CALIFORNIA ENERGY COMMISSION

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ENERGY RESEARCH AND DEVELOPMENT DIVISION

FINAL PROJECT REPORT

The MountZED EcoVillage
Where Design Meets Lifestyle

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The project team hopes that the project will inspire and inform other researchers, practitioners, and policymakers who are interested in pursuing similar goals and initiatives. The project team also hopes that the project will benefit the people and communities of California, who deserve to live in comfortable, healthy, and resilient neighborhoods that are powered by clean and renewable energy . . . by design.

To everyone who made this journey unforgettable, thank you for being a part of our story and for helping the project team script a future powered by innovation and sustainability.

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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 increased safety for the California electric ratepayer and include:

- Providing societal benefits.
- Reducing greenhouse gas emissions 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

Communities for Global Sustainability (C4GS-ZEDlife, LLC) presents the final project report for its innovative sustainable housing solution, aligning with California's zero-net-energy goals and promoting equitable access to carbon-neutral living. We call this solution the MountZED EcoVillage.

The MountZED EcoVillage is a zero energy live/learn residential ecovillage, in the Mount Hope area of San Diego, that integrates green building practices with community engagement. This initiative addresses the urgent need for sustainable, zero-carbon, and zero-waste design in fast-growing communities of concern. The project challenges norms by providing affordable access to cutting-edge technology, fostering a clean, healthy, and peaceful living environment. The project incorporates workforce development, including green building and eco-stewards programs, which foster skills in green industries.

The project focuses on key performance metrics emphasizing efficiency, cost-effectiveness, and community well-being. From reducing annual maintenance costs and operational expenses to ensuring affordability and energy efficiency, each metric contributes to the overall success of the community residents. The project team measures success through resident and community participation, environmental impact, impressive clean energy generation, and the adoption of eco-friendly practices. Circular economy principles guided the project team, tracking materials wastage and resident recycling, and integrating electric personal transportation.

The project demonstrated tangible outcomes, including reduced energy bills, enhanced comfort, and increased market value. The project's success is not merely technical; it hinges on effective outreach and education, with the goal of achieving a 70-percent response rate and knowledge transfer.

Keywords: Sustainable community, zero-carbon solutions, affordable living, performance metrics, circular economy, high performance, community-driven design, knowledge transfer

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Background

The MountZED EcoVillage project addresses the need for sustainable, zero-carbon housing in San Diego, California. The project team developed a Kit of Parts building system to facilitate affordable home construction and integrated renewable energy solutions to meet community needs.

San Diego's current energy landscape reflects recent market trends, environmental imperatives, and evolving energy policies. In response to the California Energy Commission's 2022 EPIC (Electric Program Investment Charge) Challenge, the C4GS-ZEDlife team developed the MountZED EcoVillage project, incorporating innovative solutions to reduce carbon dioxide emissions during construction. C4GS-ZEDlife is a joint venture formed by Communities for Global Sustainability LLC (C4GS).

The C4GS-ZEDlife project design addresses on-premises renewable and shareable energy systems, crafts a new model for mobility solutions, and proposes a viable approach for educating and housing a new green-building workforce. The multi-pronged strategy takes into account construction material fluctuations, supply chain challenges, and economic issues prevalent in the market. It also sets the stage for disruption to business-as-usual construction practices by introducing a Kit of Parts building system.

The Kit of Parts solution offers a do-it-yourself solution to affordable home building by reducing demand on material needs. With the potential for do-it-yourself building, the Kit of Parts building system provides education and employment opportunities that advance both the Mount Hope community and the growing green-building economy.

This report provides an in-depth analysis of the MountZED EcoVillage project led by C4GS: its goals, strategies, and outcomes. The report further outlines how the MountZED EcoVillage project demonstrates strong alignment with the San Diego Climate Action Plan by addressing various strategies and measures related to decarbonization, renewable energy, mobility, a circular economy, resilient infrastructure, and emerging climate action, with a focus on inclusion and sustainability. The project offers policy suggestions that benefit all California stakeholders seeking change in the housing and energy markets.

Project Purpose and Approach

The project's purpose was to reimagine affordable mixed-use development in a carbon-constrained future. The MountZED project's design charter outlines this mission with a positive vision of community, sustainability, and energy efficiency, and with the integration of cultural identity and environmental responsibility. It also defines steps required to participate fully in a sustainable, resilient, circular clean-energy economy that is human, and culture centered

This project calls for a focus on pressing challenges facing Mount Hope and other communities in San Diego and throughout California. The project zeros in on three challenges that are

systemically intertwined: affordability, environmental sustainability, and equitable economic development. The California Energy Commission's EPIC program called for an affordable housing project design to meet the challenges of living in a carbon-constrained future. The MountZED EcoVillage project plan met these challenges by taking a Zero Energy Development (ZED) approach to designing a multi-level housing and transport environment fueled by the sun with a state-of-the-art data management system. The solar housing system uses a Solar PowerClad canopy and data collection system located on top of a residential development constructed from a duplicable Kit of Parts building system. Both systems are discussed in this report.

The scope of the project is expansive, encompassing the creation of a ZED-built environment. This environment is not just a physical space; it also offers a defined cultural space for the local Mount Hope community while harnessing the power of the sun and utilizing state-of-the-art data management systems. The innovative Kit of Parts building system serves as the engineering backbone, stabilizing the construction of duplicable and sustainable urban living, while the microgrid system serves as the development's nervous system, sourcing and distributing energy throughout the built environment and calculating energy consumption.

The design concept addresses the challenge to demystify the building process for communities wishing to engage more fully in building development. It also outlines a plan for energy efficiency by integrating plug-and-play energy solutions that overcome existing technical challenges.

C4GS-ZEDlife approached this project by first conducting preliminary research and asking a number of what-if questions: what if the team demystifies green building industry practices while advancing affordable mixed-use housing development?; what if the project could reduce the carbon footprint of car emissions in multi-family housing, while assisting historically marginalized communities in making the leap to electric vehicle (EV) transportation?; what if emerging technology and clean energy home features could reduce residential ratepayers' energy and financial burdens?; finally, what if the project could serve to train a future generation of clean energy professionals, helping them overcome barriers to entering clean energy professions?

The team learned through its research that the barrier to entry for re-schooling or continued education has resulted from a lack of funds and educational resources for cultivating both youth and adult internships and apprenticeships. An additional barrier to entering clean energy professions is a lack of affordable housing, transportation, and the time to pursue higher education and higher-paying jobs. Solving affordable housing, in combination with workforce training, would enable the green building and energy industry to train the next generation of green workers.

Communities First Approach

The research team examined the energy, environmental, housing, and education vulnerabilities within Mount Hope using a community first approach. The research phase leveraged three robust data tools: CalEnviroScreen 4.0, the City of San Diego's Climate Equity Index, and the United States Department of Energy's (U.S. DOE) Community Leap energy

burden guidelines. These tools, rooted in scientific methodologies, assessed the impacts of climate change, environmental stressors, energy consumption, housing conditions, and educational access at the census-tract level.

Data collection revealed alarming environmental hazards, a stark deficiency in green spaces, limited access to higher education, and the prevailing existence of food deserts. These factors served as pivotal indicators of an urgent need for development of the MountZED EcoVillage. Described as a beacon of hope, this initiative serves as a best-practice demonstration project, not only for San Diego but also for global communities struggling with similar challenges.

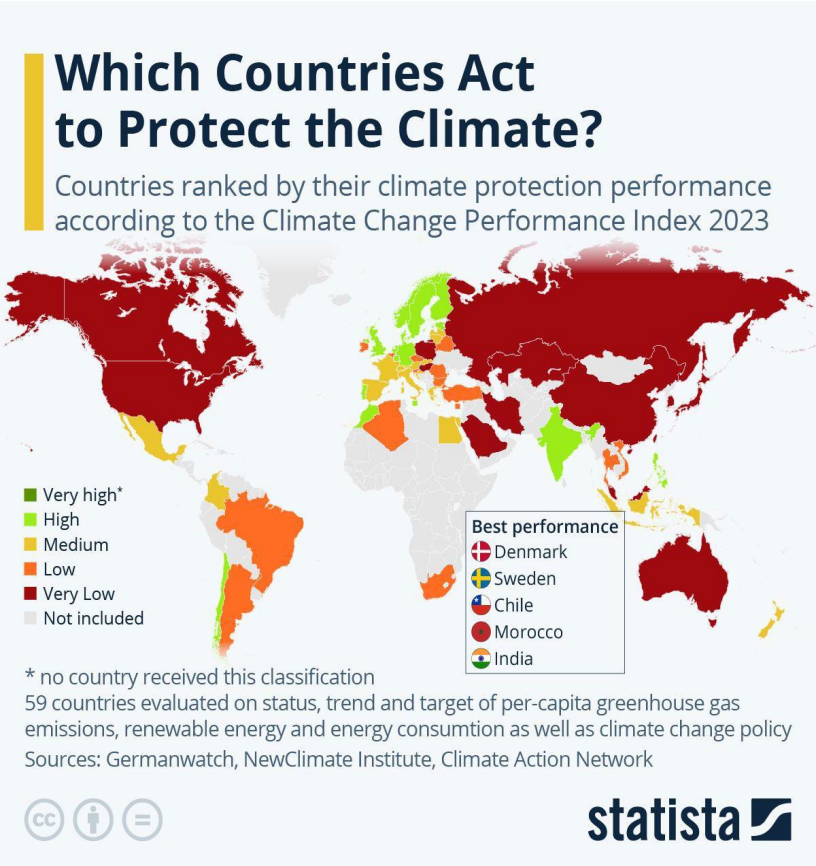
The community first principle is a call to action for people to choose between maintaining the status quo or becoming part of the solution. The team regards the people who reside within each neighborhood as a critical sector of community stewardship. For example, during concept design, the project team actively engaged with local residents, community organizations, and stakeholders to solicit input and gather feedback. The project therefore reflects the needs and priorities of the community; community contributions set the stage for community stewardship.

Working Assumptions and Precedent Studies

The team based its initial research on a fundamental disconnect between traditionally marginalized community awareness and available opportunities for upgrading homes with photovoltaic (PV) solar. This research began just as the cost of fossil-fueled energy hit all California residents, disproportionately impacting residents with fewer means. EV sales then began to drop. Collectively, the team walked into the project with personal experiences of the systemic challenges of both growing a real estate development company and buying and renting in San Diego. The diverse research team understood the history of institutional red-lining and segregation in the community's economic and political systems. Given the major impact of redlining's history on communities like Mount Hope, the project team recognized that there is no single path to untangle complex social webs woven over centuries of self-interested urban planning and predatory real estate practices. This research project formulated a working hypothesis that considered these barriers of entry to both green careers and affordable housing.

The team also researched the experiences of other nations through knowledge exchange initiatives. Figure ES-1 shows how countries rank by their climate protection performance according to the Climate Change Performance Index 2023. In 2018, C4GS-ZEDlife founders met Bill Dunster, author of *ZEDlife: How to Build a Low-Carbon Society Today* and one of the early leaders of sustainable architecture. With the help of his team at ZEDfactory, Dunster designed and assisted in the first community-built, all-clean-energy multi-family community, BedZED, named for the town Beddington and its ZED status (Figure ES-2). BedZED, the United Kingdom's first major sustainable community, delivered energy savings, lower bills, abundant green space, and a friendly community.

Figure ES-1: Climate Protection Graph



Source: Statista

Figure ES-2: BedZED Multi-Family Passive House

Multi-Family Passive House Early Innovation. BedZED, United Kingdom, 2002.

Source: Bill Dunster, ZEDpower

Design Objectives

With systemic challenges atop the precedent study, the C4GS-ZEDlife design team established four fundamental energy pillars upon which to base the foundational goals of the design concept:

1. Reduce energy burdens for tenants by providing access to solar PV and energy efficiency.
2. Create resilience through clean transportation and a focus on health and wellness for all community members.
3. Reduce embodied carbon through the use of low- or no-carbon materials and the use of local supply chains.
4. Ensure equity through shared energy and communal EV rideshare programs.

The success of the MountZED EcoVillage project would be evaluated through measurable outcomes from the project's multifaceted team approach. These measurable outcomes included:

1. A decrease in energy consumption by using advanced architectural modeling and data collection tools.
2. A reduction in the cost to build and maintain the development over the lifetime of the building.
3. A reduction in pollution by using low embodied carbon materials and an operational approach to reducing carbon footprints.
4. Time efficiencies in construction through onsite, community-led modular building construction.
5. Ratepayer benefits, including greater electricity reliability at lower cost.

Key Results

The MountZED EcoVillage project is an inspired development plan for an affordable housing project prepared to meet the challenges of living in a carbon-constrained future. As a ZED project, the ecovillage was designed as a multi-level housing and transport-built environment fueled by solar PV and a state-of-the art solar management system. The solar housing system was engineered using a duplicable Kit of Parts and building process. The MountZED EcoVillage project represents the sustainable values of the Mount Hope community design charter that guided the project development process.

1. To Provide a Positive Vision of Community
2. To Promote Sustainability and Energy Saving Practices
3. To Express Cultural Identity and Environmental Responsibility

The Kit-of-Parts Strategy: This strategy involved using three-dimensional (3D) modeling, a detailed assembly manual, car park construction, computer numerical control 2D cutting, and a training curriculum that enabled entry-level labor to complete over half of the construction. This project integrated photovoltaics into buildings and used long-lasting, safe, lithium titanate oxide batteries for homes and pool vehicles; the project additionally required a grid connection for only about 5 percent of its life. This model, when applied to urban design and planning, would allow the densification of American suburbs without introducing on-street parking or the additional air pollution found in conventional developments.

Emerging Energy Technologies: The project team incorporated several emerging energy technologies to create this zero-emission mixed-use development, surpassing the performance of standard technology in various aspects. The design showcases innovative all-electric applications in both the residential and the nonresidential segments of the development.

Electric Vehicle Integration and Sharing: The initiative to promote EV adoption represents a groundbreaking approach and surpasses standard transportation options. The project's provision for dedicated EV charging stations, coupled with an innovative program such as the I Am Green Go EV sharing program, encompasses both EV trucks and cars and demonstrates a holistic commitment to sustainable mobility.

Housing People, Not Cars: The project's unique design both integrates EVs into the design and maximizes use of the space. The development project's foundation is evidence-based upon comprehensive density studies. These studies influenced the sustainable housing design to develop a new typology that optimizes space utilization by integrating EVs. In addition, the development provides direct access to San Diego Metropolitan Transit System trollies and buses.

Advanced Lighting Design and Controls: The project features a highly energy-efficient lighting design that not only meets but surpasses standard code mandates for both residential and nonresidential spaces. This goes beyond conventional lighting systems by incorporating advanced lighting controls, which contribute to both energy savings and enhanced indoor environments.

Passive Envelope Strategies: Aligned with passive house standards, the project employs passive strategies to achieve optimal indoor thermal comfort without overreliance on mechanical systems. Daylighting, shading, cross-ventilation, and optimal orientation are main passive strategies in this design. The highly thermal-efficient envelope, utilizing state-of-the-art computer numerical control cutting technology, minimizes thermal bridging and addresses deficiencies often encountered in traditional construction methods. The commercial spaces use the same technology as the residential units.

HVAC and DHW Innovations: The utilization of a highly energy-efficient packaged single zone heat pump unit with energy recovery ventilation and variable air volume demonstrates a leap beyond standard heating, ventilation, and air conditioning (HVAC) systems. The individual water-source heat pump systems for domestic hot water (DHW) in each dwelling unit, which exceed standard requirements, further contribute to energy efficiency and comfort. These systems are used for the commercial sections as well.

Renewable Energy Integration: The inclusion of a substantial 682.5-kilowatt solar PV system not only satisfies the project's energy demands but also offsets operational and embodied carbon emissions throughout the building's lifespan. This approach significantly surpasses the impact of standard energy sources, promoting sustainability and reducing the project's carbon footprint.

Battery Storage Integration: The project implemented two types of battery storage: individual 10-kWh battery storage units and communal battery storage units. This contributes to energy resilience and grid stability, outperforming conventional reliance on the grid.

Demand Flexibility and Energy Management: The energy management system by Ivy Energy provides demand flexibility through load shedding and shifting. By prioritizing and managing distributed energy resources and loads, the project showcases adaptive and responsive energy consumption, ensuring efficient utilization of available resources.

All-Electric Applications in Nonresidential Spaces: The project takes innovation a step further by demonstrating all-electric applications in the nonresidential portion of the development. This approach challenged the status quo and set a precedent for sustainable, efficient energy use in commercial and mixed-use settings.

The MountZED Ecovillage also aligns with the following California clean energy and climate goals.

- Reducing fossil fuel consumption: The all-electric ecovillage reduces the use of fossil fuels by 100 percent by providing EV charging stations for all vehicle types. This research project introduces a unique building integrated solar array that generates enough renewable electricity in one year to power the development’s all-electric homes. The operational energy needs at 7.5 megawatt hours (MWh)/duplex plus another 7.5 MWh of power to replace the 20,000 miles per year of gasoline-powered private car use typical in a California household.
- Creating new jobs: The MountZED EcoVillage is a workforce housing and training community with a built-in training center for the green building industry.
- Saving Californians healthcare costs due to pollution: The MountZED development improves public health by reducing the fossil fuel combustion that adversely impacts the local environment. The development therefore reduces harmful indoor pollutants by using all-electric appliances, reducing the need for and cost of healthcare for treating conditions caused by environmental hazards.
- Reducing the demand for oil and fossil fuels: The MountZED EcoVillage is the first of its kind to reduce the use of all fossil fuels in both housing and transportation.
- Creating alliances between energy partnerships and policy research: The project team worked closely with Ivy Energy and Enerlite. Ivy Energy worked with the California Energy Commission in solar metering and Enerlite developed energy analytics for buildings. Additionally, the project team worked with the climate action campaign and the San Diego Green Building Council to determine where the project either aligned or bested the city’s climate action plan.

Knowledge Transfer and Next Steps

C4GS-ZEDlifes's ambition extends beyond a single project; its aim is to revolutionize the mixed-use development industry. The team's approach to this transformation called for taking steps to activate the following key strategies.

Design Standards Blueprint: C4GS-ZEDlife created a blueprint for future mixed-use developments by developing a library of standardized architectural designs that prioritize sustainability. These designs are adaptable to different locations and can be customized to meet specific requirements while maintaining core sustainability principles.

Modular Building Components: C4GS-ZEDlife employed modular construction methods, allowing for standardized, repeatable, and scalable building components. These modules can be prefabricated in controlled environments, enhancing quality control and efficiency.

Cost Predictability: C4GS-ZEDlife offered cost predictions for its projects through cost analysis and optimization. This predictability attracts investors and financing partners, making sustainable mixed-use development a financially viable option.

Collaborative Ecosystem: C4GS-ZEDlife collaborated with developers, architects, and construction companies, and the project team offers training programs and consulting services to ease transitions to the standardized, repeatable, and scalable model.

Community Engagement: C4GS-ZEDlife recognized the importance of community buy-in for widespread adoption. The project team actively involved local communities in the development process, seeking input and feedback to create developments that align with community needs and values.

Benefits of Building the Knowledge Base

The community and stewardship sectors represent two critical aspects of creating a zero-carbon lifestyle. Community buy-in allows sustainable, low-embodied carbon housing developments to become part of the neighborhood. Early neighborhood engagement is the most critical step for community stewardship. This step encourages dialogue and actions to prevent future gentrification and redlining.

The project knowledge base extends beyond technical advancements. It promotes tenant engagement, incentivizes energy efficiency, and utilizes the ZEDPower-platform for emission-free transportation. With proof of energy efficiency in hand, the Mount Hope community is empowered to accelerate the community's transition to sustainable living. Research findings will be shared with the public through future publications.

Achievements and Implications

Recognizing the need for transformative development in the area, the MountZED project team reimagined affordable mixed-use development while prioritizing environmental sustainability and community empowerment. The project built upon the principles of environmental justice to address systemic inequalities and create a more equitable future for residents of Mount Hope.

The MountZED EcoVillage project design provided the following attributes for stakeholders and their implications.

Design for Affordable Housing Units: The MountZED EcoVillage project team developed a plan for a mix of affordable housing options, including permanent supportive housing units, live/work units for students, and market-rate apartments.

Implication: Implementing community first and complete community initiatives will ensure a process of early community development discussions between developers and communities, ensuring adequate time to learn about community needs.

Solving for Carbon Reduction Within an Affordable Housing Development: As a primary design initiative, the team set out to demystify the building process. With the EPIC challenge for solutions to energy-saving development, the team recognized the opportunity to demystify the building process to design and engineer for both efficiency and longevity.

Implication: The ZEDlife lithium titanate oxide batteries were an integral part of the project. Their reduced carbon and extended lifespans enabled a continuous surplus of renewable energy generation, gradually balancing the initial carbon debt incurred during construction.

Putting All Government Land to Good Use: The MountZED EcoVillage development encroaches on three dead-end streets owned by the city. These spaces will be put to good use through the increase in affordable housing units and publicly accessible green spaces.

Implication: The design team worked to meet and integrate city codes into the ZEDhousing and transportation development plan.

CHAPTER 1: Introduction

The MountZED EcoVillage project created a Zero Energy Development (ZED) built environment. This project, funded by the California Energy Commission's (CEC) Electric Program Investment Charge (EPIC) program, addresses challenges in affordability, sustainability, and economic development. In the pursuit of a sustainable future, the C4GS-ZEDlife MountZED EcoVillage project developed an affordable housing community tailored for a carbon-constrained world. It goes beyond construction, envisioning a revolutionary shift in affordable mixed-use development paradigms that align with California's clean-energy mandates. (C4GS-ZEDlife is a joint venture formed by Communities for Global Sustainability LLC (C4GS).

Scope, Focus, and Purpose

The scope of this research project was expansive, encompassing the creation of a ZED-built environment. This environment is not just a physical space; it is a concept that harnesses the power of the sun and utilizes state-of-the-art solar photovoltaic (PV) management systems. The innovative Kit of Parts building system developed for this project serves as the project's engineering backbone, ensuring duplicable results and sustainable urban living.

The project's purpose was to reimagine affordable mixed-use development in a carbon-constrained future, guided by the MountZED project's design charter. This charter articulates a vision of community, sustainability, energy efficiency, and the integration of cultural identity with environmental responsibility.

The Mount Hope community is 77 percent Latino, 10 percent African-American, and 7.2 percent Asian, with the remaining 5 percent being mixed race. The design process was deliberate about the incorporation of the local Mount Hope community's values, heritage, and diversity into the design and function of the EcoVillage. This ensures that the development not only respects but celebrates the cultural narratives of the community. Through active engagement with residents, the design process reflects the needs and traditions of the people, fostering a sense of belonging and stewardship.

The design team was guided by three interdependent initiatives:

- A community-centered design process.
- A cutting-edge solar canopy with a virtual data management system.
- A Kit of Parts, a replicable carbon reducing system of building components.

These initiatives were meticulously designed for energy efficiency, integrating plug-and-play energy solutions to overcome existing technical challenges. The project's significance lies in its contribution to California's clean-energy and climate mandates, which advance establishment of a sustainable, resilient, and clean energy economy.

Context and Background

In response to the dynamic energy landscape characterized by recent market trends, environmental imperatives, and evolving policies, the MountZED Ecovillage project emerged as a proactive solution. The material fluctuations, supply chain challenges, and economic issues in the market set the stage for a unique approach – a Kit of Parts building process onsite. This strategy addresses the market challenges, reduces demand on material needs, and provides education and employment opportunities.

California's housing policies have struggled to keep pace with the global shift toward clean energy, resulting in significant gaps that hinder progress toward sustainable development. One major issue is the inconsistent adoption of zero-energy standards across municipalities, with some regions mandating all-electric buildings while others lag behind. Additionally, many local building codes still include exemptions for certain building types, which delays the broader transition to zero-energy development. Another challenge lies in the lack of comprehensive workforce training in clean energy technologies, which slows the implementation of net-zero practices across new construction projects.

Moreover, integrating affordable housing with clean energy initiatives presents challenges, particularly due to the high upfront costs of implementing these technologies. The Kit of Parts developed for the MountZED project directly addresses this by offering a modular and scalable approach to construction. This system minimizes material waste and lowers construction costs, making it easier to incorporate energy-efficient features, like solar power and battery systems, into affordable housing developments without driving up costs for low-income residents.

Current State of Knowledge and Technological Maturity

The project introduces cutting-edge solutions, including the solar array canopy system, exchangeable battery systems, and a microgrid system. The solar array canopy addresses the inefficiency of rooftop solar installations and offers an innovative and sustainable solution for harvesting and distributing solar power. The exchangeable battery system introduces a novel concept by utilizing the same batteries for both homes and electric vehicles (EVs), addressing the fire-safety challenges for regulatory compliance and promoting a holistic approach to energy consumption.

Benefits of Building the Knowledge Base

The project knowledge base extends beyond technological advancements. It promotes tenant engagement, incentivizes energy efficiency, and utilizes the ZEDPower-platform for emissions-free transportation. With proof of energy efficiency, the Mount Hope community is empowered to accelerate the community's transition to sustainable living. Research findings will be shared with the public and other stakeholders through future publications.

Project Goals and Metrics

The MountZED EcoVillage design team designed 102 units for an affordable multi-family mixed-use housing development. The design demonstrates a forward-thinking, holistic strategy that prioritizes sustainability, efficiency, and community engagement. It contrasts

sharply with traditional affordable housing, which tends to focus on immediate cost concerns and conventional construction methods. By addressing long-term energy consumption, pollution, and construction efficiencies, this housing is affordable, environmentally responsible, and community-centric.

The success of the project was gauged through measurable outcomes and a multifaceted approach. The goals and measurable outcomes included:

- Decreasing energy consumption using advanced architectural modeling and integrated data collection tools.
- Reducing the cost of construction and maintenance over the lifetime of the building.
- Reducing pollution through low-carbon materials and an operational carbon footprint.
- Supporting construction efficiencies through onsite, community-led modular building construction.
- Increasing ratepayer benefits, including greater electricity reliability and lower costs.

With traditional affordable housing, in contrast, energy costs and reliability are addressed but much less comprehensively. Following are characteristics of traditional costs and reliability.

- Renewable energy integration is less frequent, and energy efficiency improvements are often basic.
- Typically, there is less emphasis on advanced modeling and data tools.
- Energy efficiency measures may be included, but they often rely on conventional approaches and older technologies.
- Initial construction costs are often prioritized, sometimes at the expense of long-term maintenance considerations.
- Traditional construction techniques are relied on, and these can be time-consuming and generate more waste.
- Conventional construction methods may be used, which could prove more labor intensive and less cost-efficient over time.
- Pollution reduction is typically a lower priority compared with immediate cost and construction concerns. Use of low-embodied carbon materials is less common, and operational carbon footprints may not be key considerations.
- Community input may be considered, but typically it is less integrated into the design process.
- Design solutions are often more standardized and less flexible.
- Design teams may not prioritize sustainability and advanced technological integration to the same extent.

The design goals, guided by the C4GS-ZEDlife design team, were achieved through community-centered design, cutting-edge solar PV, and a Kit of Parts System. The measures,

informed by data and research, ensure project alignment with energy goals and community needs.

The MountZED EcoVillage pilot project and overarching goals align closely with the goals and strategies in the San Diego Climate Action Plan. Table 1 identifies ways that the EcoVillage pilot project helps the city of San Diego implement specific strategies and measures within its climate action plan (CAP).

Table 1: Project Alignment With CAP Strategy

CAP Strategy	Aligned Contributions From Pilot Project
Strategy 1: Decarbonization of the Built Environment Measure 1.1: Decarbonize Existing Buildings Measure 1.2: Decarbonize New Building Development	• The project exemplifies all-electric new construction in a communities of concern and demonstrates how a developer can successfully utilize "less greenhouse gas (GHG) intensive materials and practices" (in this case, a carbon neutral build). • The project provides an example of decarbonized housing to neighboring homes, strengthening buy-in for existing building retrofits. C4GS engages with the community in an ongoing effort to incorporate members' input and foster an inclusive development process. With city programming support, owners of adjacent homes can access Inflation Reduction Act funds to retrofit their homes in alignment with 1.1 and access benefits of decarbonization also provided by the pilot project.
Strategy 2: Access to Clean and Renewable Energy Measure 2.1: Citywide Renewable Energy Generation Measure 2.3: Increase Electric Vehicle Adoption	• The project contributes to Measure 2.1 by expanding local generation of renewable energy sources through the inclusion of an integrated solar PV facade that provides a significant onsite energy source. This will reduce energy costs for residents and reduce the need to draw power from the grid. The project also includes solar-powered battery storage, exemplifying a comprehensive local distributed energy resource project. This aligns with the "deployment of building scale renewables and mandates the use of renewables through building codes, while engaging residents and other stakeholders in the process." • The project includes electric bicycle and micro-mobility charging stations, as well as EV charging, which are open to the public, which aligns directly with the city's goal. • The project provides shared electric mobility options, as listed above and including EVs, supporting "the citywide electric vehicle strategy to accelerate EV adoption within communities of concern."

CAP Strategy	Aligned Contributions From Pilot Project
Strategy 3: Mobility and Land Use Measure 3.2: Increase Safe, Convenient, and Enjoyable Transit Use Measure 3.3: Work From Anywhere Measure 3.6: Vehicle Management	• The project includes strategies to reduce vehicle miles traveled and GHG emissions from the transportation sector, which is the greatest source of emissions in the region, through the provision of several micro-mobility options. • The project provides low-cost upgrade features, such as shading and benches at the existing transit stop, which aligns with Measure 3.2. • The project offers a residential three-year live/work program for green professional trades and entrepreneurs (ZEDworkshops and ZEDhub). The program aligns with the CAP's telecommute efforts, as well as the CAP's green economy and just transition section. • On every level, each unit will have a parking spot with a charging station directly parallel to the home. This "will optimize use of curb space including the management of on-street parking" for others living in the community, which aligns with Measure 3.6.
Strategy 4: Circular Economy and Clean Communities Measure 4.4: Zero Waste to Landfill	• The project will include onsite composting in order to divert organic waste, including food scraps, from the landfill. The compost will be utilized in onsite gardens and landscaping.
Strategy 5: Resilient Infrastructure and Healthy Ecosystems Measure 5.2: Tree Canopy	• The project includes living art murals, a garden, and shade trees that capture stormwater. This aligns with CAP actions to "increase tree planting in Communities of Concern."
Strategy 6: Emerging Climate Action	• The project is a proof of concept for deploying technologies and practices that reduce GHG emissions from buildings and transportation in an inclusive and equitable process. • C4GS, as an innovative, mission-driven developer, supports the city's goal to "build programs and partnerships to recognize and incentivize business practices that align and implement the CAP strategies and measures." • C4GS will support the city in "identifying opportunities to improve city processes to facilitate faster deployment of technologies and practices in San Diego." The project will inform areas of improvement between the city and developers looking to construct carbon neutral developments.

Source: C4GS-ZEDlife. | The MountZED EcoVillage Case Study | www.mountzed.com

Advancing Market Adoption

The audience for the research findings includes stakeholders in the clean energy, construction, and policy sectors. The factors contributing to the acceptance of the project's results include its cost-effectiveness and ease of installation and maintenance. By pioneering innovative solutions today, the project not only aligns with California's clean energy goals but also sets the stage for widespread acceptance and adoption in other markets.

Through innovative systems and invented products, the project introduces the C4GS ZEDlife Pop-up Manufacturing System, the Kit of Parts System, the microgrid system, the Solar PowerClad System (patent pending), exchangeable batteries, the renewal energy system, and the ZEDlife Virtual Data Management System. These products impact future energy codes, architectural designs, and building practices, and they offer ratepayer savings. The project acts as a proof of concept for reducing GHG emissions and aligning with the San Diego Climate Action Plan.

Tackling challenges like commodity pricing fluctuations and supply chain disruptions, the project strategically adopted a systematic kit of parts for onsite construction. This bypassed outdated housing policies by offering an integrated design plan for EVs, which contribute to a cleaner, more sustainable future.

In discussing the details of the transformative MountZEDEcoVillage described in Figure 1, the team shows that this is both a research endeavor and a visionary movement capable of shaping the future of mixed-use development in California.

Figure 1: MountZED EcoVillage Design

Source: C4GS-ZEDlife | The MountZED EcoVillage Case Study | www.mountzed.com

CHAPTER 2:
Project Approach

The project approach integrates community engagement, sustainable design, and workforce development. The team employed modular construction techniques to streamline the building process and utilized green building materials to ensure sustainability. The MountZED EcoVillage project exemplifies a forward-thinking, comprehensive approach to sustainable urban development. The research and methods employed in this project are grounded in the principles of environmental sustainability, community engagement, and economic inclusivity. The project brought together an integrated design team consisting of architects and civil, structural and mechanical, electrical, and plumbing engineers. The following section outlines the project approach, detailing the research objectives, methodologies, and technologies utilized to achieve the project's ambitious goals.

Overall Design Approach and Strategies

Standard baseline design aims to satisfy the minimum requirements of code and regulatory bodies for the structure, interior environment, and exterior envelope of buildings. These base requirements, established decades ago to protect the health and welfare of occupants and communities, assume a knowledge of material and building systems that is often quite outdated and does not incorporate recent advances in material and systems technologies.

Standard baseline design is not intended to encourage innovation or forward thinking with respect to environmental considerations. As an example, there are no explicit requirements for green thinking or carbon-neutral approaches to maximize the efficiencies of building envelopes, develop sustainable transportation strategies, or develop renewable energy initiatives, specifically solar, wind, and water harvesting. Baseline construction is not required to incorporate locally sourced or low-hazard materials, implement energy efficient fixtures and building systems, or take into consideration new paradigms of community planning and organization.

The MountZED EcoVillage project counters this lack of forward thinking by incorporating into the foundation of its planning and design processes the very features that would be considered "extra" in a standard baseline design.

Research Objectives

The primary objectives of the MountZED EcoVillage project follow.

- Achieve Net-Zero Energy Consumption: Design and construct a community that produces as much energy as it consumes, through renewable sources.
- Promote Sustainable Building Practices: Implement cutting-edge construction techniques and materials to minimize environmental impacts.

- Ensure Affordability and Inclusivity: Provide diverse housing options that serve various income levels and prevent displacement of current residents.
- Foster Community Empowerment: Engage the local community in the planning and development process to ensure that its needs and concerns are addressed.
- Create Economic Opportunities: Generate local jobs and training programs to build a skilled workforce in green building practices.

Methodology

The team methodology follows a Renaissance tradition of project building, basing itself on a master builder approach to organizing and orchestrating an integrative project system design. By bringing together multi-disciplinary teams that have successfully implemented design processes and technologies into the market, the team's approach seeks to scale all of these into an affordable building solution that simultaneously serves to demystify the construction process.

To achieve the stated research objectives, the research team adopted a multifaceted approach involving the following key methodologies:

Community Engagement and Collaboration

- Inclusive Planning and Design Processes: Establish a community focus group led by I Am Green. Engage with residents, stakeholders, and community leaders from the outset to gather input and foster a sense of ownership. Hold community-led townhalls and listening sessions.
- Stipended Stakeholder Consultations: Provide financial incentives for community members to participate in planning sessions, ensuring diverse representation and meaningful feedback.
- Public Forums and Workshops: Host events to discuss project plans, address concerns, and incorporate community suggestions into the development process. Create a community calendar for ongoing engagement and feedback.
- Weekly Design Meetings: Explain the Kit of Parts building system modular method created by Bill Dunster. Continue to co-create and design a modular maisonette kit of parts for the MountZED EcoVillage.

Sustainable Design and Construction

- Modular Construction: Use modular building components and techniques to streamline construction, reduce waste, and enhance energy efficiency.
- Green Building Materials: Select materials with low environmental impact, high durability, and energy efficiency to ensure sustainable construction.
- Renewable Energy Integration: Incorporate solar panels, wind turbines, and other renewable energy sources to achieve net-zero energy consumption.

Educational and Workforce Development

- Live and Learn Initiatives: Partner with local educational institutions to provide onsite training and apprenticeships in green building practices.
- Green Building Training Programs: Develop a curriculum and hands-on training modules in collaboration with universities and trade schools to prepare the next generation of green builders.
- Community Jobs: Create over 100 local jobs during construction, prioritizing hiring from within the community.

Regulatory and Policy Advocacy

- Collaboration with regulatory bodies: Engage with local and state regulatory agencies early in the process to navigate approvals and advocate for policy updates that support sustainable development.
- Pilot Programs: Propose regulatory pilot programs to streamline permitting and provide flexibility for innovative building techniques and energy systems.

Technology and Innovation

- Advanced Energy Systems: Implement state-of-the-art energy management systems to optimize energy use and ensure net-zero performance.
- Smart Building Technologies: Integrate smart home technologies that enhance energy efficiency, resident comfort, and overall sustainability.
- Resilience Testing: Conduct rigorous testing of modular components under real-world conditions to ensure resilience to environmental factors such as temperature fluctuations, moisture exposure, and seismic activity.

Detailed Project Components

As a result of these diverse methodologies, specific initiatives are developed, including new paradigms for multi-family housing and enhanced community education and engagement in green design processes. The integration of carbon reducing innovations impacts the standard real estate development for affordable multi-family housing. The detail includes the following innovations.

Affordable Housing Solutions

- Mixed Housing Types: Develop a mix of affordable, middle-income, and luxury housing units to create a diverse and inclusive community.
- Permanent Supportive Housing: Provide housing for vulnerable populations, including individuals experiencing homelessness.
- Student Housing: Allocate units for live/work student housing to support affordable living options for students.

Environmental Impact and Sustainability

- Energy Efficiency Measures: Incorporate high-efficiency insulation, windows, and heating, ventilation, and air conditioning (HVAC) systems to reduce energy consumption.
- Water Conservation: Implement water-saving technologies such as low-flow fixtures, rainwater harvesting systems, and greywater recycling.
- Green Spaces: Design communal green spaces that promote biodiversity, improve air quality, and enhance resident well-being.

Community Engagement and Support

- Transparent Communication: Maintain open lines of communication with the community throughout the project, providing regular updates and opportunities for input.
- Community Ownership: Explore models for community ownership and management of housing units to ensure long-term affordability and resident empowerment.
- Support Services: Provide access to social services, job training programs, and educational opportunities to support residents' economic and personal development.

Economic and Workforce Development

- Job Creation: Focus on creating jobs for residents during construction and ongoing operations of the Ecovillage.
- Training and Apprenticeships: Partner with local institutions to offer training programs in green building practices, providing pathways to stable, well-paying jobs.
- Local Business Support: Prioritize contracts with local businesses and suppliers to boost the local economy and ensure community investment in the project's success.

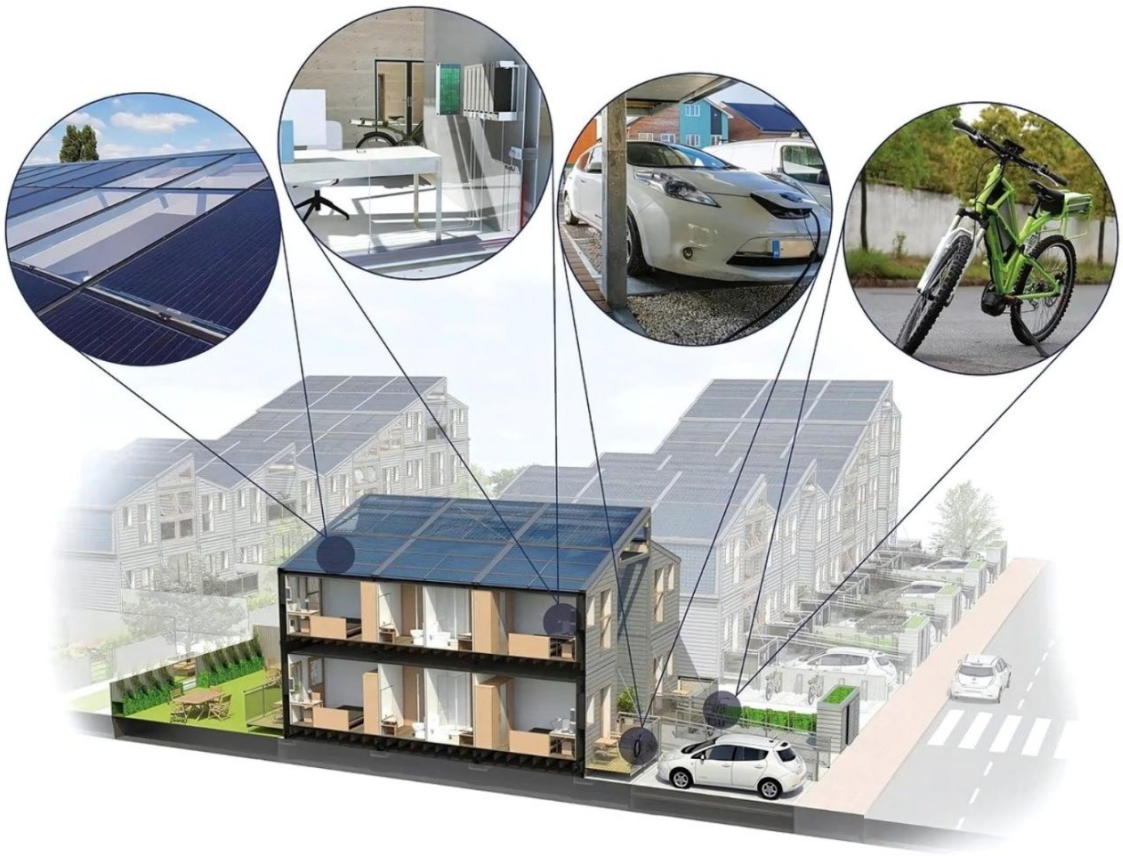
Carbon Reducing Inventions and Innovations

Figure 2 displays some of the carbon reducing inventions and innovations discussed in the following:

- C4GS Kit of Parts System (patent pending US): An economically feasible, replicable, carbon reducing building system that is not dependent on hiring principal architects or contractors. The system provides a solution for carbon reduced and affordable modular building construction.
- The Solar PowerClad System: A building integrated photovoltaic (BIPV) solar panel roofing and facade cladding system. C4GS, CAP, Bill Dunster, and engineers invented the Solar PowerClad System, a proprietary brand of cladding for the solar array canopy.
- ZED Exchangeable Battery System: Bill Dunster, lead environmental architect, solved for the battery storage system by creating an exchangeable battery system using lithium titanium oxide (LTO) battery chemistry. The adoption of this battery chemistry allows for the same battery system to be used in home and bike.

- Ivy Energy and Enerlite created an integrated virtual metering system designed to support micro-grids for a mixed-use multifamily apartment community. They developed cutting-edge solar tech and data management systems that benefit both the EcoVillage residents and the Mount Hope community.

Figure 2: Carbon Reducing Inventions and Innovations



Source: C4GS-ZEDlife | The MountZED EcoVillage Case Study | www.mountzed.com

C4GS Kit of Parts Building System

Integral to the goals of the project, the C4GS-ZEDlife Kit of Parts is an onsite prefab, 12-step construction process that enables building a MountZED maisonette unit in one week.

The Kit of Parts building system represents a groundbreaking approach to construction that demystifies the standard building design process and makes advanced technology breakthroughs accessible to a wider audience. This innovative methodology can be applied across multiple construction projects, ushering in a new era of transparency, accessibility, and sustainability in the construction industry.

In this respect, the C4GS Kit of Parts System construction of complete maisonette development departs from the standard stick-built phased process. More akin to an old-fashioned barn-raising event, the maisonette can be assembled efficiently and safely in one week, using the 12-step building process described in Figure 3.

Figure 3: Building a Maisonette in 12 Steps

Source: C4GS-ZEDlife | The MountZED EcoVillage Case Study | www.mountzed.com

Key to the implementation of the C4GS Kit of Parts System is the organization of construction training workshops involving skilled contractors, ZEDlife Pre-Apprenticeship Certificate fellows, and community residents. Workshops employ a learn-by-doing approach to training and building. The C4GS design team will lead the training and include University of California, San Diego engineering students as interns.

Milestones are set to address building and construction administration progress. A community celebration of achievement marks each milestone attained.

The C4GS Kit of Parts system introduces sustainable design features that standard baseline designs (SBDs) do not. SBDs default to implementing fossil fuels as a solution. The C4GS Kit of Parts building system solves for the SBDs' weaknesses by providing:

- A tight building envelope through innovative modular construction methods.
- Insulation with triple-pane windows that reduce energy costs.

- Solar panels that are an integral component of both the overall project design and its function. These are designed to maximize stored energy to offset peak hours.
- Housing units, community spaces, and a vehicle microgrid solution, all powered with solar energy, which enables the community to go off-grid.
- An all-systems solution that charges all electric home appliances, heating systems, and transportation options.
- The C4GS Kit of Parts System and its innovative approach to modular community-led construction also presents new solutions for the modular housing market, as it stands today.

Table 2 compares and contrasts the C4GS Kit of Parts System and standard baseline design practices.

Table 2: Comparative Building Design Systems

Construction Phase	Standard Construction	Kit of Parts Building System
Design	• Involves architectural design, engineering, and planning. • Requires extensive time for design iterations and approvals. • May involve costly design. • Changes during construction due to unforeseen issues.	• Design is based on predefined modular components. • Reduced design time due to standardized components.
Construction	• Sequential construction with multiple contractors. • Onsite assembly, often leading to construction delays due to weather and other factors. • Increased labor costs due to onsite work.	• Modular components are manufactured offsite, minimizing weather-related delays. • Onsite assembly is quicker and requires less labor.
Materials Procurement	• Procurement of materials from various suppliers. • Potential for delays and cost fluctuations due to market conditions.	• Bulk procurement of standardized materials for all projects. • Lower cost due to bulk purchasing and reduced market sensitivity.
Quality Control	• Quality assurance and control are critical but can be challenging to maintain. • Costly rework may be required to meet quality standards.	• Stringent quality control applied during the manufacturing process. • Fewer onsite quality issues and rework.

Construction Phase	Standard Construction	Kit of Parts Building System
Training and Certification	• Limited opportunities for training and certification for green building jobs. • May require specialized professionals for complex tasks.	• The Kit of Parts assembly process allows for easy training and certification. • In-house training programs are more feasible and cost-effective.
Sustainability Considerations	• Sustainable practices may be an add-on, increasing costs. Carbon footprint may not be a primary focus.	• Sustainable practices are integrated into the kit, reducing costs. Emphasis on a net-zero carbon footprint and eco-friendly materials.

Source: C4GS-ZEDlife | The MountZED EcoVillage Case Study | www.mountzed.com

Implementation Strategy

The implementation of the MountZED EcoVillage project follows a phased approach to ensure thorough planning, community involvement, and successful execution from design to construction and post-occupancy evaluation. The project phases integrate technical, regulatory, and policy initiatives into the standard design phases to maximize seamlessness of implementation and efficiencies across the entire project process.

Phase 1: Planning and Design (3-6 months)

- Conduct comprehensive site assessments and feasibility studies.
- Engage with community members and stakeholders to gather input and build support.
- Develop detailed architectural and engineering plans incorporating sustainable design principles.

Phase 2: Permitting and Approvals (3-4 months)

- Navigate regulatory requirements and secure necessary permits.
- Advocate for policy changes to support innovative building techniques and energy systems.
- Establish pilot programs in collaboration with regulatory bodies to streamline approval processes.

Phase 3: Construction and Development (6-9 months)

- Implement modular construction techniques to expedite the building process.
- Utilize green building materials and technologies to ensure sustainability.
- Create local jobs and provide training programs to build a skilled workforce.

Phase 4: Community Integration and Operation (3-6 months)

- Facilitate the move-in process for residents and provide ongoing support services.
- Monitor energy consumption and performance to ensure that net-zero targets are met.
- Maintain open communication with residents and stakeholders to address any issues and gather feedback for continuous improvement.

The Kit of Parts construction process significantly reduces the overall timeline for the MountZED EcoVillage project compared to traditional construction. The key efficiencies are derived from the ability to perform site work and module construction concurrently, the streamlined permitting process often associated with modular projects, and the quicker assembly of prefabricated modules onsite. This not only expedites project completion but also can lead to cost savings and reduced disruption for the community.

Lessons Learned and Best Practices

The MountZED EcoVillage project offers valuable insights and lessons that can inform future sustainable development initiatives.

Early and Inclusive Community Engagement

- Engaging the community early in the planning process builds trust, ensures that diverse perspectives are considered, and fosters a sense of ownership among residents.
- Providing financial incentives for stakeholder participation can enhance engagement and ensure meaningful contributions.

Innovative Construction Techniques

- Modular construction can significantly reduce construction time, minimize waste, and improve energy efficiency.
- Rigorous testing of modular components under real-world conditions is crucial to ensure resilience and compliance with safety standards.

Sustainable Design Principles

- Integrating renewable energy sources and advanced energy management systems is essential to achieving net-zero energy consumption.
- Prioritizing green building materials and technologies enhances the overall sustainability and durability of the development.

Collaborative Regulatory Frameworks

- Partnering with regulatory bodies and advocating for policy updates can streamline approval processes and support the adoption of innovative building practices.
- Regulatory pilot programs can provide valuable flexibility and encourage the development of carbon-neutral projects.

Workforce Development and Economic Opportunities

- Creating local jobs and providing training programs in green building practices can build a skilled workforce and support the local economy.
- Fostering partnerships with educational institutions and local businesses enhances community investment and ensures long-term project success.

Project Partners and Advisors

Engineering and Technology (Ivy Energy): A company with a legacy dating back to 1956, Ivy Energy specializes in engineering and commissioning services, emphasizing healthy indoor environments and sustainable solutions.

Enerlite Consulting: The company specializes in providing innovative design solutions for energy conservation, daylight abundance, and automated energy model calibration in buildings. Enerlite Consulting's comprehensive analysis is the key to creating buildings that are beautiful and environmentally responsible.

Westberg White Architecture, Architect of Record and Construction Management: The firm is experienced in various markets and collaborated closely with the project team to co-design the MountZED EcoVillage.

Community Outreach (I Am Green): Founded by Maria and David Muhammad, I Am Green focuses on green entrepreneurship, environmental justice, and community empowerment through education and workshops.

Workforce Development (Workforce Solutions Pros): With over 30 years of workforce experience and a strong track record of community engagement, the company is well-equipped to secure job placement and meet local and state diversity, equity, and inclusion goals with the ZEDlife Studio Certificate program.

Project Participants

Guttmann & Blaevoet, San Francisco (Steve Guttmann, Principal): Supported the initial design grant process and MEP Engineer and project design services.

BWE: Provided structural design and consultation for the Kit of Parts System and superstructure.

WSP: Provided civil engineering services and consultation for the development.

San Diego Green Building Council: Provided green building consultation.

San Diego Climate Action Campaign: Provided climate action policy alignment.

Beyond Development: Provided real estate development and project management services.

SCS Engineers: Was responsible for Phase 1 reporting.

Willis Environmental (Christina Willis, CEO): CEQA environmental specialist.

Workforce Solutions Pros, Sacramento (Mack Ross): Design support and consulting for the ZEDlife Studio Workforce Development Programing.

Cleantech San Diego (Jason Anderson, President and CEO): Technical advisor.

US West Engineering (Eric Solrain, Architect, Design Leader at Integral Group): Technical advisor.

Santa Ana Unidos (Alan Woo, Deputy Director): Technical advisor and board member.

San Diego State University (Saeed Manshadi, Assistant Professor): Technical advisor.

VCA, San Diego (Moe Fakih, Principal): Technical advisor.

Architectural Design, Aesthetics, and Functionality

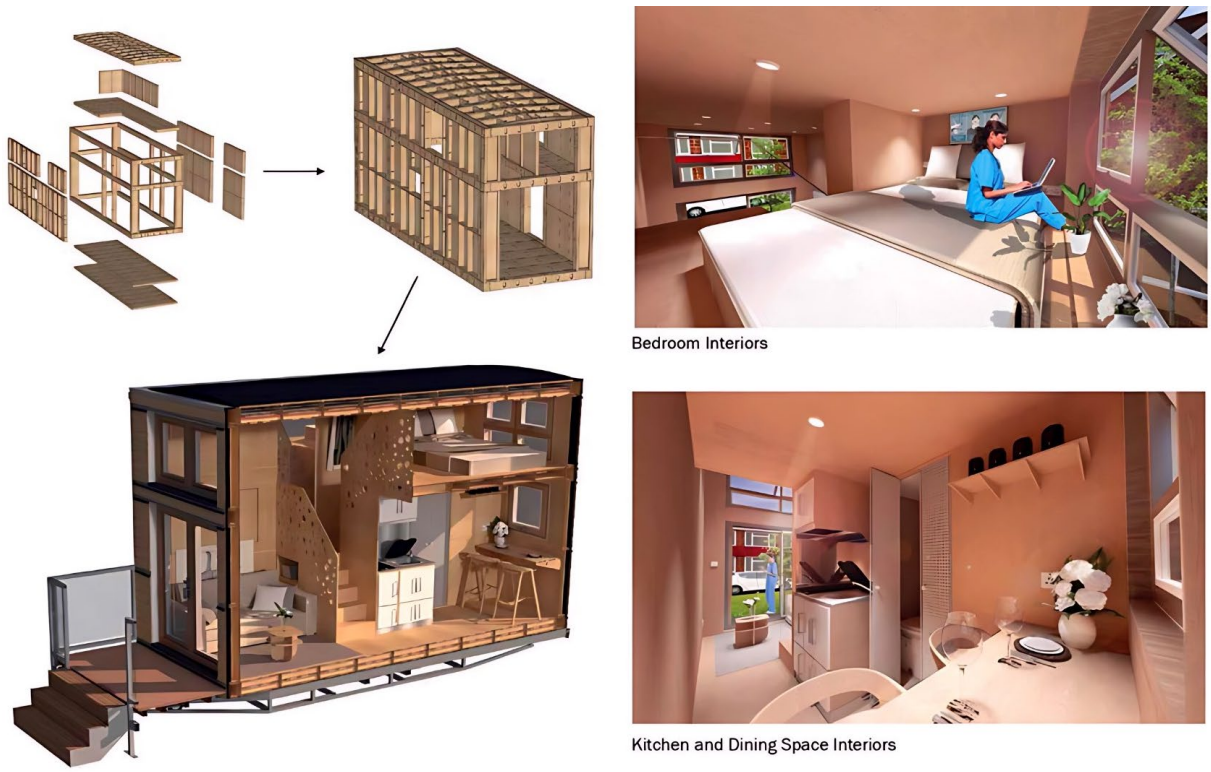
Architectural Design

The project team radically rethinks standard baseline design by incorporating many of its own inventions and innovations into the project design. The team adopted a pavilion approach to the site design, which allowed for substantial views and green communal space in the spaces between. The standard building enclosure and interior is replaced by community-built maisonette units and integrated EV access ramps. Each unit incorporates an EV charging station, a private balcony, and direct access to external corridors, enhancing access to light and integrating interior and exterior systems as one holistic event.

Aligned with this, two other novel features are the generous inclusion of ample greens and public space, shaded by the solar canopies on the south side that simultaneously generate surplus energy (more than the project consumes); both give back to the local community. Using voids, translucent panels, and lightwells, the project filters light to the lower levels without obstruction.

The C4GS Kit of Parts System is clearly the system component that most influenced the form factor of the proposed design and distinguishes it from standard baseline design. These plug-and-play units allow flexibility and modularity in ways that can help establish new standards for affordable multi-family units. They push the performance envelope, being fully insulated and airtight, while at the same time being highly accessible and community-built by the simple means of assembling pre-cut plywood paneling, as illustrated in Figure 4.

Figure 4: Aesthetics and Functionality



Source: C4GS-ZEDlife | The MountZEDEcoVillage Case Study | www.mountzed.com

Aesthetics and Functionality

The design seamlessly merges functionality with aesthetics. Deliberate choices were made in favor of energy-efficient materials and systems that not only reduce carbon footprint but also introduce visually appealing alternatives to traditional construction methods. Following are features employed to improve functionality and aesthetics.

- Solar PowerClad System: Instead of attaching conventional solar panels to a metal roof, the project opts for a cutting-edge translucent bi-facial BIPV. This innovative choice both harnesses sunlight efficiently and creates a harmonious play of light and shade. It also reduces the need for a separate roofing system and the additional materials typically required for solar panel installation.
- Flush Soffits: In line with the latest advancements in eco-friendly commercial garage construction, the project team adopted flush soffits. These soffits are designed without upstand or downstand beams, offering a clean and contemporary look that promotes an efficient use of materials and contributes to sustainability.
- Building Skin: The modular Kit of Parts utilizes computer numerical control-cut flame-proofed plywood with a stressed skin design. This empowers entry-level workers, promotes skill development and replication in other locations, and ensures safety and skill transfer in construction.

- Exchangeable Battery Systems: Beyond aesthetics, the project team incorporated exchangeable battery systems for electric micro-mobility, promoting sustainability.
- Locally Sourced Materials: Gabion retaining walls, filled with locally sourced stone, replace traditional concrete, thereby enhancing resilience and supporting the local ecosystem.
- Enhanced Accessibility: The walkable ramping system transforms the development into a vibrant urban neighborhood, fostering community engagement and a sustainable, livable environment.

Design Strategies for Integrating Conventional and Emerging Energy Technologies

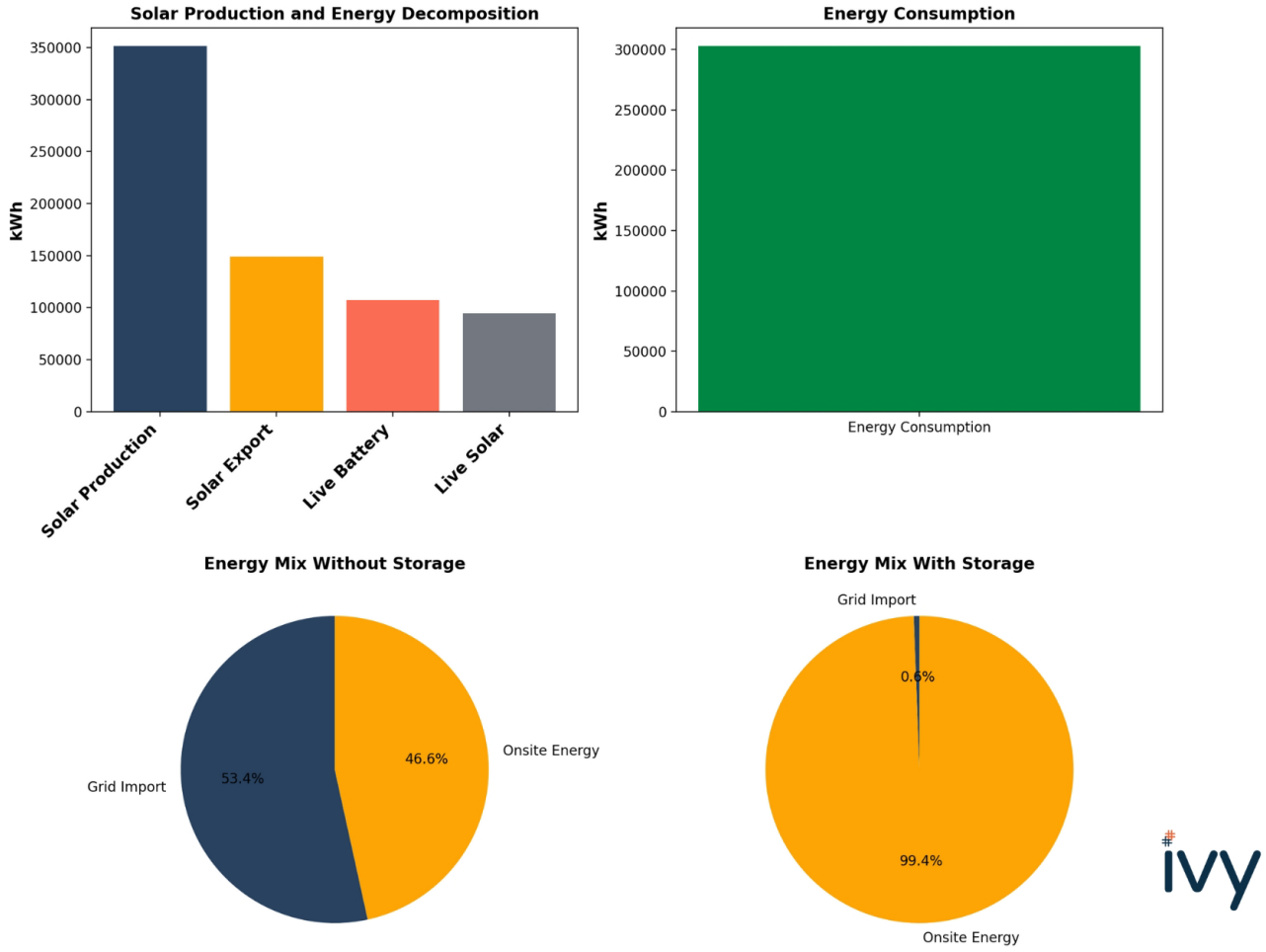
Renewable Energy Management Design Philosophy

The first priority throughout the energy management design was to leverage solar, storage, and EVs for an individual's future eco-friendly lifestyle, putting how users engage and interact with these systems at the forefront of how they are designed and operated.

The second priority was to create an architecture and control scheme that provides resilience, maximizes the use of onsite resources, and minimizes the community's impacts on the electrical grid.

Figure 5 presents a few snapshots of the results of a simulation for a single pavilion. The graph on the top right shows how well the system utilized onsite solar production to serve energy consumption, based on when solar was consumed live or when the battery was discharging to serve the community's needs. The bottom two pie charts show the energy mix of the community with only solar and with solar and storage controlled as a microgrid. The results are forecasting a 99-percent reduction in grid-imported energy with minimal grid reliance.

Figure 5: Energy Management Simulation



Source: C4GS-ZEDlife | The MountZED EcoVillage Case Study | www.mountzed.com

Approach to End-Use Energy Efficiency

Leveraging Renewable Energy and Empowering Eco-Friendly Lifestyles: In the pursuit of sustainable energy solutions, the project team developed a comprehensive approach centered around customized control of renewable energy systems tailored to individual lifestyles. The heart of this design philosophy is the concept of a microgrid, coined "Island all the Time." Rather than create an island of the community solely during emergency events, the microgrid always operates independently when resources allow, ensuring resilience and self-reliance every day, even in the absence of grid outages.

Emphasizing the integration of various distributed energy resources (DERs) into a cohesive community ecosystem, energy management algorithms prioritize both their individual functionalities and their collective contribution to a community's energy needs. Meticulous energy modeling at every stage of the design process allows the project team to optimize energy efficiency, understand design tradeoffs on energy performance, and minimize environmental impacts. This endeavor extends beyond a single project. The goal is to establish a reusable toolkit for future energy management projects. The customized Renewable Energy

Management Toolkit is designed to be reused for all future projects, able to ingest specific production and consumption forecasting for new projects and to simulate various control algorithms to determine the performance of DERs.

The toolkit is intended to facilitate informed decision-making and foster sustainable practices in the design of communities to come. This introduction encapsulates the team's commitment to leveraging solar, storage, and EVs to forge a greener, more resilient energy landscape while emphasizing user engagement and long-term viability.

- Microgrid-based Design and Control — Island all the Time.
- Ecosystem of DERs for Energy Lifestyle.
- Integrated Energy Modeling Through Every Step in the Design.
- Reusable Toolkit for Solar and Battery Sizing Optimization and Control Logic Performance Simulations.

Some outputs of the toolkit are optimal system sizing for battery storage, simulations of DER energy performance at the individual and community levels, and an analysis of how the onsite resources, as opposed to the utility grid, serve the community's needs. This vital data would be used to design an ecosystem of DERs to maximize community use and resulting benefits and to inform the carbon accounting to be offset by onsite renewable energy.

Load Flexibility, Grid interactions, and Resident Engagement

It is critical to the carbon-neutral goals of the community to provide resilience and self-reliance at the core of the design. The project was designed as a microgrid with the goal to island all the time, not just when the grid has an outage. Controlling DERs as part of a microgrid maximizes the impact of this project on affordable housing models, by improving the air quality in historically marginalized communities and providing the largest financial benefit, as maximizing the usage of onsite energy would avoid the costs associated with purchasing energy from the grid.

The project focused on integrating an ecosystem of DERs rather than designing them as individual components. It was critical to understand both how each DER would be used individually and how all DERs interact to build a lifestyle that fits seamlessly into the community.

The project team performed integrated energy modeling throughout the design phase. Each design choice, be it an electrification measure, a hardware decision, or a solar array configuration, has an impact on the entire energy design for the community. As changes and updates occur in any aspect of the design, the toolkit was used to simulate the performance of all the DERs together to understand the community-wide impact of every decision.

The goal was to build the Customized Renewable Energy Management Model as a reusable toolkit for the energy design of future communities. The Mount Hope Energy Simulations app, which is an energy management and control tool, was created as the first version in a series of future applications. This tool can ingest energy consumption and solar production time-series forecasts from commercial building engineering software, as well as simulate various energy

management control algorithms. It can simulate the energy use of the various DERs in the design and the impact a design and its control schema have on energy utilization.

Microgrid Design Strategy

The microgrid system is made up of four integrated component systems:

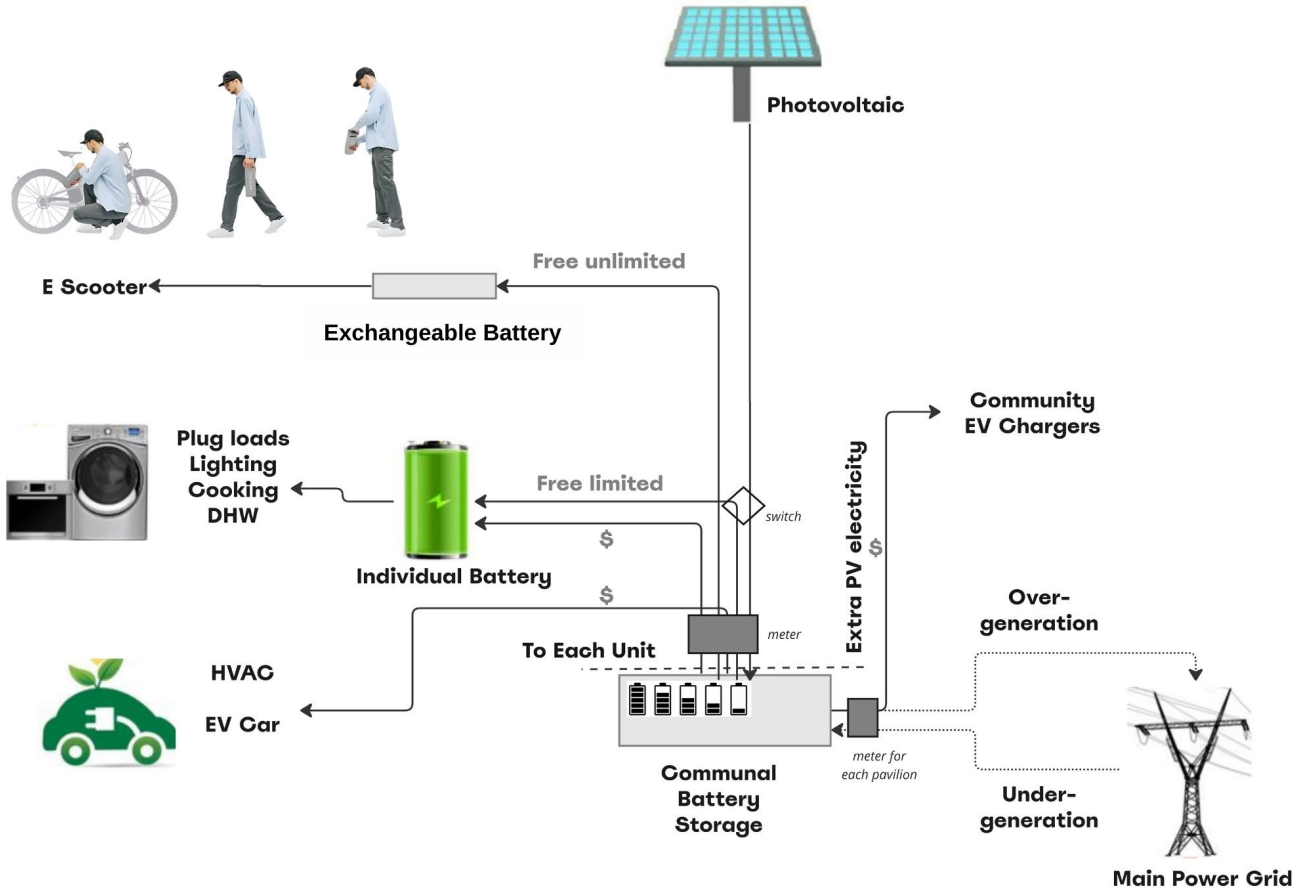
- Customized Solar PowerClad System (US patent pending)
- Customized Data Management System
- C4GS ZEDlife Exchangeable Battery System
- Customized Renewal Energy System

Solar PowerClad System: The system addresses the inefficiency of rooftop solar installations, offering an innovative solution for harvesting and distributing solar power. The MountZED 1,121-kW Solar PowerClad canopy generates enough energy to provide 10 kW of free energy per unit through a virtual microgrid while allowing storage of excess production and conservation to power additional homes in the neighborhood.

Customized Data Management System: Instead of attaching conventional solar panels to a metal roof, the project team opted for a cutting-edge translucent bi-facial BIPV system. This innovative choice both harnesses sunlight efficiently and creates a harmonious play of light and shade. It reduces the need for additional materials typically required for solar panel installation. The system addresses the inefficiencies of rooftop solar installations, offering an innovative solution for harvesting and distributing solar power.

In Figure 6, a logic diagram shows the various DERs utilized in the community as part of this microgrid. Exchangeable batteries can be freely charged to power personal electric transports like an e-scooter. Individual 10-kWh batteries in each dwelling unit can be charged fully for free daily, and large-scale 1-MWh batteries will serve the commercial loads. All the DERs within the community are controlled by an energy management system specifically designed to optimize the performance of the community as a whole.

Figure 6: Smart Microgrid Diagram, Individual Pavilion



Source: C4GS-ZEDlife | The MountZEDEcoVillage Case Study | www.mountzed.com

EV Charging and Electric Mobility Strategy, V2B and/or V2G Capability

Given the project's emphasis on energy storage and management, battery technology fireproofing challenges became an obstacle leading to opportunity. Overcoming this obstacle involved evaluating various battery options, considering factors like energy density, lifespan, and safety. The decision to utilize LTO batteries, known for their enhanced safety and longevity, addressed the constraint while solving for battery storage and management.

The Power for Life exchangeable battery system, illustrated in Figure 7, introduces a novel concept to use the same batteries for both homes and EVs. The system promotes a holistic approach to energy consumption. The exchangeable batteries last 10 times longer than standard LiFePo4 (lithium iron phosphate) batteries and can recharge in 20 minutes. The system makes possible the ability to swap out individual battery packs for maintenance and efficiency renewal, without replacing the entire system.

The battery chemistry used, lithium titanium oxide or LTO, is a type of rechargeable battery. The benefits of LTO batteries include enhanced safety, longer lifespan, and reduced risk of peak lithium. The LTO is lighter than the slightly heavier and larger standard LifePo4 battery,

making the LTO a prudent choice for urban applications. Given rising temperatures due to climate change, opting for stable and long-lasting LTO battery chemistry represents an important innovation for building-integrated electrical storage systems.

Through the integration of the Power for Life exchangeable batteries, the project expands the capacity of the microgrid to solve for a community micro grid. As a component in a community micro grid, each household battery storage and bi-directional EV car charging system is integrated into a shared grid system. This shared storage is critical in the event of an emergency disruption of grid power.

Figure 7: Exchangeable Battery System

Source: C4GS-ZEDlife | The MountZED EcoVillage Case Study | www.mountzed.com

Advanced Construction Planning and Practices

The project team embarked on a journey of advanced planning, innovative design, and sustainable construction methods to transform the suburban Tompkins Street in the Mount Hope Community in San Diego into a groundbreaking and environmentally conscious community. At the outset, density studies were conducted, aiming for six-story densification while carefully considering the need for dual-aspect apartments with cross-ventilation. The climate in San Diego, conducive to open windows and outdoor living for most of the year, guided the rejection of internal corridors and single-aspect dwellings. Instead, the team embraced the concept of a two-story maisonette, meeting the community's demand for front doors and single-family occupancy.

Each maisonette utilizes the team’s modular design and Kit of Parts, drastically reducing construction time. A team of 5 people can assemble each structural module in about one week. With approximately 12 parallel teams, this pop-up assembly line can construct the frame and cladding with floors for 4 apartments per week. For a total of 72 apartments, this means completing the entire complex in about 54 weeks.

The team also streamlined the installation process with pre-tested prefabricated heat pods, reducing measurement and verification installation time. Each maisonette includes private outdoor balcony decks and parking bays for micro EVs. These adaptable units can be constructed using various methods, including timber frame, light-gauge steel, concrete blocks, or CNC-cut plywood panels filled with rock fiber insulation.

The use of two-story homes not only meets community needs but also maximizes daylight and ventilation while minimizing access decks and ramps. To further optimize space and reduce costs, the design integrates a multi-story supporting frame for both homes and EVs, complete with access ramps, lifts, and public amenities.

Recognizing the importance of personal transportation in the suburban context, the team designed the community with the convenience of personal EVs, including scooters, e-bikes, and trikes, which minimized the reliance on vertical lifts. External ramps and stairs encouraged resident mobility, fostering impromptu interactions and minimizing the isolation often associated with traditional apartment blocks.

Advanced Construction Methods in Parking and Charging: Smart Grid

The team's well-engineered and documented EV ramping system brings parking and charging as close as possible to each unit. This advanced transportation system solves the challenge of developing walkable communities with lighter carbon footprints and healthier streets. The system integrates EV transportation ramps as the superstructure for the development, breaking the rules for standard construction practices, where traditional parking lots can cost an average of $50,000 to $80,000 per parking space.

The open design allows mobility EVs and powered wheelchairs to access almost every home's front door. This prevents scooters and e-bikes cluttering the areas around elevators and staircases and avoids the need for sunken parking lots.

Full-size electric cars were given access to the ground and second floors only, with lighter scooters, two- and three-wheeler EVs allowed on the ramp to the fourth floor.

The intention is to make the transition from large fossil-fueled cars as easy as possible, with the good weather in San Diego encouraging residents to meet on the ramps and at the vehicle pools, and to promote higher levels of social interaction than would be achieved by descending in an elevator to a basement car park.

Key Benefits of EV Ramps

- Saving up to $25,000 per parking space
- Minimizing the building's footprint while maximizing the land total lot footprint
- Providing parking spaces for residents
- Creating a net zero carbon footprint for personal transportation
- Turning parking spaces into multiple profit streams
- Furnishing EV charging stations
- Providing energy storage
- Incorporating exchangeable battery distribution centers

To create a pedestrian-friendly environment, ramp inclines were lowered to match pedestrian, bike, and scooter traffic while reducing vehicle speeds. Green open spaces were integrated into the landscape, cascading down the site's steep bank to the existing tramline, with future plans for a tram station included in the master plan. Meeting both the building's energy requirements and transportation power needs demanded a substantial renewable energy installation, featuring panels mounted vertically and inclined for optimal solar PV harvesting.

Innovative design choices, such as a diagonal grid layout, ensured that residents' views were preserved while maximizing solar panel efficiency. The inclined solar panel roof was strategically cut to allow daylight penetration into internal light wells, and a BIPV vertical cladding system offered panoramic views and communal spaces. Additionally, the project incorporated energy optimization algorithms and management programs to determine the ideal battery sizes for homes and communal storage, a vital aspect given the complex relationships between energy generation and consumption.

The MountZED EcoVillage proposal shows how to increase residential density in low-rise suburbs without good public transportation with a net zero carbon footprint for both the homes and personal transportation. The net zero carbon footprint would allow:

- Saving each household approximately $3 thousand on fossil fuel and $3 thousand on home energy bills each year.
- Giving every home access to and views over green open space, thereby creating an improved quality of life.
- Avoiding congested surrounding streets, with parking generated by the new development.

Savings in Construction Cost and Time with Advanced Methods

The goal for any developer is the return on investment; the sooner a project is completed and occupied, the sooner it can start collecting rents or other revenue. There are several ways the C4GS-ZEDlife Kit of Parts System saves time and money, in contrast to standard baseline construction:

- **Design Phase:** The C4GS-ZEDlife Kit of Parts is estimated to reduce design time by 30 percent, resulting in cost savings of approximately $300,000.
- **Construction Phase:** Offsite manufacturing and efficient onsite assembly can reduce construction time by 30 percent, saving about $2.5 million in labor costs.
- **Materials Procurement:** Bulk purchasing and reduced market sensitivity can yield approximately $500,000 in savings.
- **Quality Control:** Fewer onsite quality issues can save $150,000.
- **Training and Certification:** The simplified training process can reduce costs by $50,000.
- **Sustainability:** Integrated sustainability practices can lead to long-term savings and potentially qualify for green building incentives, contributing to savings of $300,000.

During the design development and construction documentation phase, the C4GS-ZEDlife team will create a more comprehensive report on actual savings for the people and the planet.

The project team discovered that the Kit of Parts approach offers significant cost savings for affordable housing compared to traditional design-build methods. The total estimated cost savings were determined during the project's design phase to be over $3 million. These savings result from shorter design times, more efficient construction, bulk material purchases, better quality control, simplified training, and a stronger sustainability focus. This approach provides both cities and communities with rapid returns on investment, with the ability to swiftly transition from concept to occupancy.

In addition to its C4GS-ZEDlife Kit of Parts solution, the project team adopted a multifaceted approach to cutting embedded emissions. This includes sustainable sourcing with local and certified materials to reduce transportation emissions and ensure responsible procurement. High-quality insulation, featuring non-toxic materials like fireproofed Rockfibre and rigid foam boards, boosts thermal efficiency, lowering long-term energy use and emissions. The team used an initial life-cycle assessment to guide emission-reduction efforts.

The team also chose low-emitting materials for better indoor air quality and less off-gassing emissions. Focusing on recycled and recyclable materials minimizes waste. For comprehensive details, please refer to the design report (C4GS-ZEDlife, 2023). The report provides an in-depth analysis of sustainable construction and material choices.

The team's efforts extended beyond construction, including education, carbon offset programs, and ongoing maintenance to reduce the building's carbon footprint and promote sustainable living practices.

Strategies and Materials to Reduce Embedded Emissions

The team pursued several strategies and materials to reduce embedded emissions from building construction and materials, mitigating the project's impact on the environment. These included:

- Incorporating embodied carbon into the modeling.
- Integrating life-cycle assessment and embodied carbon analysis into design and purchasing decisions.
- Using low-embodied carbon material such as wood, over concrete and steel construction.
- Locally manufacturing panelized construction; modular prefabricated construction with 3D wood panel structure produced with a computer numerical control (CNC) machine.
- Purchasing all materials locally, if available.
- Using alternative solar materials and battery storage chemistries.
- Using mineral wool batt insulation without rigid insulation.
- Using integrated and passive design strategies that reduce material quantity.

Market Transformation

At the heart of the ever-evolving building industry, a transformation is underway, one that promises to reshape the industry and set a new standard for mixed-use, multifamily development. As demonstrated by this project, C4GS-ZEDlife is at the forefront of this revolution. As an innovative company harnessing the potential of carbon reducing modular construction methods and cutting-edge energy technologies, the project team aimed to redefine the "green" way people build and live.

Transitioning to a Standardized Mixed-Use Development Model

C4GS-ZEDlifes's ambition extends beyond just a single groundbreaking project; the team aims to revolutionize the mixed-use development industry. The team's approach to this transformation encompassed the following key strategies.

- **Modular Building Components:** C4GS-ZEDlife employs modular construction methods, allowing for standardized, repeatable, and scalable building components. These modules can be prefabricated in controlled environments, enhancing quality control and efficiency.
- **Design Standards:** By developing a library of standardized architectural designs that prioritize sustainability, C4GS-ZEDlife is creating a blueprint for future mixed-use developments. These designs are adaptable to different locations and can be customized to meet specific requirements while maintaining core sustainability principles.
- **Cost Predictability:** Through rigorous cost analysis and optimization, C4GS-ZEDlife can offer accurate cost predictions for its projects. This predictability attracts investors and financing partners, making sustainable mixed-use development a financially viable and appealing option.
- **Collaborative Ecosystem:** C4GS-ZEDlife fosters collaboration within the industry, encouraging developers, architects, and construction companies to adopt the project team's practices. The project team offers training programs and consulting services to help transition others to the standardized, repeatable, and scalable model.
- **Community Engagement:** C4GS-ZEDlife recognizes the importance of community buy-in for widespread adoption. The project team actively involves local communities in the development process, seeking input and feedback to create developments that align with community needs and values.

Financing Strategies

The project team pursued diverse financing strategies and sources to make advanced energy elements in the development affordable and replicable for other projects lacking grant funding. This involved thoroughly exploring financing options and documenting project achievements, challenges, and lessons during the design phase, with a focus on private investment, public-private partnerships, energy performance contracts, community-based financing, energy service agreements, and tax incentives. While the project is in the design development phase,

establishing a replicable funding pathway without grants or duplication details is challenging. However, the team plans to initiate scenario planning, like community land trust and government solar programs, to explore potential funding options. After completing a comprehensive case study, the team will identify affordable and replicable funding strategies and advocate for policies supporting these methods for widespread adoption.

Moreover, fostering partnerships and networks within the sustainable energy community promotes knowledge exchange and collaboration. The financial approach used for fund-raising in the design phase proved that collaboration simplifies the adoption of similar financing strategies for other developments and reduces reliance on grant funding.

Standards and Protocols for Plug-and-Play Energy Technology

To create a more plug-and-play environment for energy technology solutions, the development will adhere to various standards and protocols, ensuring compatibility and ease of integration.

- **Wi-Fi, Bluetooth, Zigbee:** These widely adopted wireless communication protocols will enable seamless connectivity between energy-efficient devices, allowing residents to control lighting, heating, cooling, and other systems through a unified interface.
- **OpenADR (Open Automated Demand Response):** Implementing OpenADR will enable automated demand response capabilities, helping to manage energy consumption during peak periods while maintaining comfort and affordability.
- **Green Button Data Standard:** The development will incorporate the Green Button Data Standard, allowing residents to easily monitor their energy consumption data. This empowers residents to make informed decisions about their energy usage.
- **ISO 50001:** Adopting ISO 50001, an international standard for energy management systems, will ensure efficient energy use, continual improvement, and optimization of energy performance in the development.
- **Energy Star Certification:** Pursuing Energy Star certification for appliances and equipment used within the development will further enhance energy efficiency and reduce operational costs.
- **Cybersecurity Protocols:** Implementing robust cybersecurity protocols will protect energy technology solutions and residents' data, ensuring the safe and secure operation of all systems.

By following these standards and protocols, the development will create an energy ecosystem that is not only user-friendly and efficient but also interoperable, promoting a plug-and-play environment that can be replicated in future affordable housing projects. In addition, adoption of the C4GS-ZEDlife Kit of Parts, as the plug-and-play form foundation of a business standard for carbon-reduced housing, will create an ecosystem of allied operative methods and protocols, which will evolve to optimize the Kit of Parts System in the following project contexts.

- Site and landscape control
- Foundation

- Superstructure (when applicable)
- Materials (shipped to site locally)
- CNC cutting files, CNC cutting diagrams and instructions
- CNC cutting template panels, modular unit assembly protocols
- Solar panel structure framing, solar panels installation protocols risk reduction contingency plan

The team's multifaceted approach, including gradual adoption, cross-training, communication, and a well-defined fallback plan, effectively reduces the risks associated with adopting new technologies in the MountZED Ecovillage project. Current contingency plans are:

- **Thorough Risk Assessment:** The team conducted a comprehensive risk assessment to identify potential challenges and vulnerabilities, helping to anticipate obstacles and to plan accordingly.
- **Staged Technology Adoption:** Instead of a sudden full-scale implementation, the team took a gradual approach to technology design. This involved understanding how PV solar power would be collected, transferred, stored, monitored, and distributed within the EcoVillage.
- **Real World Testing:** Technologies were tested and monitored in real-world scenarios in existing developments like BedZed and the Isle of Wight. Virtual modeling helped streamline the design and functionality, allowing for adjustments without disruptions.
- **Cross-Team Education:** Multiple team members were educated in the new technologies to reduce dependence on a single individual or group. This provided flexibility in design and equipment.
- **Continuous Communication:** The team maintained regular communication and collaboration with building architects and technology designers. This facilitated quick access to technical support and timely updates.
- **Fallback Plan:** A fallback plan was established in case new technologies proved unsustainable or led to unexpected issues. This plan outlined steps to revert to existing emerging technologies or to adopt alternative solutions like virtual net metering.
- **Community Feedback and Support:** Community engagement and partnership development were also essential risk-reduction strategies. The MountZED EcoVillage project benefited from:
    - Early Involvement: Involving the local community early helped identify concerns, build support, and prevent potential conflicts.
    - Stakeholder Collaboration: Partnerships with local authorities and stakeholders provided resources, expertise, and regulatory support, ensuring compliance and minimizing legal risks.
    - Risk Sharing: Collaborative agreements with technology providers and investors allocated risks and responsibilities, mitigating financial and operational risks.

- Knowledge Exchange: Engaging with the community and partners facilitated knowledge sharing, helping the team make informed decisions and avoid common pitfalls.

Community Engagement

Methods for Soliciting Community Input

The project team employed a multifaceted approach to solicit community input and incorporate feedback into the design of the MountZED EcoVillage, including the purpose of nonresidential space. I Am Green, the project team's community outreach and engagement experts, demonstrated a robust commitment; this ranged from boots-on-the ground surveys and pop-up community event surveys to organizing special community gathering events like Everyday is Earth Day and online town hall Zoom meetings with community members from the Mount Hope neighborhood.

The Mount Hope community endured a long history of being ignored, marked by empty promises, systemic barriers, and disenfranchisement. I Am Green prioritized active and empathic listening to address this historic neglect. The team knew that, before design, zero-energy development or anything else could be discussed, a space had to be created to address decades of built-up frustration. In addition to organizing community town halls and listening sessions, I Am Green participated in Mount Hope neighborhood meetings and remained attuned to local concerns and desires, all of which were shared with the C4GS design team.

I Am Green recognized the community's expertise in effectively engaging its neighbors, taking steps to co-create with community leaders a community outreach framework that ensured inclusivity and documented community response.

These community development efforts resulted in organizing a community-based environmental league of justice, a collaboration involving community residents, business owners, educational leadership, board members, and green building coalition members — all committed to working for environmental and social justice in Mount Hope and the greater San Diego community.

Steps to Ensure Alignment With Community Needs and Vision

The following steps were taken to ensure alignment with community needs.

- Initial Community Meetings: The project team organized meetings to introduce the concept of the EcoVillage and gather preliminary feedback from residents. These meetings provided a voice for community members.
- Stakeholder Consultations: In-depth discussions were held with key stakeholders, including community leaders, local businesses, and advocacy groups. These consultations helped identify community priorities, guiding the project's design process.
- Design Workshops: Residents actively participated in design workshops, where they collaborated with architects and developers to shape the layout and features of the

EcoVillage. This participatory approach ensured that community concerns and preferences were integrated into the design.

- Public Forums and Information Sessions: Periodic forums and sessions were conducted to provide updates on project progress and address community concerns. These events allowed residents to engage directly with the project team and provide feedback on specific aspects of the development.
- Consideration of Gentrification: The project team gave serious consideration to the question of gentrification. The deeply disheartening prospect of gradually being priced out of the very community that has nurtured one, is an ever-present concern. The team's efforts and energies are dedicated to countering this encroaching reality.

Under the guidance of I Am Green, the MountZED project is designed to establish an opportunities framework of re-development and community benefits by working first with the community to understand its view of gentrification: the perceived challenges and the nonnegotiables. In addition, the team developed working relationships with key community-based organizations, policy makers, and advocates to develop a knowledge base for the design.

The team worked to minimize the fear of gentrification by using a different time signature for entering the community, namely by going in a year ahead of designing the actual project. The team's primary community development and design focus was on the life-giving, sustainable reality the community would like to see and co-create. This focus translated into a key ZEDlife Studio initiative: to provide early community access to green building awareness, green technology, innovation, and career-level jobs. Together with I Am Green, the project team established clear pathways to maintain a rooted presence within the neighborhoods that many have called home for generations. The shift in the time signature helped to create a united front against the unwelcome economic changes that threaten to uproot the community.

The I Am Green scope of work plan for the build phase includes outreach for the establishment of a community land trust, a Mt. Hope community cooperative, and a community development corporation for shared community governance. Additional measures taken to align with community needs include:

- Affordable Housing: A significant portion of the housing units, ranging from 30 percent to 60 percent of the area median income (AMI), are earmarked for residents within this income range. The project includes permanent supportive housing and live + learn units that are exclusively reserved for households within the specified AMI bracket.
- Mixed Housing Types: By offering a mix of affordable, student, and market-rate housing, the project aims to strike a balance between affordability and sustainability, ensuring that residents from diverse income backgrounds can afford to live in the community.

Positive Impacts of the Development on the Local Community

The MountZED EcoVillage is more than just a development; it's a transformative force for the local community. The team's commitment to sustainability, innovation, and community

engagement sets this project apart. The I Am Green outreach campaign was implemented to ensure the positive impacts of this development; the outreach resulted in the creation of a focus group from the local community that is composed of residents, business owners, and leaders. Through the I Am Green's process of direct hands-on engagement and the community's direct participation, myriad opportunities and benefits emerged. From environmental stewardship to job creation, from educational initiatives to fostering a sense of togetherness, the MountZED EcoVillage elevates the quality of life for all who call this vibrant community home.

The MountZED EcoVillage is a live-and-learn community that fosters the following positive attributes:

- **Proximity to Transit:** Convenient access to high-frequency transit options.
- **Increased Density:** Tier 3 zoning, which allows for higher density construction.
- **Innovative Co-Living:** Cost-efficient co-living design that promotes openness and collaboration.
- **Micro-Forest to Park:** Conversion of a micro-forest into a pocket park with ZEDlife solar trees, natural horticulture, and aquaculture.
- **Local Food Production:** Integration of urban agriculture, enabling micro-businesses to sell fresh produce to local eateries.
- **Mobility Choices:** Integration of an EV transit hub that offers discounted or free bus passes and annual EV rideshare passes.
- **Educational Center:** The mixed-use ZEDlife Lab for hands-on education and knowledge transfers.
- **Green Job Creation:** Creation of a local green talent pool, with a 10-percent increase in green building job readiness each year for the first five years.
- **Local Job Opportunities:** The expected creation of over 100 local jobs during the construction phase, supporting workforce development initiatives aimed at building a skilled and diverse workforce in the green building sector.
- **Resilience Development:** The empowerment of communities of concern and the showcasing of adaptable development models.
- **Community Engagement:** Hosting Reimagine my Block community events such as brunches and Earth Day festivals.
- **Community Ownership:** A sense of community ownership and pride fostered through ongoing engagement with residents, collaborative decision-making processes, and events aimed at building community cohesion.
- **Environmental League of Justice:** Facilitated collaboration among community leaders and breaking down silos in Mount Hope and surrounding San Diego communities.

- **Environmental Sustainability:** The incorporation of green building features such as solar panels, energy-efficient appliances, and sustainable materials, resulting in minimized energy consumption, reduced carbon emissions, and improved air quality in the community.

Improvements in access to electric mobility, solar PV, and demand response for tenants were achieved through:

- **Onsite EV Charging:** The project included infrastructure for off-street EV charging, ensuring that residents had access to electric mobility options without the creation of carbon-intensive parking structures.
- **Renewable Energy Integration:** Solar PV systems were integrated into the building design to generate renewable energy, reducing tenants' reliance on grid electricity and promoting sustainability.
- **Energy Efficiency Measures:** Demand response technologies and energy-efficient appliances were incorporated into the development to optimize energy usage and reduce overall consumption, benefiting both tenants and the environment.

Workforce Development and Local Job Creation

Workforce Development and Green Careers: C4GS-ZEDlife designed a workforce development program with the objective of training and placing the next generation of green job building industry talent. The ZEDlife Studio certificate program introduces youth and returning professional students to green building skills, values, and career paths that will advance the eco-smart greening of the Mount Hope community.

Education: The C4GS ZEDlife Studio Education program is designed for onsite live-learn-work participation and offsite white-label licensing activation. Curriculum and hands-on workshops in each case are taught by experts drawn from the C4GS team, as well as from professional experts in carbon-neutral solutions for:

- Architectural and prefab studio practices.
- Contracting solar panel engineering.
- Job readiness skills.
- Future career paths in environmental policy, green building and real estate development, architecture, urban planning, and EV transportation.

C4GS-ZEDlife is partnering with the Green Build Council, I Am Green, Workforce Solutions Pros and Beyond-Development to deliver industry-recognized subject matter. I Am Green's content is a United States Department of Labor-approved apprenticeship and pre-apprenticeship program with a strong focus on environmental literacy and social enterprise development. With a ZEDlife Studio certificate in hand, graduates (called fellows) will be eligible to receive college transfer degree credit for environmental design and policy degrees through the partnership with the University of California, San Diego (UCSD) extension degree program. Upon completion of the ZEDlife Studio Certificate program, fellows will also be ready for placement in apprenticeship intern programs in the green building industry.

Training and Job Placement: Completion of the ZEDlife Studio certificate program is also rewarded with fellowship opportunities to intern with the MountZED residential ecovillage building and participate in future builds. The fellowship removes barriers of entry into an internship job. First, it ensures that fellows will have a place to live onsite while contributing to the building of the project; second, fellows who complete the pre-apprenticeship certificate program enter into the internship placement process with journeymen craft trades and professional design firms. Fellows will have the first option to intern with C4GS and work directly in the Mount Hope community; a second option is to receive placement assistance in seeking pre-apprenticeship internships in the industries shown in Table 3.

Table 3: ZEDlife Fellow Pre-Apprenticeship Opportunities

Professional Services	Green Building Craft Services
Life Cycle Assessment Consultants	Electrical Techs for Solar Cladding and Battery
LEED Certification Consultants	Prefab Structural Assemblers
Green Building Designers	Conventional Electricians/Plumbers
AUTOCad Designers	Building Envelope Air Tightness Installers
Environmental Engineers	Heat Pump Installers
Green Building Urban Planners and Real Estate Developers	CraftWorker Jobs: CNC Machinists, Carpenters, Cement Masons
EV Transport Consultants	

Source: C4GS-ZEDlife | The MountZED EcoVillage Project Narrative | www.mountzed.com

Enhancing Access to Electric Mobility, Solar PV, and Demand Response

This project will significantly improve access to electric mobility, solar PV technology, and demand response for the tenants, through a combination of the following innovative strategies:

- Electric Mobility Access: The inclusion of the I Am Green Go EV Car share program, charging stations, and the EV bikes program provides tenants with convenient access to EVs for their transportation needs. These amenities and programs not only promote sustainable mobility but also make EVs readily available to residents who may not have owned one otherwise, thus enhancing their access to electric mobility.
- Solar PV Integration: The provision of 10 kWh of free electricity per day directly benefits residents by reducing their energy costs. This allocation of free electricity encourages the utilization of solar PV-generated power, which not only enhances access to solar energy but also incentivizes residents to be more conscious of their electricity consumption, which also aligns with the principles of sustainable living.
- Demand Response Engagement: The project actively involves tenants in demand response initiatives. Through these programs, residents can participate in grid management by adjusting their energy consumption during peak-demand periods. By doing so, they can earn incentives or credits, further improving access to cost-effective and sustainable energy practices.

CHAPTER 3:
Results

The MountZED EcoVillage project successfully reduced energy consumption and construction costs. The use of low-carbon materials and modular construction techniques contributed to these achievements. The project's design model focuses on communities of concern (or disadvantaged communities). It is aesthetically pleasing to the senses and will be completely net zero in the build phase and beyond, to co-create zero (fossil) energy developments (ZEDs).

The project team and partners designed an affordable multi-use housing community that counters the forces of accelerating climate change over the buildings' expected lifespan. All buildings will be designed to maximize energy efficiency, integrate renewable energy and durability, minimize embodied carbon, and keep energy demand to a minimum; knowledge transfer taking place during the process will help people understand the potential of new and emerging energy technologies.

The project demystifies the building process and empowers citizens to take control of their own health and wellbeing. The design solution accommodates residents of low-income and marginalized communities and sets up opportunities for citizens to design and implement their own sustainable paths to a better future, thereby creating bridges of hope to live in self-sustaining, green housing. The C4GS-ZEDlife Kit of Parts System solves the problem of standardizing energy systems and accounting for the efficiencies. By using the Kit of Parts System, small developers can viably enter the zero-energy housing market. All these factors give residents the power to shape their communities.

Design Challenges

The design team came together during the design phase of the project to find solutions for specific technical and policy barriers. These challenges, once overcome, became opportunities for technological innovations and new green protocols. Figure 8 depicts the innovations introduced to solve design challenges and address technological barriers. The first and foremost of these was addressing the challenge provided by the CEC:

Challenge: Creating an affordable mixed-use housing development that can island in the event of a power outage or long-term climate changes.

Solution: The MountZED EcoVillage creates more power than is needed to support the needs of homes, cars, and community spaces, through the self-reliant microgrid. In addition, the team approached technical barriers and challenges by instituting MountZED guiding principles, which set priorities for recognizing challenges at the outset.

Challenge: Building a solar harvesting canopy that doesn't compromise resident and neighborhood views.

Solution: The comprehensive plan aims to maximize the number of homes with views through openings in the solar roof and solar wall.

Challenge: Privacy in multi-family housing.

Solution: The project is designed to ensure approximately 60 feet between homes to maximize privacy.

Challenge: Ensuring that light is not blocked by the solar harvesting canopy.

Solution: A void area is placed in the solar roof to allow light to filter to the streets below. This is a trade-off from having a monolithic solar roofing system with additional solar harvesting capability.

Challenge: Incorporating parks and green space.

Solution: Public green spaces at the street level make the area more open and inviting for everyone in the community.

Challenge: Making solar-powered personal electric transportation easily accessible within the living space.

Solution: The C4GS-ZEDlife plans for the MountZED EcoVillage project recognize that public transport is not convenient and that wheels are needed to connect the Mount Hope community to the nearest urban center and its communal facilities. This proposal maximizes the convenience of personal electric transportation, allowing a mix of scooters, e-bikes, e-peds, three-wheelers, and electric cars to replace the 20,000 miles/year of gas-powered private car use that is typical of a household in this part of San Diego.

The main innovation is that electrically powered wheeled transport has ramped access to almost every front door and can be parked and charged as close as possible to residents' homes. Full-size electric cars were given access to the ground and second floors, while lighter scooters and two- and three-wheeler EVs are allowed on the ramp to reach the fourth floor. This avoids scooters and e-bikes cluttering the public streets and pavements around elevators and staircases. It also avoids the need for partially sunken basement car parks that create a sterile streetscape for passing pedestrians, and it avoids the security issues associated with basement car parks.

Challenge: Creating access for the disabled in ramp design.

Solution: Large elevators are included in the design, enabling disabled access to all floors. Pedestrian stairs allow residents direct access to the street level and the shared green communal open space, as well as the top floor roof gardens. It is possible for mobility scooters and powered wheelchairs to access almost every home's front door. The same elevators are sized to accommodate a hand cart loaded with 4-foot x 8-foot sheets of plywood, enabling the easy transfer of building materials stored in the ground-level workshops to the upper floors.

Challenge: Reducing permit policy barriers. Anyone who has tried to build a home in San Diego or Southern California has faced the challenge of meeting traditional building construction deadlines. Traditional construction requires a completely linear time period:

Permits are acquired, the site and foundations are developed, and then the building is constructed.

Solution: In clean energy modular construction, the modules themselves are built either in a ZEDlife prefab factory or with the pop-up factory model. This allows the project team to concurrently move through permitting, acquisition, and site development.

The design approach to clean energy modular construction involves three interlocking initiatives:

- Smart Building Technology. The inclusion of smart building software and electronic feedback loops ensures that the as-built performance is continually monitored. This not only enhances building efficiency but also aids in training the commissioning team, further reducing the complexity of the construction process.
- Automated Manufacturing. The digital 3D model serves a dual purpose by providing dimensional coordinates for individual component manufacture. To streamline the process, efforts are made to automate and expedite the offsite construction of sub-components by using computer-aided design and computer-aided manufacturing.
- The C4GS Kit of Parts System represents a groundbreaking approach to construction that demystifies the building process and makes advanced technology breakthroughs accessible to a wider audience. This innovative methodology can be applied across multiple construction projects, ushering in a new era of transparency, accessibility, and sustainability in the construction industry. See C4GS-ZEDlife, n.d., 108.

Figure 8: C4GS-ZEDlife Design Innovations

Source: C4GS-ZEDlife | The MountZED EcoVillage Case Study | www.mountzed.com

Policy and Market Barriers

As San Diego promotes a housing market that is more accessible, affordable, equitable, and sustainable, housing developers like C4GS-ZEDlife must be deliberate about understanding the diverse needs of residents within a desired community, down to the neighborhood level. C4GS-ZEDlife intentionally embraced this role in housing markets and the tradeoffs inherent in the diverse policy options available at the time, specifically using city mandates such as Complete Communities and its predecessor, Title 24.

The project team experienced several challenges relative to fluctuating markets, equivocal housing policies, changing tariff policies, and lack of policy coherence across state and local entities. Each of these challenges was met and solved thanks to the dedication, resourcefulness, and multi-faceted talents of the project team.

Policy: Net metering and interconnection permitting posed significant challenges, especially as local and state energy companies altered their positions on solar savings. For instance, the promotion of rooftop solar installations in 2021 was a key strategy to advance climate action, sustainability, and environmental impact reduction across California. However, policy changes in 2023 reduced rebates and residential discounts, discouraging new installations and adversely affecting the green industry workforce. To overcome this, the C4GS-ZEDlife team partnered with third-party nongovernmental organizations like San Diego Community Power to create a direct line from solar power generation to distribution. This approach enables the housing development to function independently from a direct connection to the local utility company and power grid. The Ecovillage is not entirely disconnected from the grid; it can draw from or contribute electricity as needed.

Planning Policy: One of the major challenges faced is the widely accepted belief that sustainable housing does not support affordable housing. Due to the existing housing crisis and lack of inventory, the city of San Diego adopted its Housing Plan 2.0 rapid housing policy, which gives developers priority in the permitting process to relocate affordable housing offsite, away from transit areas, but it would also allow single-family homes to develop their parcels to include multi-level housing. This impacted MountZEDEcoVillage directly, since the master plan did not fit the criteria of the existing planning and permitting process during the time the team was introducing innovations in building, transportation, and sustainability.

Market and Housing Policy: With policy changes come market fluctuation and lack of inventory. The city of San Diego adopted a controlled construction activity, reducing the likelihood of a significant oversupply of housing units. The city of San Diego implemented Housing Plan 2.0, which allowed for single family homes to develop rapid housing on a single parcel, up to four stories. This response impacted the project team's ability to acquire the necessary parcels to complete and develop a master plan within the development's master plan.

Housing Policy: Incentives to develop housing next to transit priority areas posed a challenge, since multiple agencies were required for the MountZEDEcoVillage to access much needed transit for the Mount Hope community. The policies and regulations would require a

10-year process to provide access. This inequity in the city policy did not align with the county of San Diego's process through the Metropolitan Transit System agency.

San Diego's moderate population growth is based on emerging companies across multiple industries employing new workers from outside of the region. In addition, increased student enrollment in local universities, along with growth in the military family population, has increased housing demand, which further stimulates severe homelessness and housing unaffordability.

In response to the host of affordability issues, developers have taken advantage of Housing Plan 2.0 and relocated affordable housing outside of desirable neighborhoods, foregoing carbon-neutrality and sustainability designs and practices to save on building costs.

The C4GS-ZEDlife team solved this by incorporating sustainability and carbon-neutrality within the design, adding EV transportation and organizing the development's housing inventory to address the economic needs of current and future residents. This allocation mitigated the housing market fluctuations caused by current policies that force developers to prioritize cost over environmental considerations.

Market Policy: Fluctuating tariffs from imports directly impact the cost of solar PV panels. Tariff fluctuations presented a challenge on two fronts: the demand for Chinese polysilicon modules and U.S. security concerns. From late 2022 into early 2023, Chinese manufacturers began to invest in more solar equipment, which allowed them to increase production. This increase supplied the demand by subsequently reducing prices. With pricing so low compared with other markets, U.S. regulators may in the future more closely examine those security concerns.

In response, the way to control US purchasing is to impose higher tariffs on Chinese imports as opposed to those from India, Malaysia, and the Middle East. This approach is contrary to the Inflation Reduction Act's benefits to US solar manufacturers, for which developers would otherwise be eligible, based on President Biden's climate action goals. The stalling of incentives through the Inflation Reduction Act forced many potential US solar manufacturers to cease building production facilities, forcing US developers to seek photovoltaic solar panels, cells, modules, and inverters from abroad. Beginning in June 2024, new tariffs are to be applied to solar cell and module imports from Southeast Asia unless importers can qualify for exemptions.

C4GS-ZEDlife first looked at solar panel manufacturers in California, but they were unable to accommodate the needs of the project due to unavailable resources. C4GS-ZEDlife then looked nationally for suppliers but was faced with the same challenge. These challenges were solved by working with the UK-based division of the company. In response to housing demand within the European market, the company increased its supply and inventory of solar panels in the UK; this allowed imports from its existing stock on hand.

Energy and Emissions Performance

Energy, Emission and Cost Performance: The MountZED EcoVillage design surpasses 2022 Building Energy Efficiency Standards. The California Building Energy Code Compliance 22

Model was specifically developed to evaluate how the proposed design compares with the Title 24 standard model. Passive design strategies incorporate features like daylighting, shading, and cross ventilation within the dwelling units. Furthermore, the project's highly thermal-efficient envelope, crafted with state-of-the-art CNC machining, substantially reduces thermal bridging, surpassing 2022 Title 24 multifamily standard requirements.

Lighting: This project involves a highly energy-efficient lighting design, complemented by in-unit access to daylighting. Lighting power densities in the regulated spaces (toilets, living rooms, and kitchens) in the dwelling units, common areas, and nonresidential spaces are at least 20 percent less than code requirements. Abundant daylighting provided in the dwelling units reduces the electric lighting significantly during the day. Advanced lighting controls are provided for nonresidential areas and for exterior lighting that goes beyond the standard.

HVAC exceeds the Title 24 requirements. A highly energy-efficient packaged single zone heat pump unit with energy recovery ventilation and variable air volume is designed for each unit.

For domestic hot water, an individual water-source heat pump system is specified for each dwelling unit that exceeds the standard efficiency required for heat pump water heaters.

Renewable energy is a 682.5-kW solar canopy. For each pavilion, a 136.5-kW solar PV system is allocated. The battery system included individual batteries with 10 kWh for each dwelling unit and communal batteries. For each pavilion, composed of 20 units, 200-kW individual batteries and a 1-megawatt (MW) communal battery is allocated.

The solar PV and battery design go beyond the code requirement of 37.6 kW PV and 40 kW battery storage for each pavilion. The energy design rating passes the standard design by 11.34 compliance margins in terms of efficiency and by 239 compliance margins once demand flexibility, PV, and the battery are included in the assessment. The source energy use exceeds the standard design by 12.42 margins (C4GS-ZEDlife and Enerlite Consulting, 2023). Future weather forecast analysis confirms the California Building Energy Code Compliance Software (CBECC) summary results for one pavilion.

To meet daily peak electricity demand, the design team uses direct solar PV generation by solar canopy and the 10-kWh individual batteries provided for each dwelling unit.

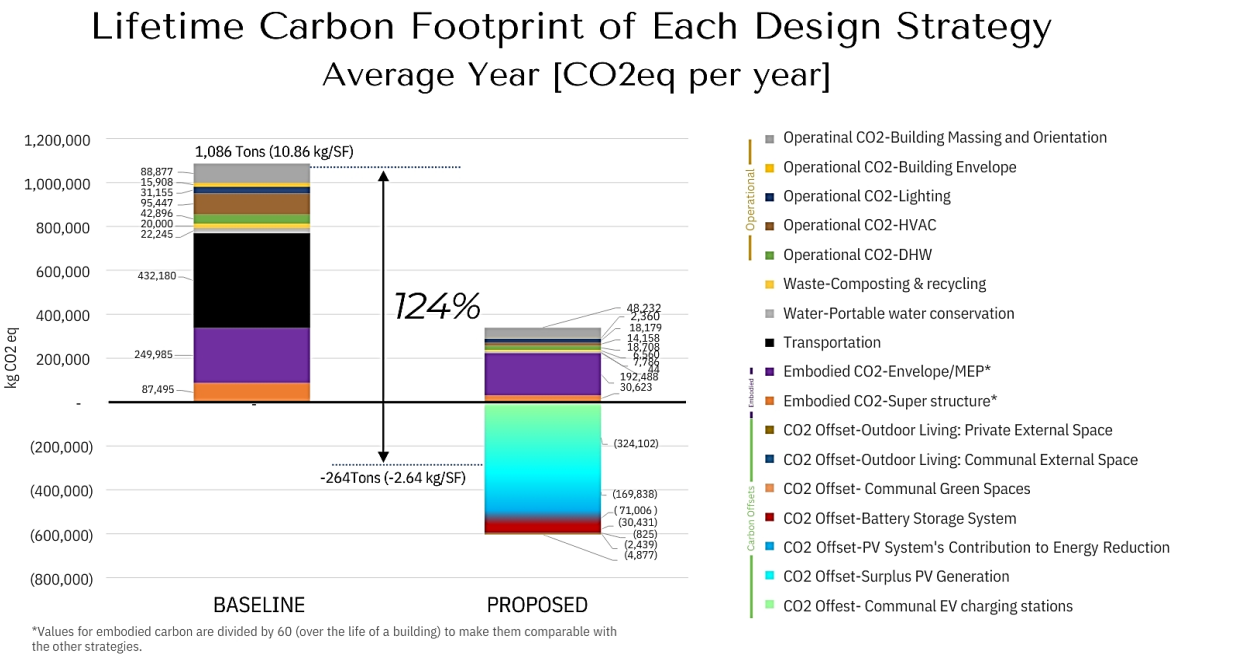
The building interactive controls prioritize the utilization of onsite energy resources to power onsite loads. This energy control hierarchy, outlined in the Energy Management Control Logic chart, maximizes renewable energy use and minimizes grid energy consumption. Notably, EV charging is deferred until after other onsite needs are met, ensuring that high-priority loads have access to onsite resources first.

The design incorporates an innovative control hierarchy to maximize onsite renewable energy resources, reduce grid dependence, and respond to real-time pricing. The system efficiently coordinates numerous onsite DERs, including EV charging. Its advanced control capabilities allow for a seamless addition of future controllers. For instance, the project team can integrate an Application Programming Interface for real-time grid energy pricing, optimizing battery dispatch to support the grid during high demand. With approximately 6 MWh of storage, this community is well-prepared for future grid needs, including real-time pricing, demand

response, and virtual power plant participation, thanks to its integrated hardware and software controls across all distributed energy resources.

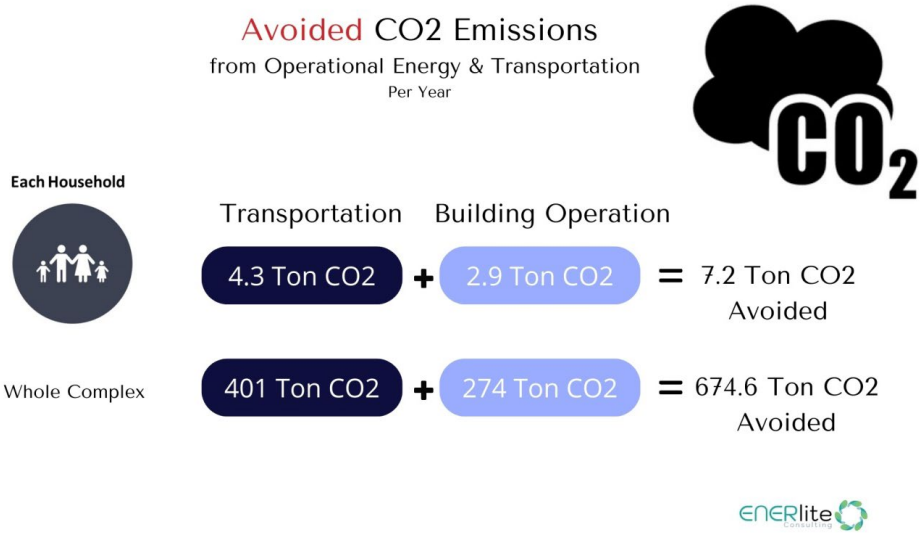
Figure 9 shows the lifetime carbon footprint for each design strategy. Figure 10 contrasts the standard baseline design and that of C4GS-ZEDlife regarding the lifetime carbon footprint per year of the built environment and of each design strategy involved in building the MountZED EcoVillage project.

Figure 9: Lifetime Carbon Footprint for Each Design Strategy



Source: ENERlite Consulting | Project Report| September 2023

Figure 10: Avoided CO2 Emissions



Source: ENERlite Consulting | Project Report| September 2023

Figure 11 accounts for savings differences (or costs avoided) in the use of solar-powered electricity versus fossil fuel. The research was conducted by Enerlite, a C4GS partner specializing in energy analyses for architectural builds.

Figure 11: Avoided Operational Carbon Emissions

Avoided Carbon Emissions per Year

Whole Complex

Annual Electric Energy Consumption		BASELINE	PROPOSED
All Residential	[kWh]	1,592,060	5,164
Commercial Space and Site Lighting	[kWh]	156,647	864
Annual Total Electricity Consumption	[kWh]	1,751,037	6,027
Avoided Energy Consumption per year	**[kWh]**		**1,745,009**
Operational Carbon Emissions			
CA Electric Grid CO2 Emissions in 2024 (mid case scenario)	*[kg CO2/mWh]*	*156.64*	*156.64*
Carbon Emissions per year 2024	[TON CO2]	274.3	0.2
Avoided Carbon per year	**[TON CO2]**		**274**

AVOIDED **CARBON** 274 metric tons of CO2

ENERlite Consulting

Source: ENERlite Consulting | Project Report| September 2023

Table 4 highlights the differences between the MountZed EcoVillage as compared to university and master plan housing communities in the San Diego area.

Table 4: Modeling for Energy Saving Outcomes Comparison

Performance Translates into Savings and Energy

Development Comp Set and Metrics	MountZED EcoVillage	UC San Diego Living and Learning Neighborhood	Columba by Chelsea Investment Co.	Impact Housing at San Diego State University
Bed Count	306	2,444	402	401
Cost	$85,000,000	$683,000,000	$102,000,000	$87,000,000
Cost per Bed	$277,778	$279,460	$253,571	$216,958
Project Sustainable Design and Community Benefits	Pavilion and Parking Design integrate EV car sharing and solar and battery storage, which offsets	On campus development by the university for its living and learning needs, housing undergraduates on campus below	Millenia master planned community has set aside this land for the purpose of subsidized affordable housing. 198	Volumetric modular construction; innovation in its speed to market, attainable/affordable rent community.

Development Comp Set and Metrics	MountZED EcoVillage	UC San Diego Living and Learning Neighborhood	Columba by Chelsea Investment Co.	Impact Housing at San Diego State University
	housing and transportation energy usage. 29% Affordable 50-60-120% AMI.	market rents. Leadership in Energy and Environmental Design (LEED) Silver; project cost reduced for <50% parking.	units at 30-60% AMI; cost saving reflected for value engineered commercial/ amenities.	Project cost per unit reflects savings from no parking or sustainability measures.

Source: C4GS-ZEDlife | Appendix#6 - Market Study Exhibit | www.mountzed.com

Costs and Benefits Performance

The goal for any developer is the return on investment; the sooner a project is completed and occupiable, the sooner it can start collecting rents or revenue. In contrast to standard baseline construction, the C4GS-ZEDlife Kit of Parts System saves time and money in a number of ways.

Construction Time and Cost Savings

Design Phase: The C4GS-ZEDlife Kit of Parts System is estimated to reduce design time by 30 percent, resulting in cost savings of approximately $300,000.

The Kit of Parts System, a revolutionary modular construction process, represents a paradigm shift in the construction industry. This approach seeks to demystify the traditionally intricate building process that was previously reserved for high-paid professionals. The C4GS-ZEDlife groundbreaking methodology can be applied across various construction projects.

The C4GS-ZEDlife process combines 3D modeling, a detailed assembly manual, slim floor car park construction, CNC 2D cutting, and ZEDlife Studio training, empowering the community to contribute over 50 percent of construction value. The project team utilized EVs, building-integrated photovoltaics, and long-lasting, safe LTO batteries, making the team's project a world-class demonstration. It relies on the grid for only around 5 percent of its life. This template can densify American suburbs without the typical parking and air pollution issues of conventional developments.

Advanced Methods Applied by the Design

Modularization Simplified: The Kit of Parts System divides the entire construction journey into discrete building components, each equipped with its own dedicated works contract or construction package. This modularization simplifies the intricate construction process, making it comprehensible and accessible to a wider audience.

Seamless Integration: One of the key features is the seamless integration of these components. They are meticulously designed to fit together effortlessly, thanks to clear work process stages. This ensures smooth transitions and handovers between different phases of the construction project.

Digital Advancements: The process leverages cutting-edge technology by creating 3D models for every stage of the work. This digital model enables the entire building to be constructed digitally before any physical work commences. This digital twin not only aids in planning but also demystifies various aspects of construction, including materials, performance specifications, origins, building physics, maintenance, cost, quantity, and even embodied carbon footprints.

Assembly Clarity: The Kit of Parts System doesn't stop at 3D modeling; it goes further by explaining the assembly process and program sequence for each component. It provides illustrations and timing for every assembly operation, offering an ideal platform for students to practice. This step contributes to making construction more transparent and accessible.

Commissioning and Training: Once the building is complete, a comprehensive commissioning manual is provided. This manual, combined with the 3D model, features a training course complete with a book and interactive computer game. This innovative approach forms the basis of a net-zero construction curriculum, making learning and participation more engaging.

Accessibility and Certification: The Kit of Parts System promotes inclusion, allowing motivated individuals to delve into every aspect of the construction process. Those who prove their proficiency in assembling the kit's components can participate in the construction project and earn a coveted ZEDlife certification.

Smart Building Technology: The inclusion of smart building software and electronic feedback loops ensures that the as-built performance is continually monitored. This not only enhances building efficiency but also aids in training the commissioning team, further reducing the complexity of the construction process.

Automated Manufacturing: The digital 3D model serves a dual purpose by providing dimensional coordinates for individual component manufacture. To streamline the process, efforts are made to automate and expedite the offsite construction of sub-components using computer-aided design and manufacturing (CAD/CAM).

The Kit of Parts System represents a groundbreaking approach to construction that demystifies the building process and makes advanced technology breakthroughs accessible to wider audiences. This innovative methodology can be applied across multiple construction projects, ushering in a new era of transparency, accessibility, and sustainability in the construction industry’s Review Design Report (C4GS-ZEDlife, 2023) for the Kit of Parts process.

On the other hand, traditional construction requires a completely linear time sequence. Permits are acquired, the site and foundations are developed, and then the building is constructed. Yet, in modular construction, the modules themselves are built either in a ZEDlife prefab factory or using a pop-up factory model. This allows the project to concurrently move through permitting, acquisition, and site development. Table 5 compares the processes and savings between standard construction build processes and the ZEDlife Kit of Parts System.

Table 5: Comparing Processes and Savings Standard Construction Build Process Versus ZEDlife Kit of Parts Process

Construction Phase	Standard Construction	Kit of Parts
Design	• Involves architectural design, engineering, and planning. • Requires extensive time for design iterations and approvals. • May involve costly design. • changes during construction due to unforeseen issues.	• Design is based on predefined modular components. • Reduced design time due to standardized components.
Construction	• Sequential construction with multiple contractors. • Onsite assembly, often leading to construction delays due to weather and other factors. • Increased labor costs due to onsite work.	• Modular components are manufactured offsite, minimizing weather-related delays. • Onsite assembly is quicker and requires less labor.
Materials Procurement	• Procurement of materials from various suppliers. • Potential for delays and cost fluctuations due to market conditions.	• Bulk procurement of standardized materials for all projects. • Lower cost due to bulk purchasing and reduced market sensitivity.
Quality Control	• Quality assurance and control are critical but can be challenging to maintain. • Costly rework may be required to meet quality standards.	• Stringent quality control applied during the manufacturing process. • Fewer onsite quality issues and rework.
Training and Certification	• Limited opportunities for training and certification for green building jobs. • May require specialized professionals for complex tasks.	• The Kit of Parts assembly process allows for easy training and certification. • In-house training programs are more feasible and cost-effective.
Sustainability Considerations	• Sustainable practices may be an add-on, increasing costs. Carbon footprint may not be a primary focus.	• Sustainable practices are integrated into the kit, reducing costs. The process emphasizes a net-zero carbon footprint and eco-friendly materials.

Source: C4GS-ZEDlife | Build Phase Project Narrative | www.mountzed.com

Total Estimated Cost Savings of Over $3M: During the EPIC Challenge design phase, the project team discovered that the Kit of Parts approach offers significant cost savings for affordable housing compared to traditional design-build methods. These savings result from shorter design times, more efficient construction, bulk material purchases, better quality control, simplified training, and a stronger sustainability focus. This approach provides both cities and communities with rapid returns on investment, swiftly transitioning from concept to occupancy.

In addition to its Kit of Parts solution, the team adopted a multifaceted approach to cut embedded emissions. This included sustainable sourcing with local and certified materials to reduce transportation emissions and ensure responsible procurement. High-quality insulation, featuring nontoxic materials like fireproofed Rockfibre and rigid foam boards, boosts thermal efficiency, lowering long-term energy use and emissions. The team used an initial life cycle assessment to guide emissions reduction efforts.

The project also chose low-emitting materials for better indoor air quality and less off-gassing emissions. The focus on recycled and recyclable materials minimizes waste. For comprehensive details, C4GS-ZEDlife (2023, 70-77, 89) provides an in-depth analysis of sustainable construction and material choices.

The team's efforts extend beyond construction, including education, carbon offset programs, and ongoing maintenance to reduce the building's carbon footprint and promote sustainable living practices.

Cost Performance: A life cycle cost analysis provides a full picture of how energy savings are balanced against the initial cost and operation cost over the 30-year period. The analysis provides the lifecycle cost of the proposed development from the residents' perspective. Net present value is used as the metric for measuring lifecycle cost, as detailed in the CEC's and the U.S. DOE's methodologies. The net present value metric is calculated from the sum of the discounted yearly net values over the 30-year lifetime of the property.

Construction Costs: Total development cost is projected at $85 million (based on a range between $75 million and $95 million for +/-12 percent), which is approximately equal to $267,694/unit total cost per bed. Costs will vary depending on a given site's conditions, infrastructure efficiencies, and community needs.

Operating Costs: In considering operating costs for the development, the project allocated 38 percent of gross revenue to operating expenses, resulting in a remarkable 7-percent cost differential, equivalent to $25,000 in monthly savings for property management and administration when compared with industry standards. This substantial reduction is attributed to the sustainable design and innovative practices. Additionally, residents benefit from annual utility and transportation cost savings of $900,990 per year, equating to $2,944 per person annually and $245.37 per month, enhancing the affordability of the project. With an $85 million budget, the MountZED EcoVillage encompasses 94 units and 306 beds, prioritizing sustainability and carbon neutrality. The cost per bed projection of $267,964 facilitates a 95-percent off-grid housing solution with essential amenities that aligns with San Diego's market conditions. Furthermore, the project's aspiration to be the lowest embodied-carbon-producing

multi-family development in the U.S. (pending peer review) demonstrates the team's commitment to sustainability. The project's mobility plan enhances accessibility with 374 EV spaces.

In contrast, the local housing market has a median home price of $925,000, making it cost-prohibitive for students, families, and investors to find affordable housing. Additionally, Project HomeKey costs for homeless housing conversions in 2023 range from $400,000 to $500,000 per unit, highlighting the economic challenges in addressing homelessness.

Following is a deeper look at some recent projects comparable to the EcoVillage community.

1. UCSD North Torrey Pines Living and Learning Neighborhood: This project, primarily student housing, was analyzed at a cost of $279,460 per bed. It's anchored by University of California, San Diego's academic school facilities and amenities for residents, campus students, faculty, staff, and the arts and humanities program. The project incorporated LEED Silver standards for on-campus development to house undergraduates at below-market rents.
2. Columba by Chelsea Investment Company in Chula Vista's Millenia Master Planned Community: This project utilized low income tax credits and master developer subsidies, resulting in 198 of 200 units rated between 30 percent and 60 percent AMI. It boasts ample parking for residents and the community, as well as gardens and sustainable amenities. However, the land area and site costs were substantially less than the urban context of the city of San Diego.
3. Impact Housing at 6440 El Cajon Blvd in the City of San Diego Near San Diego State University: This project, under construction, is estimated at $87-plus million total development. It includes 324 units and 400 beds of attainable, affordable, and privately financed studios and one-bedroom units. However, it lacks amenities or open space, has no electrification, and has limited parking. Using volumetric modular construction, speed to market is prioritized. This cost savings is reflected in their overall cost per bed through the elimination of parking, amenities, and community benefits.

Resiliency and Safety: To address the impacts of climate change, the project team conducted a thorough analysis of future weather forecasts, which can be found in the Future Weather Forecast (C4GS-ZEDlife and Enerlite Consulting, 2023). This analysis involved the use of climate data containing modified weather scenarios, specifically, mild climate change and medium and high scenarios. These scenarios were utilized to model the thermal performance of a typical home, simulating the years 2035, 2050, and 2080, with the aim of anticipating global warming.

Insights from future heating and cooling load projections have guided plant sizing and future-proofed the building. Weather data shaped the design with features like higher ceilings, light wells, modified weather tapes, and glazed window apertures to enhance natural ventilation, daylight, and water efficiency. Structural calculations considered extreme winds due to climate change, while rainwater storage and greywater treatment accommodated reduced rainfall.

Safety measures include a safer battery chemistry, fire safes, and insulation for thermal performance. An airtight structure prevents hot air from entering, and interior room designs support natural ventilation. Private balconies promote outdoor living in changing climates. The project bans fossil fuel vehicles and manages solar panel heat.

These measures showcase a comprehensive approach to climate change adaptation and mitigation, addressing energy efficiency, water conservation, fire safety, and sustainable transportation for a resilient and eco-conscious development.

Technology Transfer Plan

Benefits of Building the Knowledge Base

The Community and Stewardship sectors represent the two most critical aspects of creating a zero-carbon lifestyle. Community buy-in allows for sustainable, low-embodied carbon housing developments to become part of the neighborhood landscape. Early neighborhood engagement is the most critical step to community stewardship. Taking this step sets in motion community dialogue and action to prevent gentrification and redlining. The community first principle is one of the vital lessons C4GS-ZEDlife brings to future developers.

The project knowledge base extends beyond technological advancements. It promotes tenant engagement, incentivizes energy efficiency, and utilizes the ZEDPower-platform for emission-free transportation. With proof of energy efficiency in hand, the Mount Hope community is empowered to accelerate the community's transition to sustainable living. Research findings will be shared with the public through publications.

C4GS-ZEDlifes's ambition extends beyond a single groundbreaking project; its aim is to revolutionize the mixed-use development industry as a whole. The team’s approach to this transformation calls for taking steps to activate the following key strategies.

Design Standards Blueprint: C4GS-ZEDlife is creating a blueprint for future mixed-use developments by developing a library of standardized architectural designs that prioritize sustainability. These designs are adaptable to different locations and can be customized to meet specific requirements while maintaining core sustainability principles.

Modular Building Components: C4GS-ZEDlife employs modular construction methods, allowing for standardized, repeatable, and scalable building components. These modules can be prefabricated in controlled environments, enhancing quality control and efficiency.

Cost Predictability: C4GS-ZEDlife can offer accurate cost predictions for its projects, through rigorous cost analysis and optimization. This predictability attracts investors and financing partners, making sustainable mixed-use development a financially viable and appealing option.

Collaborative Ecosystem: C4GS-ZEDlife fosters collaboration within the industry, encouraging developers, architects, and construction companies to adopt G4GS-ZEDlife’s practices. C4GS-ZEDlife offers training programs and consulting services to help transition others to the standardized, repeatable, and scalable model.

Community Engagement: C4GS-ZEDlife recognizes the importance of community buy-in for widespread adoption. The project team actively involved local communities in the development process, seeking input and feedback to create developments that align with community needs and values.

Achievements and Implications

Recognizing the need for transformative development in the area, the MountZED project team embarked on a mission to reimagine affordable mixed-use development while prioritizing environmental sustainability and community empowerment. The project builds upon the principles of environmental justice, aiming to address systemic inequalities and create a more equitable future for residents of Mount Hope.

The MountZED EcoVillage project design reached conclusions with the following implications for stakeholders:

Design for Affordable Housing Units: The MountZED EcoVillage project team successfully developed a plan for a mix of affordable housing options, including permanent supportive housing units, live/work units for students, and market-rate apartments.

Implication: Implementing community first and complete communities initiatives will guarantee a process of early community development discussion between the developer and the community, to learn about community needs and desires.

Solving Carbon Reduction Within Affordable Housing Developments: As a primary design initiative, the team set out to demystify the building process. With the EPIC Challenge calling for solutions to energy saving development, the team recognized the opportunity to take a systemic approach to demystifying the building process to design and engineer for efficiency and longevity.

Implication: The ZEDlife LTO batteries are an integral part of the building equation. Their reduced embodied carbon and extended lifespan enable a continuous surplus of renewable energy generation, gradually balancing out the initial carbon debt incurred during construction. This surplus isn't merely a bonus, it's a game-changer.

Putting All Government Land to Good Use: The MountZED EcoVillage development encroaches on three dead-end streets owned by the city. These spaces will be put to good use through the increase in affordable housing units and public accessible green spaces.

Implication: The design team worked to meet and integrate city codes into the ZEDhousing and transportation development plan.

Introducing Research and Increasing Awareness and Outreach: In collaboration with I Am Green, the project team developed a multi-pronged approach to developing environmental literacy among the general community, launching Reimagine My Community, ZEDlife Studio workforce training, and a rideshare program.

Implication: The Reimagining My Community initiative, led by our Environmental League of Justice members, works to establish a consensus on community values and priorities through hands-on activities, such as creating the eco-stewardship program, a mix of eco-education and

activism, as well as community workshops, arts and culture socials, conflict resolution workshops, and emergency preparedness.

Implication: There will be ongoing communication and listening opportunities, such as monthly focus groups, online community platforms, surveys and feedback loops, meet the developer events, town hall meetings, Every Day is Earth Day, and Environmental League of Justice's Sunday Brunch in the Garden.

Implication: Co-creation of the Mt. Hope Community Eco-Stewardship Agreement, a living document set to evolve alongside community needs and aspirations.

Implication: Outreach to a broader audience through media platforms and local events:

- C4GS Website
- MountZED Website
- LinkedIN: https://www.linkedin.com/company/c4gs-ZEDlife
- Youtube: https://www.youtube.com/@C4GSZEDLIFE
- C4GS-ZEDlife + Secret Pop Up Dinner
  C4GS-ZEDlife + Arcimoto Electric Vehicle Test
- C4GS-ZEDlife + Sound Bath by Chocolate Yoga

CHAPTER 4:
Conclusion

The MountZED EcoVillage project presented by C4GS-ZEDlife demonstrates the feasibility of sustainable, affordable housing. The project's success highlights the importance of community engagement, innovative design, and renewable energy integration. We are living at a time of disruption in technology, economy, and building development. Climate change, the most powerful disruptor, awaits no one. The MountZED EcoVillage pictures how disruption leads to transformation of green building values and practices that can and will reshape the industry and set a new standard for mixed-use development. C4GS-ZEDlife is at the forefront of this revolution, a company committed to harnessing the potential of modular construction methods and cutting-edge energy technologies.

In keeping with this commitment, the MountZED EcoVillage creates new residences with a groundbreaking promise: annual net-zero energy consumption for both living spaces and personal transit. It is a bold step toward minimizing environmental impacts and reducing the carbon footprints of traditional housing models.

In other words, for the C4GS-ZEDlife team, the MountZED EcoVillage is more than just a development; it's a transformative force for the local community. The team's commitment to sustainability, innovation, and community first engagement sets it apart from traditional developers that approach real estate development solely in terms of geography and financial profit.

Redefine the Way We Build and Live.

Reflecting on the lessons learned and their relevance for stakeholders, particularly real estate developers and government policymakers, C4GS-ZEDlife understands the pivotal role the project plays in reshaping industry standards and policy initiatives. The design journey with the MountZED EcoVillage project has illuminated key insights that can drive meaningful change in the real estate and government sectors.

Real Estate Developers: The project underscores the imperative of prioritizing community collaboration and sustainable design principles from the outset. By embracing a community first approach and integrating green building practices, developers can both meet regulatory requirements and advocate for resilient, inclusive communities that thrive in the face of inevitable climate challenges.

Government Policymakers: Policymakers must recognize the urgency of updating outdated regulations and zoning policies to support carbon-neutral development. The team's experience highlights the importance of streamlining permitting processes, providing financial incentives, and promoting workforce development initiatives to stimulate the transition to sustainable urban development.

In conclusion, the project sets a new benchmark for the real estate development and energy tech industries and for government policymakers by demonstrating the feasibility and benefits

of carbon-neutral mixed-use development. The team calls upon all stakeholders to collaborate and partner with the project's vision. Together, all stakeholders can pave the way for a more sustainable and equitable future.

The MountZED EcoVillage Project's Impact on Future CEC and California Policy

The CEC provided valuable learning opportunities in designing affordable housing with a sustainable plan for reducing carbon footprints. From designing for new solar charging options for bringing home and car together in one space to developing user-friendly knowledge transfer modules to demystify the modular building process, the CEC EPIC Challenge provided time and economic support to imagine and plan for a best-case scenario, state-of-the-art, carbon reducing lifestyle in an affordable housing development.

The community development effort in Mount Hope yielded valuable insights regarding how to grow the trust of a community from the outset, bringing residents along in the design process. This challenge brought together a team of experts to design a carbon reducing housing project grounded in evidence-based analysis. The project presents best practices for measuring and projecting carbon footprints, and it presents a best-case scenario for ratepayer data management. The design project provides space for training the next generation of green builders, solar energy consultants, and data analytic managers who will design future communities like Mount Hope.

With an eye to policy and future research, the project team found that the MountZED EcoVillage project design confronted current state policies. This final report highlights the obstacles and the challenges, and it suggests ways to advance future policy changes.

First and foremost, California needs to update policies that meet the demands of innovation in clean energy that have been proven in other countries, including in the United Kingdom and China, which have comparatively strict restrictions. California presents numerous policy obstacles that impact both developers and ratepayers. Attempts to design a state-of-the-art carbon reducing housing development are met with well-intended policies caught in the headwinds of maneuvering technology and economic change.

The MountZED EcoVillage Design Report (C4GS-ZEDlife, 2023) maps out a viable plan for reducing carbon in affordable housing projects, with several implications for policy change, including policy changes that target:

1. An updated LEED model for building green.
2. A new approach to standardizing how to assess carbon footprints.
3. Building for solar-generated housing that incorporates solar-generated EV charging.
4. A systems approach to incorporating data analysis seamlessly into a carbon-reduced energy design.

With energy and building policy challenges in mind, the model saves time and money on building development with sophisticated state-of-the-art data analyses and management. The multi-talented design team reduced the number of hours and dollars spent on construction by using building physics to access carbon footprint. Furthermore, the design team improved the

data managing rate paying to include solar power for generating cars and homes in the same immediate vicinity.

Most importantly, the project reimagines how a developer can and should approach a community poised for impacts by development. This includes holding community charrettes to discover the needs and desires of the community, which may include access to education in the green building industry. The MountZED EcoVillage project shows how to offer green workforce training by removing barriers to entry, namely by including housing in the training offer. An ethical and empathic mindset must put community first in the effort to create human-centered designs that meet the CEC's EPIC Challenge.

MountZED EcoVillage Inventions and Implications

C4GS's community first approach paved the way for a future of design and building with full EV integration of home and transportation. The marketable inventions that follow will benefit the Mount Hope neighborhood as well as any community situated in an urban island cut off from easy access to transportation and political representation and impacted by toxic climate conditions. These inventions maintain many implications for markets, environment and economy, California environmental policy, and the San Diego Complete Communities and Housing for All initiatives.

- C4GS ZEDlife Pop-up Manufacturing System, which allows for onsite construction to eliminate the need for factories.
- C4GS ZEDlife Kit of Parts System, which enables modular construction as an onsite green building process beyond LEED platinum certification.
- C4GS ZEDlife microgrid system.
- Customized Solar PowerClad panel canopy system, patent pending.
- C4GS ZEDlife exchangeable batteries.
- Customized renewal energy system.
- Customized data management system.

The team recognizes that marketing building systems is contingent upon community adoption and that community adoption is contingent upon up-to-date building policy. Nevertheless, the team remains optimistic that California will resolve current policy struggles so that plans to introduce additional community first products to the market can focus on education and work development. These products include:

- A Live Learn Build Camp: created to train the future green workforce and create housing at the same time.
- A policy initiative for a community-driven environmental league of justice.
- Lifestyle by Design: human-centered designing for the green lifestyle.

The project serves as a test case that shows the way forward for pop-up plug-and-play building design and construction processes.

Implications for Future Policy and Research

As this final report describes, the MountZED EcoVillage project highlights the need for policy changes in addressing time-sensitive rebates for solar rooftops and building carbon-neutral housing that is affordable and accessible to transit-constrained areas. The project also points to the need for nimble data-smart policies that address market fluctuations and lack of affordable housing.

Implications for Community Development

This project points to the need for more research on the community face of any building or energy policy. The project team is not suggesting mandating community spirit; rather, this project offers clear guidelines and methods for entering into a community with enough time to grow trust and inspire community leadership and input. The Environmental League of Justice is an outgrowth policy initiative that can help guide CEC policy for human-centered and community-centered energy projects.

Implications and benefits for the environment, the economy, and utility ratepayers follow.

- A model for increasing rooftop solar, which increases grid stability (microgrid)
- Community pathways to educational opportunities through live/learn solutions
- A circular economy: affordable housing, workforce development, and local manufacturing
- Advancement of carbon-neutral last-mile transportation solutions, e-bikes and car sharing
- Increased green and park spaces
- Reduced urban heat island effects, creating equity ownership opportunities for existing residents.

Implications for the actual real estate development market follow.

The Mount Hope project team is committed to keeping the community affordable and preventing gentrification by taking a proactive, community-driven approach. The ZEDlife approach prioritizes community/developer collaboration and acting inclusively, with an unwavering commitment to sustainable building; together, all three actions work to undo red-lining, eliminate harmful zoning laws, and increase limited resources. The project team addresses urgent community needs and maintains a strong neighborhood presence, avoiding economic pitfalls that could displace residents.

The MountZED multifamily housing project prioritizes affordability in response to the dynamic housing market. To align with the community's specific needs, a significant portion of the housing units are earmarked for residents earning between 30 percent and 60 percent of the area's median income The projects have been intentionally segmented into two categories: permanent supportive housing and live + learn units, which are exclusively reserved for households within the 30 percent to 60 percent AMI bracket. This tailored approach ensures that the housing project accommodates financial differences within the Mount Hope community. Market rates strike a balance between affordability and sustainability. This not only generates revenue to support the project's long-term viability but also provides an

opportunity for residents outside the specified income range to become part of the vibrant Mount Hope community. In essence, this comprehensive strategy caters to both the specific affordability needs of the community and the project's overall sustainability.

Implications for Mixed-Use Public Centers

The design for mixed-use public centers like ZEDlife Lab for skill development, green talent pool creation, and community empowerment addresses college student home insecurity.

The project included the ZEDlife Lab based on early research assessments of the barriers to entering green careers. The team found there are many barriers, including the lack of reinforcement within the current education systems. In turn, preparation for green careers is slowed by the need for re-schooling or continued education, especially when communities and individuals lack housing and sufficient financial resources to participate in career advancement programs. Complicating the matter further is the limited availability of community resources dedicated to cultivating green building internships and apprenticeships for both youth and adults.

The team concluded that, if the team was going to design and build a state-of-the-art electrified ecovillage, the result must include a solution that prioritizes training the next generation of green builders.

Knowing the building industry offers journeymen apprenticeships, the team designed a live and learn pipeline that moves youth and industry professionals from learning to working in the green building industry. The MountZED EcoVillage concept design necessarily includes a live and learn initiative to train future leaders in the green building industry, with an option to live onsite.

As a result, the team designed for and developed collaboration partnerships to create viable futures for student housing and a green workforce:

- Of 102 units, 27 are dedicated to live/work student housing.
- There is onsite green building training in partnership with UCSD.
- Over 100 local jobs will be provided to community members during construction.

Implications for Transportation and Social Justice

California Solar Housing Policy: The Mount Hope EcoVillage project presents a strong case for the challenge of designing state-of-the-art solar-charged housing at a time when local and state energy companies are changing positions on solar savings. This project can serve as a model for win-win solutions for state energy providers and affordable home developers.

Win-Win Solutions for Transportation, Housing and Social Justice: The project points to how to bring all of this together with innovations in building construction, development of an innovative solar roofing system, and innovations in how to make green transportation accessible in an affordable way by bringing EV charging to residents' doorsteps.

Making the MountZED EcoVillage is more than just a development; it is a transformative force for the local community. The team's commitment to sustainability, innovation, and community

engagement sets the team apart, as does the C4GS integrated approach for a multi-disciplinary team of experts, community engagement activists, and energy-saving protocols.

The journey to energy and market transformation is more than just a construction project; it is a visionary movement seeking to redefine the building industry's future for a ZEDlife lifestyle. By promoting emerging energy technologies and embracing standardized, repeatable, and scalable practices, C4GS-ZEDlife is paving the way for a more sustainable, efficient, and inclusive world of mixed-use development. As the team’s vision takes shape, it carries the promise of a brighter and more sustainable future for urban landscapes everywhere.

GLOSSARY AND LIST OF ACRONYMS

Term	Definition
AMI	Area Median Income
BIPV	Building Integrated Photovoltaics
CBECC	California Building Energy Code Compliance Software
CEC	California Energy Commission
CAP	Climate Action Plan
CNC	Computer Numerical Control
DER	Distributed Energy Resources
DHW	Domestic Hot Water
EPIC	Electric Program Investment Charge
EV	Electric Vehicle
GHG	Greenhouse Gas
HVAC	Heating, Ventilation, and Air Conditioning
LEED	Leadership in Energy and Environmental Design
LTO	Lithium Titanate Oxide
MEP	Mechanical, Electrical and Plumbing
PV	Photovoltaic
SBD	Standard Baseline Design
UCSD	University of California, San Diego
ZED	Zero Energy Development

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Project Deliverables

C4GS-ZEDlife's MountZED EcoVillage design project delivered significant contributions to affordable mixed-use housing in a carbon-constrained future.

- C4GS-ZEDlife Kit of Parts Manual - The manual is a step-by-step guide to organizing a design workshop to ensure the Kit of Parts can be assembled efficiently and safely as a 12-step process. Workshops will involve skilled contractors.
- ZEDlife Certificate fellows and community residents
- C4GS-ZEDlife "Reimagine Our Community" guide (or Green Charrettes guide)
- Virtual Power Grid Management System and Microgrid Reusable Toolkit
- All-Electric Transportation Integration
- Hands-on Workforce Development and Training Model - ZEDlife Studios

Project deliverables are publicly available by request at pubs@energy.ca.gov.