexibility. An additional onsite renewable energy production measure includes energy producing flooring.

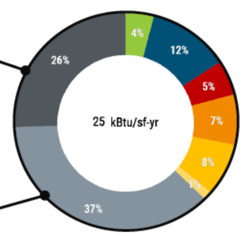


DEMAND FLEXIBILITY

Innovative HVAC controls are estimated to shift up to 16% of the building's energy load. These controls along with lower lighting levels in the common area can reduce energy demand for the entire mixed-use development by 10-30%.

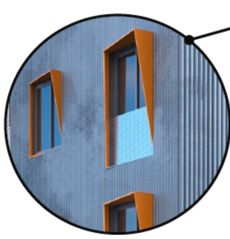
WATER SAVING

The buildings water saving strategies include shower controls, smart shower heads, native landscaping and rainwater collection.



ENERGY PERFORMANCE

The building has an energy use intensity (EUI) of 25 kBtu/sf-yr and is designed to be 113% Net Positive. The regional baseline is exceeded by 15.3% TDV.



CARBON PERFORMANCE

The strategies that reduce operational carbon emissions include building effiecency measures, onsite renewables and the energy storage system.

kWdc: Kilowatt direct current; BIPV: Building-integrated photovoltaics; TDV: Time Dependent Valuation

Source: Architectural Nexus, 2023

CHAPTER 2: Project Approach

In preparation for the California Energy Commission's (CEC's) solicitation "GFO-20-305 The Next Electric Program Investment Charge (EPIC) Challenge: Reimagining Affordable Mixed-Use Development in a Carbon-Constrained Future" (Next EPIC Challenge), Mutual Housing California and Architectural Nexus formed a design build team and identified project sites that could embrace the solicitation's goals. The research objective of this project was to design a project that met the following minimum requirements.

Minimum Site Requirements[4]

The following describes the minimum site requirements that project teams were to meet in their designs for the Next EPIC Challenge competition:

- A single development project of one or more buildings
- The development can be new construction or an adaptive reuse of an existing development.
- The development must be mixed-use.
- The project site must be located within the service territories of Pacific Gas & Electric Company (PG&E), Southern California Edison Company (SCE), or San Diego Gas & Electric Company (SDG&E).
- The development must dedicate a minimum of 20 percent of the total units to affordable housing with at least 10 percent of the total units being dedicated to lower income units (CDHCD, n.d.).[5]
- The development must include a minimum of 50 housing units.
- The development must achieve a minimum density of 30 residential units per acre.

Minimum Design Requirements

The following describes the minimum design requirements that project teams must meet in their designs for the Next EPIC Challenge competition:

- All building end-uses must be electric (no gas consumption is allowed).
- A minimum of 20 percent of the peak load of the building(s) must be available to be temporarily managed or curtailed to respond to grid conditions.

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[4] CEC (California Energy Commission) staff. 2023. *GFO-20-305 - The Next EPIC Challenge: Reimagining Affordable Mixed-Use Development in a Carbon-Constrained Future*. Available at https://www.energy.ca.gov/solicitations/2020-12/gfo-20-305-next-epic-challenge-reimagining-affordable-mixed-use-development.

[5] Affordable housing as specified can include moderate income (80 percent to 120 percent of area median income (AMI)) and lower income (0 to 80 percent of AMI) units; based on California Department of Housing and Community Development.

- The residential load of the building(s) during peak demand hours, 4:00 p.m. to 9:00 p.m., must be met through a combination of onsite renewables, onsite storage, and load management.
- All residential end uses must be controllable through the home energy management system and be capable of responding to real-time pricing signals.
- The microgrid controller(s) must be interoperable with distributed energy resource (DER) aggregation platforms such as virtual power plants.
- The building(s) must be able to island from the main grid during an outage and be able to shed discretionary loads to provide power to Tier 1 critical loads (10 percent of peak load) and Tier 2 priority loads (25 percent of peak load).
- The microgrid must be sized for indefinite renewables-driven backup power of Tier 1 critical loads using any combination of onsite renewables, onsite storage, and load management.
- Twenty percent of all parking spaces associated with the development must have EV-charging stations that can respond to grid- and building-signals.

All remaining parking spaces must be EV-ready, meaning they must have a dedicated electrical circuit with the capacity to eventually become a charging station.

For this project, the team selected a site that Mutual Housing California was developing within the disadvantaged community[6] of south Stockton (CA OEHHA, 2018). The Mutual Housing at Fairview Terrace Project was designed in collaboration with the city of Stockton and STAND. The team grew further to incorporate engineers and technology providers to design a project with promise in terms of providing healthy, affordable, and supportive housing to seniors in south Stockton.

Project Partners

- Mutual Housing California
- Architectural Nexus, Inc.
- STAND
- The Engineering Enterprise
- Castlegate Engineering
- Community Energy Labs (CEL)
- Miyamoto International
- Capital Engineering
- Cunningham Engineering
- Icarus RT

[6] "Disadvantaged communities" means communities identified pursuant to Section 39711 of the Health and Safety Code.

Technical Advisory Committee

- Logan Parmel, Delawie
- Thomas Hall, CleanStart
- Paul Ainger, Former Affordable Housing Developer in San Joaquin County

Key milestones of the project included making a schematic design phase focused on optimizing site orientation, reducing the energy use of the building, refining massing, and researching possible technologies. A design development phase further developed the design solutions and refined the microgrid solution based on energy modeling iterations and feedback.

Overall Design Approach and Strategies

Standard (Baseline) Design

A standard (Baseline) design is a building that meets the energy and emission reduction requirements of the 2022 Building Energy Efficiency Standards (Title 24, Part 6). Time dependent valuation (TDV) values were compared to these standards to identify certain key performance components that would help achieve this.

The proposed design has 15 percent better TDV efficiency and 17 percent lower operational carbon emissions compared to a Title 24, Part 6 standard design before considering PV and battery. The proposed PV kilowatt direct current (kW_{dc}) size is 2.5 times larger and battery kilowatt hour (kWh) size is 8 times larger than code requirements, making the building an all-electric net-positive energy and net zero (operational) carbon project.

Additional energy efficiency strategies include the lighting design for the common areas that is up to 60 percent more efficient compared to the code-prescriptive lighting power densities in Title 24, Part 6 Table 170.2-M. Common area and dwelling units also have individual all-electric heat pump water heaters specified that comply with Northwest Energy Efficiency Alliance Advanced Water Heater Specification Tier 3 or higher ratings and have JA13 certification with 4.02 Uniform Energy Factor compared to the code minimum of 2.6 Uniform Energy Factor. In addition to an efficient water heater, Icarus RT's Quartet system is sized to use waste heat from PV panels for pre-heating municipal cold water feeding the domestic hot water heaters. This strategy is estimated to reduce overall annual DHW system energy by 70 percent and reduce overall building electricity demand by up to 22 percent.

Typically, an affordable housing project would maximize the building footprint and unit count. On this site that would mean having a simple "L" shaped building with a large number of units exposed to the west solar heat gain (see Option 1 in Figure 5).

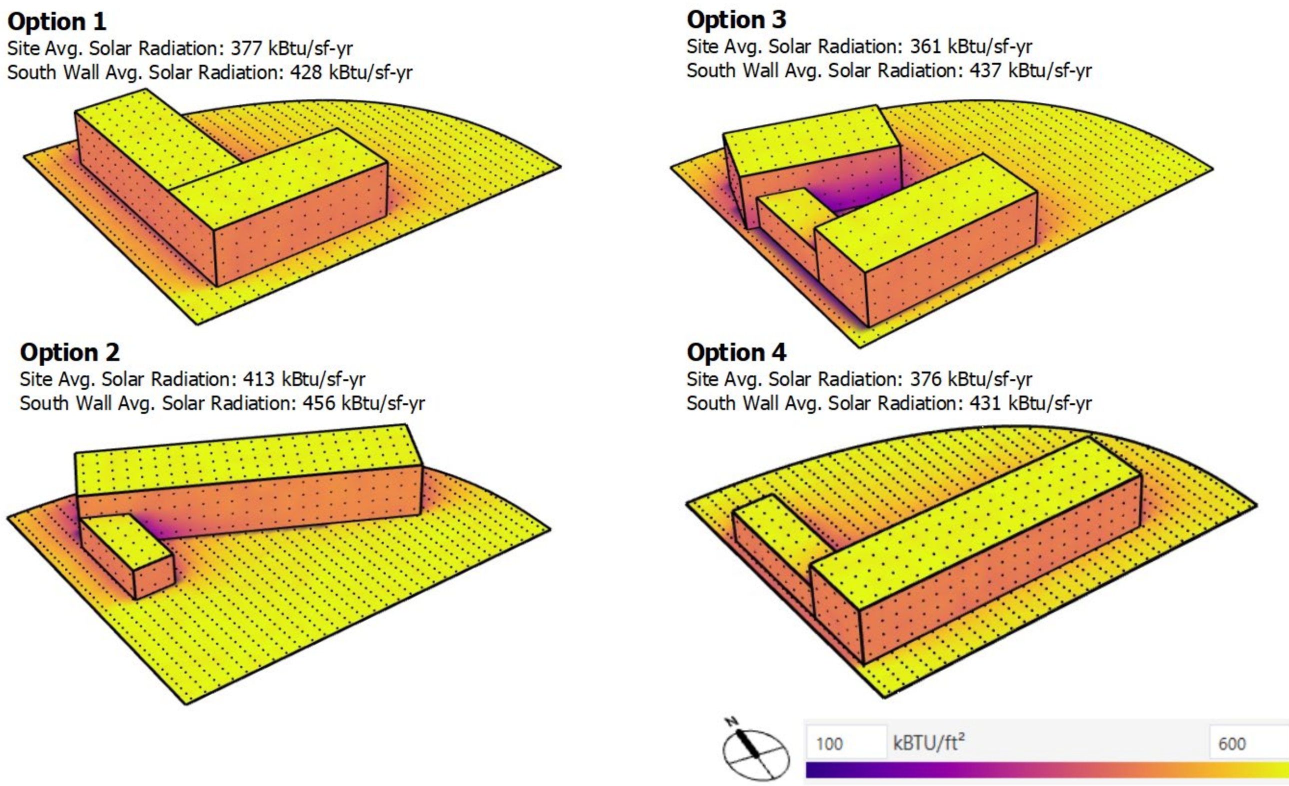
Overall Approach for the Proposed Design

The design process started with best practices for building placement and site orientation, reducing energy demand. The team then applied load shifting strategies specifically during the daily peak grid hours. Figure 5 shows some of the results from massing and daylighting studies which informed the design in early phases. The design team chose Option 2 in Figure 5 to maximize access to daylight for dwelling units and available unshaded site area for PV.

- Many units in option 1 face west, which contributes the most to peak cooling loads in the hours when the grid is most stressed (approximately 4:00 p.m. to 9:00 p.m.).

Option 2 and 4 offer better site and south wall solar exposure, which would be crucial in meeting net zero-energy goals.

Figure 5: Schematic Design Site Radiation Study



Source: Architectural Nexus, 2023

The team evaluated emerging technologies to help create a highly efficient, comfortable, and affordable mixed-use development wherein residents, staff, and visitors are included and engaged. To surpass the zero-emission goal, the design process was oriented around three areas of strategy for emerging technologies: passive, active, and interactive.

1. Passive Emerging Technologies

To begin investigating passive clean energy technology solutions, the team started with the best practices of sustainable design. The project team studied several massing options and chose the option that best maximized daylight availability, kept roof and carport areas unobstructed for photovoltaics, and which could control solar heat gain effectively. Even with limited fenestration on the west façade, there was still a need to reduce solar heat gain during the peak hours of the day. Solar heat gain was reduced in the design through the addition of a green screen, thermobimetal shading, and external shrouds.

Invert shading, by TBM Designs, is a dynamic passive technology that will be tied into the community art wall on the prominent west façade and placed in key nonresidential locations. The invert shading will limit direct sunlight penetration to 409.5 hours a year, 60 percent fewer hours a year than without a shading device.

2. Active Emerging Technologies

The next step involved investigating active all-electric technologies that could further reduce energy use while improving comfort and aesthetics. The project team spent several months iterating and researching exciting new-to-market technology solutions.

The selected technologies will benefit both the residential and nonresidential portions of the building. The selected technologies include the Icarus RT Quartet solar-thermal heat extraction system, CEL building controls, a compact low-global warming potential (low-GWP) heat pump model with heat recovery ventilator, and a mural wall that serves a dual purpose of providing beauty and building-integrated photovoltaics.

- **Icarus RT's Quartet Heat Extraction Technology:** This technology is proposed for a portion of the upper roof PV for 84 panels. This technology aligns with the domestic hot water demand to be offset and allows the design team to reduce space constraints by utilizing only one thermocline storage tank to accommodate space limitations.

  The Icarus RT Quartet Hybrid Solar Energy heat extraction system extracts and stores solar thermal energy from the PV panels to produce hot water while improving the PV system performance by 12 percent or more. The system uses a proprietary snap-on heat extractor design that allows the system to be integrated into solar PV arrays (Figure 6).

Figure 6: Domestic Hot Water Animation

Source: Architectural Nexus, 2023

- **All-Electric Heat Pump HVAC:** The CEL building control platform is part of a holistic strategy where each technology works together for an integrated design solution. The energy savings with the CEL controls strategy is combined with electric heat pump models offered by Ephoca AIO (all-in-one): vertical stack, ceiling-suspended, and ceiling-ducted. The Epocha units outperform standard heat pumps as these innovative, high-efficiency, inverter heat pumps are designed to be all-in-one systems that each include an indoor fan, minimum efficiency reporting value (MERV) 13 filter, energy recovery system, and condensing system. The inverter heat pumps are stored in one compact package located in a simple cabinet that is all-electric, which reduces carbon emissions from the project. This product contains less refrigerant quantity than traditional heat pumps and eliminates refrigerant piping to the outdoors. The next-gen R-32 refrigerant chosen has a low GWP of 675, and zero ozone depletion potential.

- **Vertical PV:** A vertical solar façade is an active emerging technology in the form of building integrated photovoltaics (BIPV). The 850-square-foot mural incorporating BIPV on the west façade will generate 7,025 kWh per year. This façade will be a powerful demonstration of how building components can contribute to onsite energy while driving down utility costs, encouraging all-electric spaces, and showcasing a meaningful beacon of community pride and ownership.

3. Interactive Emerging Technologies

The final strategy was applying a human-driven approach to selecting clean energy technologies that would be beneficial to the design. This involved using both passive and active strategies, alongside education and occupant engagement to reduce water usage, shift energy load, and achieve the project goals. Additionally, visitors to the project site will be able to be educated on sustainable habits that will have a positive impact to the built environment beyond this one building.

Key Project Milestones for the Build Phase

Mutual Housing California has received development entitlement approval from the city of Stockton and has had discussions with potential financing partners about the project. Key build phase milestones will align with the following objectives:

1. Signing CEC build phase agreement in April 2024,
2. Applying for and receiving award of tax credits and tax-exempt bonds in May 2024,
3. Issuing of the construction permit in summer 2024,
4. Issuing notice to proceed to general contractor in fall 2024, and
5. Completing construction and obtaining certificate of occupancy in summer 2026/2027.

Architectural Designs, Aesthetics, and Functionality

Community-inspired Mural

The project team participated in several community events to gather input and feedback on the Mutual Housing at Fairview Terrace Project including on the proposed community-inspired mural wall, which has a serendipitous origin story. The project team wanted to incorporate a mural that connected the neighborhood's past, present, and hopeful future of Stockton, California. Prominent features of the mural include the delta, port, diverse culture, agriculture and the industrial hub, which community events had demonstrated were what local residents love the most about their city. The project team asked individuals, "What do you feel makes Stockton unique from other Central Valley areas?" The inland port was easily the most prominent response, with many respondents also mentioning the growing technology presence fostering a bright future. One individual mentioned their love of a group that worked toward the rescue and rehabilitation of barn owls. After further research, the importance of the barn owl to the Port of Stockton became apparent. Throughout the history of Stockton, barn owls were welcomed to nest in and around the port to reduce the presence of damaging rodents. The Port of Stockton even has an owl cam, indicating the interest of local residents in the well-being of these owls. The mural artwork thus features an owl looking to the future, with the background consisting of linework inspired by the delta, vignettes of the aforementioned spaces, and landscapes between waterways. The owl is shown as a hybrid of organic and mechanical elements, highlighting the history and technological evolution of Stockton. The image of an owl is a perfect fit for the west facade when paired with the emerging technology of the thermobimetal fins of the thermobimetal (TBM) shading system. The shape and design of the thermobimetal fins evoke feathers ruffling and adapting to the environment (Figure 7).

Figure 7: Community-inspired Mural

Source: Architectural Nexus, 2023

Features to Improve the Sustainability and Aesthetics

By considering the history of the project site, the project team fostered a design that can be used as a catalyst for future progress. The materials chosen for the building design root the project in the industrial and agricultural history of Stockton. The corrugated metal panels play off of warehouses and agricultural buildings seen in the everyday life of Stocktonians. The horizontal siding brings warmth and a reminder of the comforts of home. The external shading elements at each fenestration also create a dynamic pattern of various colors, shapes, and shadows on the façade of the building. These thin metal shading elements embody the concept of essentialism. The shape of each shade has been manipulated specifically for the shading needs of each façade, considering their relationship to the sun. Thus, each façade varies slightly, paying tribute to the importance of site orientation in reducing solar heat gain and energy needs within these spaces. Carefully placed angled reveals on the façade of the building pique interest and subtly break up the repetitive patterns. These reveals act, in a way, as a sundial. Passersby can understand the time of the day based on the shadows and their relationship to these markers. In addition, during the hottest day of the year on average, July 10th, the adjacent shadows will align with the angles of the reveal, again emphasizing the priority of the project of reducing energy demands. The building is optimally oriented to reduce energy demand, boost PV performance, and minimize the impact of pollution and noise on the residents by orienting the units away from the major traffic corridor (Figure 8).

Figure 8: Design Strategy Animation

Source: Architectural Nexus, 2023

Design Strategies for Integrating Conventional and Emerging Energy Technologies

End-Use Energy Efficiency

Table 1 shows the end-use energy efficiency of the systems as compared to Title 24 requirements, with corresponding greenhouse gas (GHG) emissions intensities.

Table 1: Energy and Emissions Workbook

End Use	Unregulated? Y/N	Site Energy Use Intensity (kBtu/sf/yr)			GHG Emissions Intensity (kilogram carbon dioxide/sf/yr)		
		Baseline	Proposed	% Improve-ment	Baseline	Proposed	% Improve-ment
Space Heating	Y	0.71	1.28	-80%	0.05	0.09	-80%
Space Cooling	Y	2.16	2.00	8%	0.15	0.14	8%
Indoor Fans	Y	3.69	3.36	9%	0.26	0.24	9%
Heat Rejection	Y	N/A	N/A		N/A	N/A	
Pumps & Misc.	Y	0.08	0.02	79%	0.01	0.00	79%
Domestic Hot Water	Y	2.86	2.56	11%	0.20	0.18	11%
Indoor Lighting	Y	3.67	1.71	53%	0.26	0.12	53%
Receptacle	N	7.73	7.73	0%	0.55	0.55	0%

End Use	Unregulated? Y/N	Site Energy Use Intensity (kBtu/sf/yr)			GHG Emissions Intensity (kilogram carbon dioxide/sf/yr)		
		Baseline	Proposed	% Improve-ment	Baseline	Proposed	% Improve-ment
Process	N	6.47	6.41	1%	0.46	0.45	1%
Other Lighting	N	0.82	0.82	0%	0.06	0.06	0%
Process Motors	N	N/A	N/A		N/A	N/A	
Load Flexibility	N/A	0.09	0.71		0.01	0.05	
Photovoltaics	N/A	10.99	27.93		0.78	1.97	
Totals		17.19	(2.05)	112%	1.22	(0.14)	112%

Source: Architectural Nexus, 2023

Load Flexibility, Grid Interactions, and Residents' Engagement

- CEL has developed a building control solution focused on optimizing energy management and advancing decarbonization for building owners. The solution, a grid-interactive building control platform, employs model predictive control (MPC) to autonomously balance energy consumption, pricing, and occupant comfort. At its core, MPC will manage energy by shaping electricity demand, aiming for energy savings between 5 to 25 percent and HVAC peak demand reductions of 10 to 30 percent. MPC will operate by relying on dynamic building models to predict and continuously refine building control actions.
- In addition to the energy savings from the Icarus RT Quartet Hybrid Solar Energy heat extraction system, the design also includes Hydrao shower heads with indicator lights that change color based on water usage and help users save on water and energy.
- The Evolve Technologies Shower Start product will limit the flow of water once the user pulls the cable. This results in better awareness of behaviors and has shown a 20-percent occupant-driven savings in water usage.
- All nonresidential electrical panels except the panels integrated with life safety equipment, telecom equipment, refrigeration, large equipment, and equipment that needs a slow shut down process, will be connected to an electrical relay device, which the project team calls a "vampire switch" in reference to the ability of the device to control or eliminate vampire/standby power (Figure 9). The vampire switches will be tied to the alarm systems of the nonresidential spaces. When a facility manager or the commercial office tenant arms the space (that is, activates the alarm system), power is cut to the panel with the relay. When the space is disarmed, all power is immediately restored.
- In dwelling units, a manual means for shutting down specific outlets and lighting with a single switch will be provided. The switch will control a set of relays, which will shut off power to the outlets. Each dwelling unit will have color-coded outlets to mark which

ones will be controlled by the vampire switch. Color coding adds to the ease of use and adoption of technology by residents.

- Pavegen is an active emerging technology powered by people that is planned for the flooring of the lobby space in this building. The Pavegen kinetic pavers collect, store, and convert the energy created by footsteps on the surface into electricity for building use. In the Mutual Housing at Fairview Terrace lobby, data collected regarding the power produced by these pavers will be displayed on a touchscreen display in the lobby, which will also be powered by these pavers.

Figure 9: Vampire Switch Unit

Resident arrives home to loads that are always on.

Resident switches on the vampire switch, which powers the remaining loads.

Resident goes to bed or leaves and switches off the vampire switch to shut off certain loads.

Source: Architectural Nexus, 2023

Microgrid Design Strategy

The project team's approach to the microgrid design was to integrate products that would provide high efficiency, monitoring capabilities, and controllability (Figure 10). These features along with onsite solar PV generation and battery energy storage allow the design to take advantage of the following operation strategies:

- **Load Shifting:** To shift building load off the power grid during peak grid demand times, the design incorporates a BESS large enough to store excess PV generation during the day and to discharge the stored energy during the 4 p.m. to 9 p.m. peak energy usage hours. This BESS size also allows for the building to draw little to no power from the grid during the months of May through July (Figure 11).
- **Resiliency:** By running Xendee model optimizations with only Tier 1 and Tier 2 load profiles and not allowing utility-provided power, it was found that a minimum BESS size of 225 kWh would be sufficient to run the Tier 1 and 2 loads indefinitely. Given that a 500 kWh BESS would be required for the 4 p.m. to 9 p.m. no-utility-power requirement, the BESS will be sized at more than double the size to also cover Tier 3 loads. Since a grid outage can happen at any time, the project team limited the minimum state of charge to 25 percent of the BESS capacity. This means that there can be an outage

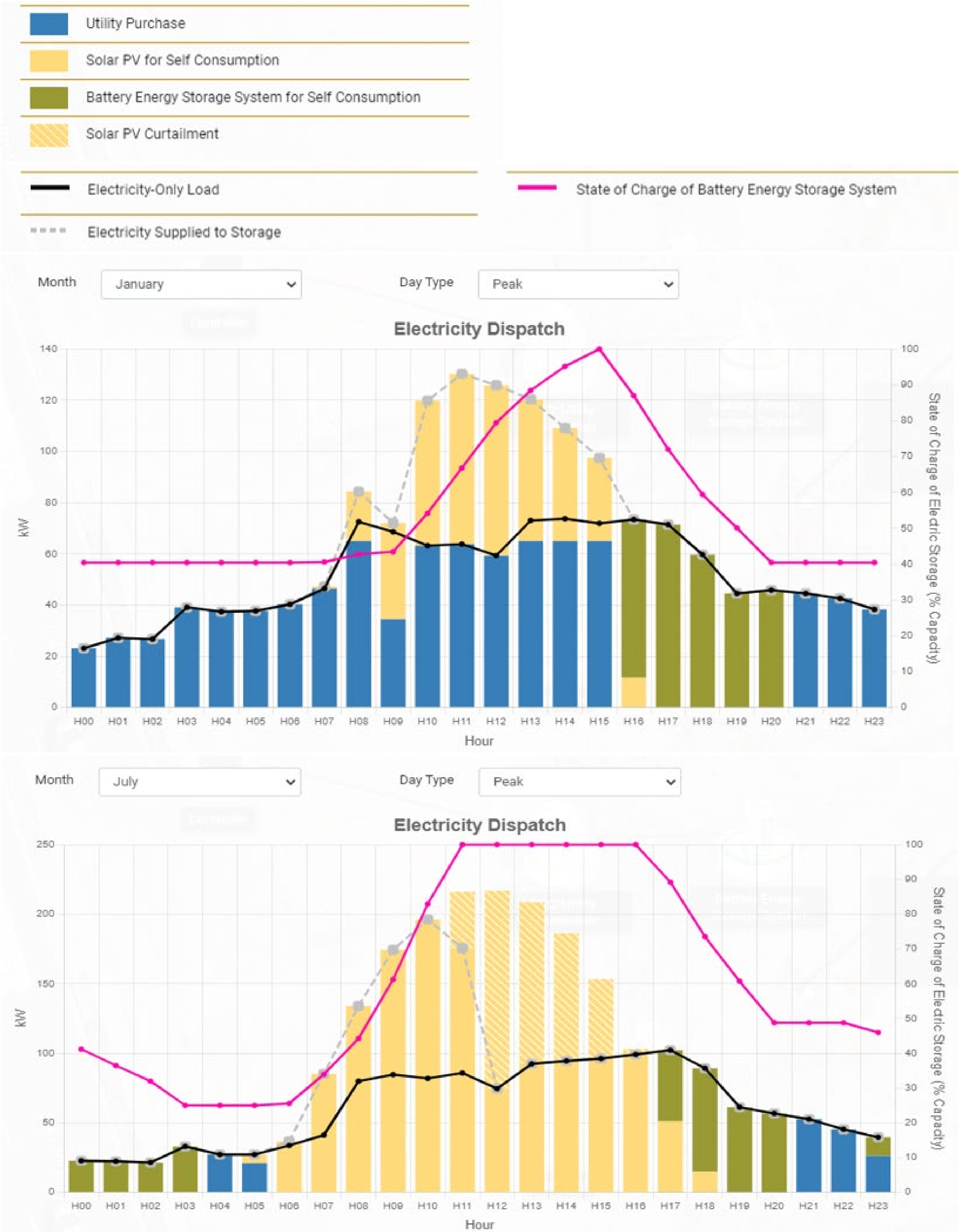
starting at any point in the day, and there will still be at least 125 kWh available to cover onsite demand.

- **Peak Shaving:** Peak shaving was included as an inherent strategy of the microgrid design. The maximum peak demand from the utility grid was projected to be approximately 102 kW. Based on microgrid modeling, the onsite generation and storage needs determined by the peak demand from the utility grid is 65 kW. This is accomplished by the size of the BESS. It will be possible to reduce peak demand further by utilizing the load management features of the battery management system and the lighting control system. The team anticipates tuning of the systems after the building is occupied to further optimize the building loads, onsite generation, and storage.

Figure 10: Microgrid Animation

Source: Architectural Nexus, 2023

Figure 11: Microgrid Results



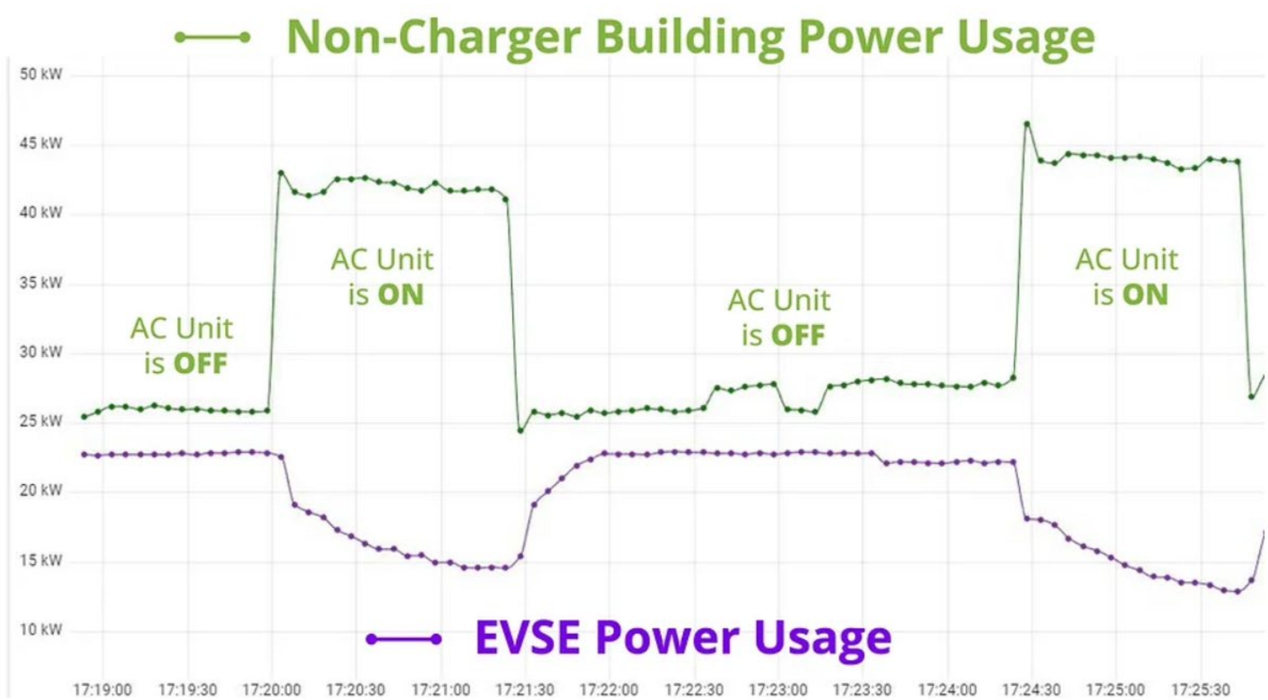
Source: The Engineering Enterprise, 2023

EV Charging, Electric Mobility Strategy, Vehicle-to-Building (V2B), and Vehicle-to-Grid (V2G) Capability

Twenty-three percent of the parking stalls have EV chargers, which is eight out of the total 35 parking stalls (27 onsite, 8 off-street). Six of the eight onsite EV chargers will be equipped with load management software and the capability to respond to grid signals. The design incorporates Atom Power EV charging panels, which centralize the technology components into a single panel, including solid-state circuit breakers, as opposed to most other EV charging products that have technical components housed within an EV pedestal or a wall-mounted unit. Thus, the units at the EV parking spaces would be able to be replaced at a lower cost if damaged. Additionally, the Atom Power EV technology is anticipated to be capable of bidirectional energy transfer by the end of Q2 in 2024, on time for the project schedule (Figure 12). The remaining onsite parking stalls will be EV-ready.

The design team infers that by the time of construction, V2G or V2B EV technology will be allowed by the utility. Part of the developing V2G technology will involve the UL 1741 SC standard, which will prevent bidirectional EV chargers from discharging EV batteries during grid outages prior to islanding. This is similar to how the UL 1741 SB standard continues to enhance the safety measures of inverters by avoiding inadvertent energy exporting. Once the microgrid has islanded, the EV chargers will interact with the microgrid controller to provide energy storage resources.

Figure 12: Atom Power's Load Management Program



EVSE: Electric Vehicle Supply Equipment

Source: The Engineering Enterprise, 2023

Advanced Construction Planning and Practices

Advanced Planning, Design, and Construction Methods

- Using building information modeling (BIM) design software for the wood structure, the framing contractor can reduce the construction time needed for the project. This BIM design software will contain all the project information, including materials, products, and performance specifications. Ultimately, the BIM design software can refine the design before construction begins, promoting time savings by eliminating the need for rework and streamlining the inspections process.
- Wall framing will be prefabricated off-site. This construction method will reduce the overall project construction timeline and development cost.
- Ephoca AIO (all-in-one) heat pumps units were chosen for their all-in-one design that efficiently combines an inverter pump, ERV, MERV 13 filter, and bathroom exhaust, simplifying the installation and maintenance process. This results in a time savings in installation time of four weeks compared to installing them as separate systems. Tier 4 construction equipment will be used by the general contractor and subcontractors. Tier 4 equipment is the grade of the Environmental Protection Agency's (EPA's) new emission standards that all new heavy equipment diesel engines must meet by applying new technologies.

Construction Time and Cost Savings

The two advanced construction methods that will have the most potential for construction time savings in this project are off-site wall fabrication and the installation of the Ephoca heat pump units. Off-site wall fabrication has the potential to reduce the project construction time by three to four weeks and reduce lumber waste, while the obviation of ducts and roof condensers can save up to four weeks.

Reduced Embedded Emissions from Construction and Materials

Using a variety of programs, the project team compared different construction materials to reduce the overall embodied carbon impact of the project. The project team will work with the design build contractor during the build phase to inform product selection to best reduce overall carbon emissions. Specifying low-carbon concrete mixes and ensuring the use of materials such as metals, plastics, and foam that contain high proportions of recycled material will reduce the overall emissions embedded in the project construction process. In addition, having a wood-framed building can help sequester carbon and minimize waste through designing in-common-sized grids and using pre-cut materials.

Market Transformation

Broader Adoption of the Emerging Energy Technologies and Advanced Architectural, Design, and Construction Practices

To ensure the broader adoption of emerging energy technologies and advanced architectural, design, and construction practices, the design team employed a comprehensive community and client engagement process. This process was not only intended for the successful implementation of the technology, but also for the education and engagement of the various stakeholders involved. This educational approach promoted the use of advanced technologies and fostered trust among the community members, utilities, and workers involved. This collaborative approach will also help catalyze broader technological adoption for sustainable energy management.

Standardized, Repeatable, and Scalable Model

For Mutual Housing California, the introduction of these emerging technologies has presented a paradigm shift in how affordable and mixed-use developments can meet ambitious sustainability and positive-net-energy goals. Mutual Housing California's concurrent exploration of modular housing and more standardized architectural plans for improved replicability across new development opportunities presents an exciting opportunity to explore the incorporation of these innovative energy features that meet the Next EPIC Challenge goals. Mutual Housing California is in the midst of a Basis of Design overhaul for the rest of their portfolio that will redefine the minimum construction standards for new developments based on energy goals and target populations. Mutual Housing California may explore the hiring of a consultant to standardize unit plans of varying bedroom sizes that pre-incorporate the Mutual Housing at Fairview Terrace energy features into the plans of other projects. This would allow for easier integration into new developments, reducing the time required for conceptual and design development phases, which often drive up the cost of affordable housing projects due to inflated design fees.

For example, during the measurement and verification period, if the Ephoca HVAC units do indeed meet or exceed EPIC and cost saving goals, Mutual Housing California would add these as an HVAC requirement into their Basis of Design and explore standardized residential unit typologies to save future design time for new projects. This same strategy can be used for the incorporation of vampire switches, energy usage monitors, and windows for natural ventilation when weather and air quality are good. While the design of electrical rooms, individual distribution frame (IDF) rooms, battery storage rooms, and similar spaces is often customized to the layout of each development, unit plans have the potential for standardization. The cost reduction opportunity would allow Mutual Housing California to introduce more cost-effective, energy-efficient development proposals to funding entities, which would increase competitiveness and indirectly push the envelope for the affordable housing development landscape.

Financing Strategies

The capital and operating costs of the advanced energy elements of the project will be funded by the same financing programs used to fund the entire development. These financing programs are used by affordable housing developers throughout California. However, certain funding programs such as the federal government's Renewable Energy Tax Credit were enhanced through the passage of the Inflation Reduction Act (IRA) in 2022. Few, if any, affordable housing developers have taken advantage of these newly enhanced energy tax credits, in part due to limited installation of robust onsite PV and battery storage among affordable housing developments. The Mutual Housing at Fairview Terrace Project will provide significantly more onsite PV than typical housing developments and serve as a model of how these enhanced tax credits can be maximized to generate additional funding for the project. Mutual Housing California is in active conversations with lenders, investors, and financial consultants to ascertain how the project can maximize equity investment by leveraging these credits.

45L Energy Efficient Home Credit: Section 45L tax credits provide taxpayers with an as-of-right tax credit for new homes that meet applicable ENERGY STAR home program or Department of Energy Zero Energy Ready Home program requirements, which the proposed Mutual Housing at Fairview Terrace project design would greatly exceeds. Each unit could generate up to $5,000 of 45L tax credits. The IRA greatly improved the applicability of the 45L credits to a wider variety of project types and extended its use to 2033. The use of this credit requires high certification fees of about $700 per unit. However, the potential generation of $380,000 in additional tax deductions for the tax credit energy investor increases financial marketability of the project and will inject more equity, as the 45L credits can be bundled and sold to the investor with the Investment Tax Credits and Low-Income Housing Tax Credits. Very few projects have taken advantage of the enhanced 45L credit post-IRA passage, especially multifamily developments more than three stories since the credit used to only be applicable to developments three stories and under. The Mutual Housing at Fairview Terrace Project will serve as a prototype that demonstrates a unique bundling of various tax credits that is only possible due to the advanced, innovative design of the project.

CEDA: The California Energy Design Assist Program is funded by California utility customers and administered by Pacific Gas and Electric Company under the auspices of the California Public Utilities Commission. This program was explored but not pursued because it was determined that the design assistance expertise the program would have provided for the Zero Net Energy (ZNE) design already existed inhouse on the project team.

CEC BUILD: The CEC Building Initiative for Low Emissions Development (BUILD) Program incentives are designed to support market transformation toward building decarbonization and reduce the upfront costs and perceived risk of adopting new technologies. Mutual Housing California has coordinated with technical assistance providers, consultants, and the design team to obtain a BUILD design reservation of $321,619. This grant funding will subsidize innovative energy features on top of the EPIC Build Phase funding and is an important gap funding source to improve the feasibility of the project.

Standards and Protocols for a Plug-and-Play Environment

As mentioned above, the Build Phase aligns with Mutual Housing California's Basis of Design overhaul. Mutual Housing California will leverage the emerging technologies introduced to improve data collection. The MPC will provide real-time monitoring of energy usage and allow management to establish ranges of occupant comfort to ensure residents are not straining HVAC units by exceeding minimum or maximum temperatures unless absolutely necessary. Mutual Housing California will also take full advantage of Castle Gate Engineering's solar monitoring interface to understand solar PV performance as the interface will be mandated for all of Mutual Housing California's future communities. This plug-and-play technology allows asset management to immediately understand solar performance once the system is connected and allows access at the property management level to troubleshoot solar production issues should they arise.

Reducing Risk

Mutual Housing California has been a leader in the incorporation of innovative energy features within affordable housing communities throughout the Central Valley region. In collaboration with the design team, Mutual Housing California hosted Architectural Nexus and other consultants at Mutual Housing at Spring Lake, an internationally renowned ZNE community in Woodland, California, for a discussion and site visit. Mutual Housing California then gathered feedback from the Mutual Housing at Spring Lake staff regarding their nearly eight years of operations experience with the energy features there, with a focus on the performance, cost savings, and maintenance perspectives.

The design team ensured that the innovative energy features in the Mutual Housing at Fairview Terrace Project could function independently of each other. While certain energy features complement others to promote system integration, this strategy of ensuring functional independence promotes risk reduction by reducing the likelihood that a failure of one technology will jeopardize other critical building functions that supply power, water, connectivity, heating, and cooling to residents.

The incorporation of new emerging clean energy technologies carries financial risk. However, Mutual Housing California was able to assess fully the financial risk with future financial partners. Proactive discussion with investors and lenders about the project, still in the predevelopment stage, revealed their risk appetites early on and clarified how these technologies may affect the terms of certain financing mechanisms such as tax credit equity and permanent debt, which was critical to understanding the feasibility of the project. For example, the IRA of 2022 provides incentive for developers to further surpass Title 24 base compliance and take advantage of more available funding. Thus, investors and lenders could potentially modify financing terms to negatively impact projects that have more novel technologies. Mutual Housing California consulted potential investors and lenders and received no major concerns nor indication that financing terms would drastically change for the Mutual Housing at Fairview Terrace Project, in part due to the stringent review and reporting requirements of the Next EPIC Challenge and the successful histories of the project team.

Furthermore, the design team considered or built in the following contingencies for each of the emerging clean energy technologies:

a. **PV/Battery/Microgrid** – The electrical design has additional room for conduits and connections, providing flexibility to choose between AC or DC connection to a battery system during construction and thus allowing more options to be evaluated in the future. In addition, the electrical power riser diagram shows continuity in connection between meters and strategically located breakers that can allow for virtual net energy metering versus net energy metering.

b. **CEL** – The software by Community Energy Labs has not been tested in field for multifamily/multitenant developments yet. However, the risk of adopting this technology is negligible as the technology is designed to interact with existing equipment without the need to replace any hardware.

c. **Icarus RT** – The Icarus RT Quartet Hybrid Solar Energy heat extraction system is designed as an attachment to the PV panels, so the technology would not alter any physical aspect of the conventional PV panel installations. If the Quartet panels were to become unusable, they could be simply disconnected from PV panels if needed. The heat exchanger between the thermal storage tank and cold-water line could also be disconnected without interrupting with the business-as-usual domestic hot water heater loop.

Community Engagement

Community Input and Community Feedback

The project team implemented the Social Economic Environmental Design (SEED) Network certification process to provide a robust community outreach process that was used to incorporate community input into the design at each phase. The SEED Network is a platform that provides projects with a third party-reviewed public outreach certification based on the mission "To advance the right of every person to live in a socially, economically, and environmentally healthy community."

The team brought interactive dot boards, comment cards, and translators to ensure community input would be successfully received. The events attended included the STAND Office food distribution and farmer's market as well as the San Joaquin County Fairground Flea Market. Both events are within walking distance of the proposed Mutual Housing at Fairview Terrace project site. Multiple rounds of outreach were attended to show design progress and obtain feedback along the way. In addition, CEL held user interface charettes to obtain the community and potential users' input on facility building interfaces.

Elements of the design that have implemented the outreach results include but are not limited to the following: increased site lighting and safe walkways throughout the development, a green screen to grow urban agriculture for resident and neighborhood use, fruit trees, herb gardens, raised planter beds for community gardening, indoor and outdoor bike storage, vibrant interiors with wayfinding features, interior biophilic elements with connection to nature, a protected courtyard to provide a gathering space, a community-driven mural wall, a barbecue area, a pet zone, rainwater cisterns for irrigation and resiliency, a stretching station for wellbeing, a cooling center, and a community room. In addition, all the units are planned to be affordable. The services, resilient elements, and onsite renewable energy will help drive down resident living costs. STAND, the local nonprofit community organization who will occupy the mixed-use office space, will continue to provide services to the community including food distribution events.

Improving Affordability and Mitigating Gentrification

Based on the community input, the cost of living is a struggle for families and individuals in different stages of life. Young families as well as seniors need special resources in the community. Building excitement and awareness within this neighborhood through targeted community events will ensure members of the local neighborhood are the first to know to apply for housing once the Mutual Housing at Fairview Terrace development is ready for leasing.

The targeted income level of the future tenants is 30 percent to 60 percent of area median income. The means to ensure affordability will include income verification of the tenants in addition to a 55-year regulatory agreement with the state, ensuring long-term affordability of all units. Mutual Housing California will also target an average affordability of 50 percent area median income or lower, making the development deeply affordable. The design and proposed density are a result of considering both the priorities of the community and the city of Stockton, which have indicated affordable housing for seniors is a much-needed housing type.

Positive Impacts on the Local Community

The positive impacts of this mixed-use development on the community of Stockton will be copious. Providing this community with affordable living options will allow them to thrive in place without having to be displaced or separated from family members. Including access to services and local nonprofit organizations will drive down costs and transportation needs while also increasing neighborhood presence and ownership. The addition of safe pathways lined with trees and plantings will reduce surface temperatures, increase access to nature, and make this community in Stockton more walkable. The community-driven art wall will be a point of pride and distinction for the community as their input directly shaped the design of the mural. In addition to driving down utility costs for residents, the energy and resiliency of the building provides the residents of Stockton an opportunity to learn sustainable living habits and better understand how these habits benefit both themselves and their communities.

Workforce Development or Local Job Creation

The space located on the prominent corner of the project will be the office space for a local nonprofit organization, STAND. STAND offers the community many services and employment. Some of the events that STAND hosts at their office include community food banks and job fairs with companies that offer employment to the community. In addition to the work opportunities that STAND offers, the project will offer local employment related to construction, property management, maintenance, and overall education and demonstration of sustainability practices. The new space for STAND in the Mutual Housing at Fairview Terrace development will give them more space and opportunities to best serve the community.

Access to Electric Mobility, Solar PV, and Demand Response for Tenants

The site will have eight EV chargers installed, and the remaining parking stalls will be EV-ready. The EV chargers will be accessible for use by the residents, staff, and visitors of the commercial space. All these EV chargers will be equipped with power management components that will balance grid demand and cost of charging. The access to EV chargers will improve access to electric mobility. In addition, several opportunities for secure bike storage will be available onsite, encouraging residents to use alternative transportation such as electric bikes.

The project will improve access to solar PV by showcasing the PV throughout the development. A variety of PV types will be on display including vertical BIPV, rooftop PV, and carport PV. The energy data collected will be displayed in the lobby on an interactive touchscreen for educational purposes. Considering the prominence of PV on the project, any visitors or residents will learn about the benefits of PV implementation and the different ways solar energy is used in the project.

Demand response initiatives are becoming increasingly essential for grid reliability, yet many commercial buildings and multifamily housing developments lack demand responsiveness due to the absence of enabling technology. CEL seeks to bridge this gap, enabling tenants to access and benefit from advanced demand response capabilities. Through this collaboration with SCE and the integration of the TeMix platform, CEL's technology will empower tenants with real-time energy pricing and dynamic load management. This approach ensures both efficient energy consumption and alignment with grid needs.

Under the real-time tariff, customers can buy or sell energy up to a defined maximum kWh quantity at prices that tenders set. These tenders, which can apply to 5-minute, 15-minute, or 60-minute intervals, establish the price and quantity of energy that can be bought or sold. If the required kW for a given interval is underestimated, then the difference is sold back to the grid at retail selling price. And if the energy is overestimated, then the difference is bought by the customer at retail buying price.

CHAPTER 3: Results

Design Challenges

One of the design team's first challenges was optimizing the shape and size of the site and building footprint. The project team aimed to maximize unit count, have an ideal site orientation for solar energy generation, and meet fire access and parking requirements of the city. After determining the best building layout for the site, the design team reduced the energy use intensity of the project by applying design strategies and incorporating clean energy technology. For example, the rooftop solar PV size was maximized, but the size of the carport canopies of PV had to be limited due to code and fire life safety requirements. The team thus turned to emerging technologies and load-shifting strategies such as vertical solar BIPV, the Icarus RT Quartet Hybrid Solar Energy heat extraction system, and CEL software to design the project to successfully meet the ZNE requirement (Figure 13).

The next largest challenge was finding a designer with experience designing small-scale microgrids to ensure the best microgrid design that would meet the Next EPIC Challenge goals would be created for the project. Most microgrid consultants and vendors work on large-scale microgrid projects and not on projects on the same scale as the Mutual Housing at Fairview Terrace Project. After approaching several vendors, the team found the right consultant, CastleGate Engineering, to work collaboratively with the electrical engineering team.

Figure 13: Mutual Housing at Fairview Terrace Bird's-Eye View

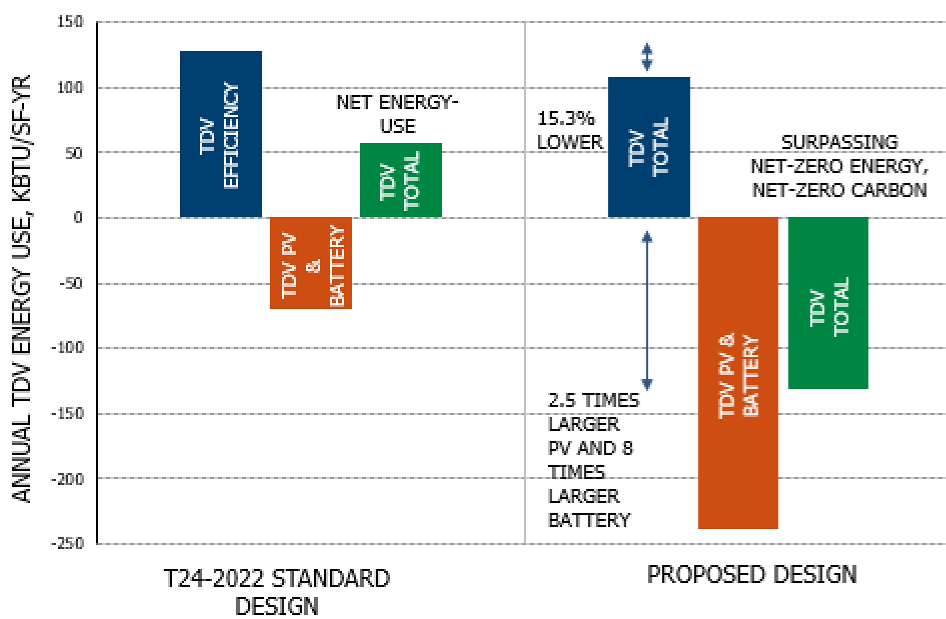
Source: Architectural Nexus, Inc.

Energy and Emissions Performance

A Standard (Baseline) Design is a building that meets the energy and emission reduction requirements of the 2022 Building Energy Efficiency Standards (Title 24, Part 6) (Standards). Time dependent valuation (TDV) values were compared to the Standards to identify certain key performance components that would help achieve this.

The proposed design has 15 percent better TDV efficiency and 17 percent lower operational carbon emissions compared to a Title 24 Part 6 standard design before considering PV and battery. The proposed PV kW_{dc} size is 2.5 times larger and battery kWh size is 8 times larger than that required by the code, making the building an all-electric Net-Positive Energy and Net Zero (Operational) Carbon project (Figure 14).

Figure 14: Title 24 (T24) Compliance Energy Model results



Source: Architectural Nexus, Inc.

Costs and Benefits Performance

The Mutual Housing at Fairview Terrace Project presents an exciting opportunity to synthesize innovative energy technologies, community-responsive design, advanced construction methods, and sustainable building operations. To help ensure the financial feasibility of the complex development project, the project team conducted intense, iterative cost feasibility analyses. The novelty of certain building features and emerging technologies required close coordination with the project cost estimator, design consultants, and the vendors and manufacturers of these features and technologies.

The project team compared the cost premiums of the proposed design to a minimally Title 24-compliant standard design. The project team projected the energy billing cost savings for residents and the owner over the 30-year lifecycle of the building by discounting future annual savings to a net present value. The net present value indicates whether the energy bill savings realized by residents and the owner due to the proposed design are indeed significant enough to be considered more cost-effective than the lifecycle cost of the minimally Title 24-compliant standard design.

The cost feasibility analyses revealed that achieving the Next EPIC Challenge goals through building features, construction methods, and emerging energy technologies is very unlikely to result in incremental first cost savings but rather first cost premiums which could be mitigated through innovative construction methods. Meeting the Next EPIC Challenge goals through the proposed design resulted in a net increase of about **$900,000** in incremental first costs of building and construction features, and about **$4,660,000** in incremental first costs for energy features. However, these premiums are still well within financial feasibility and can be further reduced through additional research of value engineering and cost savings measures during the Build Phase, when additional estimates are performed with more developed construction documents.

On the operations side, lifecycle cost savings through energy bill reductions are realized in part due to the first cost premiums for both residents and the owner. In other words, the higher upfront investment during construction results in higher lifecycle cost savings during operations (Table 2). These bill reductions are significant. Residents will essentially see their energy bills reduced to zero, as will the owner. The lifecycle costs for both residents and owner based on a 30-year building life both result in large negative values, indicating that the first cost premiums result in an operational cost benefit due to lower energy bills than a standard minimally Title 24-compliant design would incur.

Table 2: Results Summary

Incremental First Cost per Unit ($/Unit)			Residents' Lifecycle cost (based on utility rates)($)			Owner Lifecycle cost (based on utility rates)($)		
Standard	Proposed	Increase(+) or Savings(-)	Standard	Proposed	Savings	Standard	Proposed	Savings
$ 370,136	$ 443,246	$ 73,109	$ (2,656,008)	$ (274,395)	$ (2,930,403)	$ 2,620,343	$ (4,768,462)	$ (2,148,119)

Source: Mutual Housing, 2023

Technology Transfer Plan

The project team is currently developing media targets and media packages, which will be shared before the Mutual Housing at Fairview Terrace Project has finished construction. The project is also currently registered with the International Living Future Institute (ILFI) and is designed to qualify for ILFI's Zero Energy Certification. The project team aims to complete this certification in the Build Phase and allow the constructed building to be a case study for future projects to promote the adoption of clean energy technologies into development designs.

In addition, the team is working with local American Institute of Architects (AIA) chapters to put together an educational webinar about the project as a case study. Future steps include presenting at other industry conferences and events, involving but not limited to: AIA, ILFI, the United State Green Building Council, and the Design-Build Institute of America. Mutual Housing California will also pursue opportunities to broadcast the achievements of the Mutual

Housing at Fairview Terrace Project to the developer community. Mutual Housing at Spring Lake, Mutual Housing California's first ZNE community, received a global Habitat for Humanity award, which presented a strong marketing opportunity. Similar awards and recognitions will be pursued. Mutual Housing California is also participating in the U.S. Department of Energy's Better Buildings Challenge, which entails a national initiative and commitment to 50 percent GHG reduction over 10 years and a 20-percent energy reduction over 10 years in commercial, institutional, industrial, and multi-family buildings. The Better Buildings Challenge also allows a platform for cross-collaboration and cross-learning among participating developers and companies and provides technical assistance, which if awarded will further support the project team in the Build Phase.

CHAPTER 4: Conclusion

The Mutual Housing at Fairview Terrace Project is a community-focused project with positive ramifications for how designers approach affordable housing projects. The project addresses two issues: affordable housing and climate change. These are often seen as separate issues, but they are actually deeply interconnected issues. Building resilient housing developments will be a crucial step toward mitigating the negative effects of climate change, especially on disadvantaged and low-income communities.

This project highlights how buildings can function without fossil fuels, which is congruent with California's goal to run on 100 percent clean energy by the year 2045. The building was sited to maximize energy generation with solar PV panels, promote clean transportation with EV charging stations, and provide resilience through a BESS / backup source of energy for the building. The Mutual Housing at Fairview Terrace Project reduces overall energy use through vampire switches, tenant and visitor training regarding sustainability behaviors, the Icarus RT Quartet Hybrid Solar Energy heat extraction system, and CEL's MPC technology, which will empower tenants with real-time energy pricing and dynamic load management. Bidirectional charging is gaining popularity across California, and Mutual Housing California put this technology to the test. The project operates on a microgrid, supporting a self-sufficient building should the larger grid system fail. During blackouts, extra energy from the BESS and EV stations flows back into the building, supporting the community cooling center. This functionality thus promotes the phaseout of fossil fuels and can help mitigate the impact of climate disasters on tenants and the local community.

The resiliency and affordability of the Mutual Housing at Fairview Terrace Project speaks to the importance of environmental justice. Close collaboration with the community identified concerns such as food deserts and air quality. Intense summers, exasperated by the urban heat island effect and poor air quality, disproportionately impact disadvantaged communities. The designed community garden and STAND food bank addresses the food deserts problem. The encompassing green screen increases the air quality of the area and reduces the urban heat island effect, while providing a connection to nature for residents. Affordable units and utility bills ease resident's financial burdens to help lift them out of poverty.

The Mutual Housing at Fairview Terrace Project is a starting point. It is not the project team's goal to simply showcase new technology, only for society to continue living in a polluted status quo. The technologies, knowledge, and design of the Mutual Housing at Fairview Terrace Project must be leveraged to greatly impact existing markets and state policy.

GLOSSARY AND LIST OF ACRONYMS

Term	Definition
AIA	American Institute of Architects
Alternating current (AC)	alternating current is the form in which electric power is delivered to businesses and residences.
AMI	area median income
Basis of Design	documents the principles, assumptions, rationale, criteria, and considerations used for calculations and decisions required during design.
BESS	battery energy storage system
BIM	Building Information Modeling
BIPV	Building Integrated Photovoltaics
BMS	Building Management Systems
BUILD Program	Building Initiative for Low Emissions Development Program
CA OEHHA	California Office of Environmental Health Hazard Assessment
CDHCD	California Department of Housing and Community Development
CEC	California Energy Commission
CEDA	California Energy Design Assist Program
CEL	Community Energy Labs
Condensing System	condensing units move energy in the form of heat by compressing a gas known as "refrigerant," then pumping this gas through a system of coils to heat and cool spaces.
Daylighting Studies	daylighting studies are calculated to understand the progression and intrusion of daylight into an environment over some defined time interval or at critical dates and times during the year.
DER aggregation	distributed energy resources aggregation is the collective management and coordination of multiple small-scale decentralized energy resources to provide grid services and meet specific energy needs.
Direct (DC) connection	direct current is the one directional flow of electric charge.
Domestic Hot Water (DHW) heaters	domestic hot water heaters are part of a system that delivers hot water to sinks, showers, and other appliances.
Energy Efficient Home Credit	tax credit offered for home improvements that increase energy efficiency
EPA	U.S. Environmental Protection Agency

Term	Definition
Ephoca AIO (all-in-one) heat pumps units	all-in-one design that combines an inverter pump, ERV, MERV 13 filter, and bathroom exhaust.
EPIC	Electric Program Investment Charge
ERV	Energy Recovery Ventilation
EUI	Energy Use Intensity
EV	Electric Vehicle
Fenestration	the arrangement, proportioning, and design of windows and doors in a building.
GHG	greenhouse gas
Green Screen	a design feature that is composed of welded wire trellises to create a 3-dimensional structure. This is used to create a green space.
GWP	global warming potential
HVAC	Heating, Ventilation, and Air Conditioning
IDF Rooms	provide a way to network an entire building without relying on long cables. IDF stands for Individual Distribution Frame.
ILFI	International Living Future Institute
International Living Future's Zero Energy Certification	a certification that demonstrates the building uses zero energy, instead using the sun, wind, or earth to produce net annual energy demand.
Invert Shading	a self-responsive technology that uses zero electrical energy and no human intervention to operate. It is a self-shading system that reduces air conditioning costs and carbon emissions.
Inverter pump	An inverter that controls a motor on a pump. They save on energy and costs and are more efficient.
IRA	Inflation Reduction Act
kBtu/sf-yr	Energy per square foot per year
kW_{dc}	kilowatt direct current
kWh	kilowatt hour
LDGWP	Lifecycle Direct Global Warming Potential
Massing	the building/structure in three dimensions, not just the outline
Microgrid	a small network of electricity users with a local source of supply that is usually attached to a centralized grid but is able to function independently
MERV	minimum efficiency reporting value
MPC	Model Predictive Control

Term	Definition
Net Positive Development	a development that produces more energy than it consumes
Pavegen	emerging technology of kinetic pavers that use, collect, and store energy from footsteps
Peak Shaving	term used to describe reducing the energy consumed during peak demand on the electric grid.
PG&E	Pacific Gas & Electric Company
PV	solar photovoltaic
Reveals	a term referring to the inner surface of an opening or recess in a wall, typically in relation to a window or door
SCE	System on Chip Environment
SCE	Southern California Edison
Schematic Design	the schematic design phase includes a complete description of building systems such as the structural, mechanical, HVAC, plumbing, and electrical systems, as well as interior and exterior finishes on the building site.
SDG&E	San Diego Gas & Electric Company
Section 45 L	tax credit offered for dwelling units that are part of a building eligible to participate in the EPA's ENERGY STAR Multifamily New Construction Program
SEED	Social Economic Environmental Design
Shrouds	architectural features used in buildings to provide privacy or sun shading
STAND	Stocktonians Taking Action to Neutralize Drugs
TBM	thermobimetal
TDV	Time Dependent Valuation
Tenders	bills
Thermobimetal	thermobimetal is a laminate of two different metals with different temperatures coefficients used for building facades or shading systems.
Tier 1 and Tier 2 critical loads	Tier 1—a facility that provides or supports fundamental public services that have a substantial impact on public welfare and/or safety Tier 2—a facility that provides or supports important public services and impacts public welfare and/or safety but would not have the same immediate, potentially detrimental impact as a Tier 1 facility should the facility be without power

Term	Definition
Tier 4 equipment	U.S. Environmental Protection Agency ruling 2004/06 on emissions for power equipment
Title 24	one of the Building Energy Efficiency Standards that includes the Energy Code and CAL Green.
transactive energy markets	a system of economic and control mechanisms that allows the dynamic balance of supply and demand across the entire electrical infrastructure using value as a key operational parameter.
UL 1741 SB	UL 1741 is the official industry standard for certification of inverter safety and includes numerous safety tests.
UL 1741 SC standard	a new standard development initiative to create requirements for bidirectional electric vehicle supply equipment and interconnection systems equipment for electric vehicles with bidirectional onboard inverters
Vampire Switch	referring to vampire energy, a vampire switch shuts off the flow of energy at a certain time to eliminate the use of power by devices that are not in use.
Virtual Power Plants	comprised of hundreds of thousands of households and businesses that offer support to the existing power grid. The devices they have can be flexible charged, discharged, and managed to meet grid needs.
Xendee	Microgrid Decision Support Platform
ZNE	Zero Net Energy

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Project Deliverables

- Kick-off Meeting deliverables
- Technical Advisory Meeting deliverables
- Critical Project Review Meeting deliverables
- Final Meeting deliverables
- Progress Reports and Invoices
- Final Report deliverables
- Project Performance Metrics
- Conceptual Design and Research Development deliverables, which include the following: Schematic Design Package, Design Development Package, Renderings, Animations, and Milestone Cost Estimates
- Community Outreach Events
- Community Engagement Plan
- SEED Submittal
- Tenant Interface Plan
- Benefits Questionnaires
- Case Study
- Market Transformation Plan
- Build Phase Application Package