CALIFORNIA ENERGY COMMISSION

CALIFORNIA NATURAL RESOURCES AGENCY

ENERGY RESEARCH AND DEVELOPMENT DIVISION

FINAL PROJECT REPORT

Sustainable Mixed-Use Community in City of Woodland

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ACKNOWLEDGEMENTS

ConSol would like to take the opportunity to thank individuals and institutions that made this concept Design Phase possible. Subcontractors for this agreement include The Hodgson Company (co-developer/landowner representative), BSB Design (planning and design representative), and Bardis & Miry Development (builder and co-developer). The technology provider vendors include Community Energy Labs, Schneider Electric, Swell Energy, SkySource (aka David Hertz Architects), Nuvve, Envoy Electric, ElectricFish, and Somfy. Community outreach was provided by the University of California, Davis Center for Regional Change and California Coalition for Rural Housing. In addition, this project had the support of Pacific Gas & Electric as a stakeholder, as well as numerous local Woodland and Yolo County community organizations. ConSol would also like to thank the following Technology Advisory Committee members for their support and guidance during the Design Phase. Technical Advisory Committee members include the following: Erika Bumgardner – City of Woodland; Melanie Mathews – Woodland Research & Technology Park; Lon Hatamiya – The Hatamiya Group; Conrad Asper – Pacific Gas & Electric; Karen Glitman – Center for Sustainable Energy; and Vance Jarrad – North State Building Industry Association.

PREFACE

The California Energy Commission's (CEC) Energy Research and Development Division supports energy research and development programs to spur innovation in energy efficiency, renewable energy and advanced clean generation, energy-related environmental protection, energy transmission, and distribution and transportation.

In 2012, the Electric Program Investment Charge (EPIC) was established by the California Public Utilities Commission to fund public investments in research to create and advance new energy solutions, foster regional innovation, and bring ideas from the lab to the marketplace. The EPIC Program is funded by California utility customers under the auspices of the California Public Utilities Commission. The CEC and the state's three largest investor-owned utilities — Pacific Gas and Electric Company, San Diego Gas and Electric Company, and Southern California Edison Company—were selected to administer the EPIC funds and advance novel technologies, tools, and strategies that provide benefits to their electric ratepayers.

The CEC is committed to ensuring public participation in its research and development programs that promote greater reliability, lower costs, and increase safety for the California electric ratepayer and include:

- Providing societal benefits.
- Reducing greenhouse gas emission in the electricity sector at the lowest possible cost.
- Supporting California's loading order to meet energy needs first with energy efficiency and demand response, next with renewable energy (distributed generation and utility scale), and finally with clean, conventional electricity supply.
- Supporting low-emission vehicles and transportation.
- Providing economic development.
- Using ratepayer funds efficiently.

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

ABSTRACT

The ConSol team's final concept design for a multitenant mixed-use development integrates seven key emerging energy technologies within a tiered resilience strategy:

1. Rooftop solar photovoltaic generation, parking lot bifacial solar photovoltaic generation, and centralized building battery energy storage
2. Vehicle-to-grid bidirectional charging stations
3. Electric vehicle car sharing program providing all residents with equitable access to affordable, on-demand, zero-emission vehicles
4. Wood-to-energy deployed water biomass power, providing a consistent power source to back up critical energy needs and using locally sourced materials
5. Combined electric vehicle direct current fast chargers with integrated battery energy storage
6. Automated indoor window shades and controls for greater occupant comfort and utility bill reduction
7. Microgrid controls for building and end-user load energy management and monitoring

The development would be located within the approved Woodland Research & Technology Park in the City of Woodland (Yolo County). It would contain one-bedroom and two-bedroom units that would be 100 percent affordable to a range of low- and very low-income households, and would feature access to public transit as well as surrounding community amenities, including neighborhood retail, parks, green belts, bikeways, local universities, and pedestrian walkways. A collaborative partnership with the Woodland Research & Technology Park, the Woodland Unified School District, the Woodland Community College, and University California, Davis would connect residents with local education and workforce development opportunities.

Keywords: Sustainability, resilience, affordability, community design, building battery energy storage, biomass power generator, renewable energy, affordable housing, community engagement, technology integration, multifamily housing, mixed-use development, research and technology park, rooftop solar PV, bifacial parking canopy solar PV, bidirectional V2G/V2B EV charging stations, EV community car sharing, DC fast chargers with integrated battery energy storage, automated window shades and controls, microgrid energy management, grid-smart building controls

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Executive Summary

ConSol pursued this innovative community design driven by three goals: sustainability, resilience, and affordability. The team's final concept design for a multitenant mixed-use development integrates seven key emerging energy technologies within a tiered resilience strategy:

1. Rooftop solar photovoltaic generation, parking lot bifacial solar photovoltaic generation, and centralized building battery energy storage
2. Vehicle-to-grid bidirectional charging stations
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The proposed development would be located within the approved Woodland Research & Technology Park in the City of Woodland (Yolo County), would contain one-bedroom and two-bedroom units that would be 100 percent affordable to a range of low- and very low-income households and would feature access to public transit as well as surrounding community amenities, including neighborhood retail, parks, green belts, bikeways, local universities, and pedestrian walkways. A collaborative partnership with the Woodland Research & Technology Park, the Woodland Unified School District, the Woodland Community College, and University of California, Davis would connect residents with local education and workforce development opportunities.

Background

Greenhouse gas emissions must be dramatically reduced to mitigate projected catastrophic impacts from climate change. Building decarbonization must be employed to support California's aggressive state and local government energy policy and zero-emission goals. Simultaneously, California's housing affordability crisis is blocking 50 percent of households from living in the area where they work. The ConSol project team's all-electric, mixed-use affordable housing development concept is designed to be 100 percent affordable to qualified low-income renters, incorporate state-of-the-art clean energy and energy-efficient solutions, incorporate flexible load management and demand-responsive controls, provide shared electric transportation, and showcase emerging innovative clean energy technologies to create an environmentally friendly neighborhood for residents.

Project Purpose and Approach

ConSol pursued this innovative community design driven by three goals: sustainability, resilience, and affordability. ConSol achieved and exceeded these goals with a net carbon negative energy design (-336 tons carbon dioxide equivalent annually), unlimited Tier 1 critical and Tier 2 priority backup power to tenant units and common areas, and an average $546 of tenant utility bill savings per year. In addition, the combination of incentives and operational cost savings for this design pays for all the advanced clean energy and efficiency features in fewer than four years. This 130-unit affordable housing project design provides a viable, scalable, plug-and-play, zero-emission pathway for the mixed-use, all-electric, 100 percent affordable housing development in the City of Woodland and sets a replicable model for communities throughout the State of California. Validating this approach, the Woodland City Council unanimously approved ConSol's community design on September 5, 2023.

ConSol's design delivers a true pathway for zero-emission solutions that are technically and economically feasible, takes advantage of advanced building design and construction practices, and provides equitable access to safe, healthy, affordable, and desirable living environments. The concept is designed to benefit California investor-owned utility ratepayers by increasing reliability with an agile and demand-responsive microgrid design, lowering tenant and building owner utility costs by $77,800 annually, and increasing safety through a multi-tiered resilience design delivering unlimited Tier 1 critical and Tier 2 priority load backup power. This project design demonstrates technological advancement and breakthroughs to overcome barriers to achieving California's statutory energy goals through both existing and emerging zero-emission technologies and increases access to affordable housing in an innovative mixed-use development within walking/biking distance of new jobs, shared community space, and electric vehicle car sharing.

The objectives of this project were to:

1. Provide uninterrupted, equitable access to resilient clean energy and clean transportation.
2. Fund the design of an all-electric, mixed-use development that addresses both greenhouse gas emissions and rising housing costs.
3. Demonstrate a scalable pathway to sustainable mixed-use development that is technically and economically feasible, takes advantage of advanced building design and construction practices, and provides Californians of all income levels with access to safe, healthy, affordable, and desirable living environments.

Using the team's combined expertise and resources, it would pursue a successful Build Phase application based on substantial community and stakeholder support and feedback, multiple use cases, simulated modeling of each use case, creation and vetting of a formal measurement and verification plan, and a thorough evaluation of project costs and available funding/incentives that support the project's economic viability and scalability.

Key Results

The ConSol project team successfully incorporated the following design features:

1. Truly scalable design and business model, applicable from very low-income (40 percent area median income) through market rate
2. A 130-unit building, with about 55 percent of units being two-bedroom, as per direct community request and feedback
3. Community electric vehicles with multiple charging options (Level 2, 100-kilowatt vehicle-to-grid, 350-kilowatt vehicle-to-building)
4. Net carbon negative energy with unique biomass carbon sequestration
5. Unlimited Tier 2 priority loads (25 percent) during outages, even when cloudy
6. Shelter-at-home for tenants with a microgrid backing up each unit and common areas
7. Low tenant utility bills with an average $35 per month
8. Location within the approved Woodland Research & Technology Park, affording access to broad community assets

Key energy modeling performance results are as follows:

1. **Energy Consumption Baseline Versus Proposed — 18 percent less space heating energy usage and 10 percent less space cooling energy usage resulting from envelope and appliance efficiency upgrades**. As seen in Table ES-1, an excerpt from the Energy and Emissions Performance Workbook, the proposed design has impacts on site energy use (and associated emissions). The most dramatic impacts on site energy use intensity are in space heating (18.3 percent reduction), space cooling (10.4 percent reduction), and domestic hot water (5.4 percent reduction). The 3.6 percent reduction in Process (Cooking/Appliances) is due to the incorporation of induction cooking in the design.

Table ES-1: Energy Consumption Baseline Versus Proposed

End-Use	Unregulated? Y/N	Site Energy Use Intensity (kBtu/sf/yr)			GHG Emissions Intensity (kg CO2/sf/yr)		
		Baseline	Proposed	% Improvement	Baseline	Proposed	% Improvement
Space Heating	N	2.30	1.88	18.3	0.131	0.105	19.8
Space Cooling	N	1.83	1.64	10.4	0.064	.058	9.4
Indoor Fans (IAQ Vent)	N	0.53	0.53	0	0.024	.024	0
Domestic Hot Water (including pump)	N	2.23	2.11	5.4	0.090	.084	6.6
Indoor Lighting	N	0.96	0.96	0	0.053	.053	0
Receptacle	Y	5.55	5.55	0	0.269	0.269	0

End-Use	Unregulated? Y/N	Site Energy Use Intensity (kBtu/sf/yr)			GHG Emissions Intensity (kg CO2/sf/yr)		
		Baseline	Proposed	% Improvement	Baseline	Proposed	% Improvement
Process (Cooking/ Appliances)	Y	5.88	5.67	3.6	0.232	0.224	3.6
Other Lighting	N	.21	.21	0	0.012	0.012	0

Source: ConSol

2. **Peak Hours Load Management — 85 percent peak energy reduction and 84 percent bill reduction**. As seen in Table ES-2, an excerpt from the Energy and Emissions Performance Workbook, the project would be able to reduce the amount of energy it needs to draw from the grid during peak hours by 85 percent. Most of this peak reduction can be attributed to on-site generation (biomass and solar) and energy storage. A smaller portion of the reduction can be attributed to taking advantage of pre-cooling, which is a heating, cooling, and air conditioning management technique that shifts heating, cooling, and air conditioning loads from peak evening hours to the early afternoon hours. Without any solar, biomass, energy storage, or pre-cooling, it would cost $122,000 annually to power the project during peak hours. Adding the proposed generation and storage to the project would cut the annual peak hours energy bill to $19,100.

Table ES-2: Peak Hours Load Management

Energy Consumption During Peak Hours (4-9 PM)

(1)	(2) = (3) + (4) + (5)	(3)	(4)	(5)	(6) = [(4) + (5)] /(2)
Annual electricity consumption (kWh)	Annual consumption during peak hours (kWh/year),	Annual Grid Purchase during peak hours (kWh/year)	Annual load reduction from onsite biomass, onsite solar and storage during peak hours (kWh/year)	Annual load reduction from load management during peak hours (kWh/year)	% Peak reduction from onsite solar, storage arid load management
867,107	292,134	43,935	238,683	9515	85%

Electric Bill Reduction due to Peak Management

(1)	(2) = (3) + (4) + (5)	(3)	(4)	(5)	(6) = (4)+(5)	(7) = (6)/(2)
Annual electricity bill ($/year)	Expected annual electricity cost during peak hours ($/year) before solar, storage, and load shifting	Cost of purchasing from grid during peak hours ($/year)	Avoided grid electricity purchases due to solar, biomass and storage ($/year)	Avoided grid electricity purchases due to load management ($/year)	Total bill reduction caused by onsite solar, storage, and load management ($/year)	% Bill reduction compared to baseline bill
$81,609	$122,011	$19,124	$102,089	$798	$102,887	84.3%

Source: ConSol

3. **Energy Bill Savings — At least 56 percent residential space energy bill reduction and at least 55 percent non-residential space energy bill reduction.** Table ES-3, an excerpt from the Energy and Emissions Performance Workbook, provides estimates of the savings on electric bills if the project incorporates the efficiency and on-site generation measures from the proposed design. The baseline building costs about $139,300 annually ($125,700 for residents, $13,600 non-residential) to serve the estimated demand for electricity. The proposed building design would cost about $61,500 to serve estimated electricity demand, resulting in a $77,800 (about 56 percent) bill reduction relative to the baseline.

Table ES-3: Energy Bill Savings

Total Estimated Residential Space Electricity Bill

Baseline	Proposed Design[13]		
First-Year Bill ($)	First Year Bill ($)	First-Year Saving ($)	Percentage Reduction (%)
$125,704	$54,801	$70,903	56.4%

Total Estimated Non-Residential Space Electricity Bill

Baseline	Proposed Design		
First-Year Bill ($)	First-Year Bill ($)	First-Year Saving ($)	Percentage Reduction (%)
$13,578	$6,649	$6,929	51%

Baseline	Proposed Design		
Lifetime[14] Saving ($)	Lifetime Bill ($)	Lifetime Saving ($)	Percentage Reduction (%)
$4,178,460	$1,843,500	$2,334,960	55.8%

Source: ConSol

Knowledge Transfer and Next Steps

ConSol's Design Phase partners, the University of California, Davis Center for Regional Change, and the California Coalition for Rural Housing-led community engagement activities related to the design development phase. The University of California, Davis Center for Regional Change and the California Coalition for Rural Housing hosted personal interviews with representatives from the Woodland community, held a community-based focus group to solicit feedback regarding the design and integrated technologies, and conducted a community engagement survey.

The questions in the survey were developed to get a baseline for the level of understanding that Yolo County residents have for potential energy efficiency and other green features that the project team considered, including in the planning and design phase as well as behaviors and decision-making that further informed the design. Most notably, the survey captured feedback regarding the topic of apartment types and spaces in the community. The initial findings showed that community members were interested in units for families rather than individuals. In light of the community feedback, the design team reconfigured the apartments to include both one- and two-bedroom units, rather than studio and one-bedroom units, addressing the market and community need for affordable family and individual units.

Additional findings from the surveys, interviews, and focus groups included the following, for which the project team worked to provide solutions in the design:

- More than half of the respondents wanted places to work, including co-working areas, office spaces, and live-work spaces. Co-working space and live-work units were incorporated into the project.
- There was interest in community rooms and children's outdoor play areas. A community room and children's play area were included in the project.
- Nearly 75 percent of respondents had experienced power outages lasting one day long. Less than 10 percent of respondents had experienced power outages lasting more than one day. Tremendous energy resiliency was built into the project, capable of delivering unlimited Tier 1 critical loads to each residential unit and unlimited Tier 2 priority loads to the common areas.
- More than half of the respondents named costs as the barrier to having all the energy efficiency features they would like. The project design incorporated high-energy-efficiency amenities, including induction range tops, triple-pane windows, Somfy's automated interior window shading, minimum 16 Seasonal Energy Efficiency Rating heat pumps with communicating thermostats, Northwest Energy Efficiency Alliance Tier 3 or 4 demand response-capable heat pump water heaters with thermostatic mixing valves for thermal storage, and ENERGY STAR-certified heat pump space heating and cooling.
- The largest number of respondents were interested in hybrid or electric vehicles. However, there were several popular options, including carpooling, biking, using Transportation Network Companies such as Uber or Lyft, transit, and micro-mobility options. Affordable community electric vehicle car sharing through Envoy will be available to all project residents, in addition to two 350-kilowatt direct current fast chargers from ElectricFish, four 100-kilowatt bidirectional vehicle-to-grid chargers from Nuvve, 20 additional Level 2 electric vehicle chargers throughout the property, and all remaining parking spaces pre-wired for future electric vehicle supply equipment installation.
- The Woodland community has a broad and diverse housing need, with more than 50 percent Hispanic population that includes families, farmworkers, and an aging population. The project is 100 percent affordable housing, and more than 50 percent of the units are two-bedroom, specifically designed for families. This complex was designed specifically with 59 one-bedroom and 71 two-bedroom units to address this need.

The results of the community engagement activities were carefully analyzed, considered, and incorporated into the final design. A complete list of the community engagement activities and major successes can be found in Chapter 2 of this report.

Using the findings from this project, the ConSol team aimed to turn this innovative concept design into a reality for the City of Woodland residents.

CHAPTER 1: Introduction

Greenhouse gas (GHG) emissions must be dramatically reduced to mitigate projected catastrophic impacts from climate change. Building decarbonization must be employed to support California's state and local government aggressive energy policy and zero-emission goals. Simultaneously, California's housing affordability crisis is blocking 50 percent of households from living in the area where they work. The ConSol project team's all-electric, mixed-use affordable housing development concept was designed to be affordable to all qualified low-income renters, incorporate state-of-the art clean energy and energy efficient solutions, incorporate flexible load management and demand responsive controls, provide shared electric transportation, and showcase emerging innovative clean energy technologies to create an environmentally friendly neighborhood for residents.

ConSol pursued this innovative community design driven by three goals: sustainability, resilience, and affordability. ConSol achieved and exceeded these goals with a net carbon negative energy design (-336 tons carbon dioxide equivalent [CO2e] annually), unlimited Tier 1 critical and Tier 2 priority backup power to tenant units and common areas, and an average $546 on tenant utility bill savings per year. In addition, the combination of incentives and operational cost savings for this design would pay for all the advanced clean energy and efficiency features in fewer than four years. This 130-unit affordable housing project design provides a viable, scalable, plug-and-play, zero-emission pathway for the mixed-use, all-electric, affordable housing development in the City of Woodland and sets a replicable model for communities throughout the State of California. Validating this approach, the Woodland City Council unanimously approved ConSol's community design on September 5, 2023.

ConSol's design delivers a true pathway for zero-emission solutions that are technically and economically feasible, takes advantage of advanced building design and construction practices, and provides equitable access to safe, healthy, affordable, and desirable living environments. The concept was designed to benefit ratepayers in California investor-owned utilities by increasing reliability with an agile and demand-responsive microgrid design, lowering tenant and building owner utility costs by $77,800 annually, and increasing safety through a multi-tiered resilience design delivering unlimited Tier 1 critical and Tier 2 priority load backup power. This project design demonstrates technological advancement and breakthroughs to overcome barriers to achieving California's statutory energy goals through both existing and emerging zero-emission technologies and increases access to affordable housing in an innovative mixed-use development within walking/biking distance of new jobs, shared community space, and electric vehicle (EV) car sharing.

Using the team's combined expertise and resources, the ConSol project team prepared a comprehensive Build Phase application based on substantial community and stakeholder support and feedback, multiple use cases, simulated modeling of each use case, the creation and vetting of a formal measurement and verification plan, and a thorough evaluation of project costs and available funding/incentives that support the economic viability and scalability of the project.

CHAPTER 2: Project Approach

The objectives of this project were to:

1. Provide uninterrupted, equitable access to resilient clean energy and clean transportation.
2. Fund the design of an all-electric, mixed-use development that addresses both GHG emissions and rising housing costs.
3. Demonstrate a scalable pathway to sustainable mixed-use development that is technically and economically feasible, takes advantage of advanced building design and construction practices, and provides Californians of all income levels with access to safe, healthy, affordable, and desirable living environments.

Overall Design Approach and Strategies

Proposed Building Uses

The proposed building features 130 units (59 one-bedroom, 71 two-bedroom). A limited number (about 10) of these units are designated as "live-work," which will allow residents to operate small businesses from their home. The ground floor of the building also features two larger scale commercial spaces. Possible uses for these include childcare, technology skills training, community computing, and community event spaces.

The proposed building incorporates significant investments into building envelope efficiency, energy efficiency technology, EV charging and car sharing, energy generation, and energy storage. These combine to make the community resilient to power outages.

Site Location

The building is proposed in the City of Woodland (Climate Zone 12) adjacent to County Road 25A, the Spring Lake Specific Plan neighborhood to the north and east, the Urban Limit Line to the south, and State Route 113 to the west. The subject property is under site control by the project team. A letter of intent was finalized between team member John Hodgson of The Hodgson Company and the landowner, assuring control of the subject property. The proposed location is a 3.3-acre site within the Woodland Research & Technology Park in the City of Woodland and is specifically zoned for a mixed-use affordable housing project. The site is strategically located adjacent to the planned village center, which will include neighborhood-serving retail and commercial uses. In addition, this site is within proximity (600 feet) to the large 11-acre community park, which includes a farmers' market, recreational uses, and community uses.

Project Participants

ConSol was the Principal Investigator, California Energy Commission (CEC) Grant Recipient, and administrator for this project.[1] ConSol is an energy consulting firm with more than 37 years of experience specializing in energy efficiency, program management, and technology integration to improve the sustainability of new and existing residential and commercial buildings. ConSol's broad clientele includes local governments, investor-owned and municipal utilities, public agencies, equipment manufacturers, installation subcontractors, land developers, and top national builders.

The Design Phase project partners included the following organizations:

- **John Hodgson of The Hodgson Company** was the co-developer and landowner representative for this project. Hodgson specializes in the entitlement and development of real estate and land use projects throughout Northern California.[2] The Hodgson Company has been involved in some of the area's most innovative master-planned communities, infill development, and mixed-use projects with an emphasis on sustainability and mixed-use. Most recently, Hodgson received approvals for the Woodland Research & Technology Park, a master-planned 350-acre scientific research park and residential community. John Hodgson is a graduate of the University of California, (UC) Davis and UC Davis School of Law (King Hall). He is the former Chair of the Urban Land Institute Sacramento Council and former Chair of the Capital Area Development Authority. He currently serves on the Boards of the Sacramento Downtown Partnership, Midtown Association, and North State Building Industry Association (Urban Infill Council).
- **Bay Miry of Bardis & Miry Development** was the builder and co-developer for this project. Bay Miry has focused as a developer and builder in delivering dynamic and impactful developments focusing on mixed-use, historic rehabilitation, adaptive reuse, and sustainability.[3] He has played a major role in the completion and delivery of a wide array of multifamily projects at all income levels. His Sacramento projects include the 16 Powerhouse mixed-use building (Leadership in Energy and Environmental Design Platinum-certified); The Hardin (mixed-use project involving the conversion of nine historic buildings into 137 units of mixed-income housing); the 1430 Q building (75 units mixed-use); and the Maydestone building (conversion of historical building into 32 affordable housing units). Miry is a UC Berkeley graduate. He currently serves on the Boards of Visit Sacramento, Downtown Sacramento Partnership, Midtown Association, and the R St Partnership. Miry has been instrumental in the start-up of Midtown Parks, a non-profit organization that focuses on capital improvements and promoting events in public spaces throughout the midtown Sacramento parks. Miry's passion is thoughtful and impactful development and well-programmed public spaces.

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[1] ConSol, Inc. 2022. "About Us." Available at https://www.consol.org/about.

[2] Hodgson Company. 2024. "About Us." Available at https://www.thehodgsoncompany.com/about-us/.

[3] Bardis & Miry. n.d. "Bardis & Miry Development." Available at https://www.bardismiry.com/.

- **BSB Design (BSB)** was founded in 1966 to specialize in the planning and design of residential housing and communities. BSB Design was the planning and design representative for this project. Through multiple offices across the country, the firm has designed cost-effective housing in all price ranges and styles for construction in all 50 states, Canada, and other countries. In addition to exceptional residential architecture, BSB Design offers land-use planning, community design, resort planning and design, landscape architecture, market research, estimating, and color services.[4] Throughout the greater Sacramento area, BSB has designed numerous multifamily projects that include affordable housing and mixed-use.
- **Community Energy Labs (CEL)** current technology includes the AirCarePlus®, a product that took a heating, cooling, and air conditioning (HVAC) diagnostics software from field trials to full utility-scale commercial deployment for Southern California Edison.[5] The technology was bundled with mechanical service contracts and eventually adopted by Pacific Gas & Electric (PG&E), Commonwealth Edison, and Nicor Gas. CEL provided controls support during the Design Phase and would be replaced by Schneider Electric in the planned Build Phase due to constraints on CEL resources.
- **Swell Energy (Swell)** (vendor) provides simple solar plus storage solutions and leading grid service programs to serve the needs of diverse stakeholder groups. For this project, Swell would provide solar photovoltaic (PV) clean-power generation, energy storage, financing products, and aggregation of Swell-deployed distributed energy resources with Swell's Fleet software platform.[6] Swell is a leading distributed energy resource virtual power plant (VPP) developer and currently has under contract 300 megawatt-hour (MWh) of energy storage based VPP agreements in territories including Hawaii, California, and New York, having raised $450 million in project financing, which represents about 14,000 homes' worth of battery storage.
- **Nuvve** (vendor) would provide bidirectional EV charging equipment for this project. Nuvve is the global leader in vehicle-to-grid (V2G) technology offering high-powered charging and grid services that optimize unused and renewable energy.[7]
- **Envoy** (vendor) is a community-based electric car sharing service and platform that would provide a shared EV service as an exclusive amenity to the residents of the project.[8]
- **David Hertz Architects (aka SkySource)** (vendor) would provide mobile infrastructure energy/water generator technology to this project. This technology is 1/10th the cost of solar per kilowatt and uses biomass to produce clean energy, clean

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[4] BSB Design, Inc. 2024. "About." Available at https://www.bsbdesign.com/about/.

[5] Community Energy Labs. 2022. "The Future of Building Performance." Available at https://communityenergy labs.com/solution/.

[6] Swell Energy. n.d. "Press Room." Available at https://www.swellenergy.com/press/.

[7] Nuvve. 2024. "Our Story." Available at https://nuvve.com/our-story/.

[8] Envoy. n.d. "Car Sharing Platform | Car Sharing App." Available at https://www.envoythere.com/about-us.

water, and biochar.[9] SkySource was the recipient of a Time Magazine "Best Invention of 2020" award and Grand Prize Winner of the Global 2018 Water Abundance XPrize.

- **ElectricFish** (Build Phase vendor that participated in Design Phase at no cost to the CEC) is a climate tech company, based in Fremont, California, and founded in 2019, that builds distributed energy storage powered by software.[10] ElectricFish's patented, turnkey energy storage solutions bring unprecedented convenience to the EV charging experience while also supporting energy resilience in local communities, all with 100 percent renewable energy. ElectricFish comprises experienced battery researchers, hardware engineers, energy scientists, creatives, and serial entrepreneurs with deep domain expertise and execution experience from leading organizations such as BMW, Oak Ridge National Lab, NASA, and Stanford. The ElectricFish team was recognized by several institutions, including Forbes 30 under 30. While their diverse team stems from different walks of life, ElectricFish is uncompromisingly united in their mission to enable a decarbonized, resilient, and equitable energy future for all communities.
- **Somfy** (Build Phase vendor that participated in Design Phase at no cost to the CEC) was founded in 1969 and is one of the largest manufacturers and suppliers of controllers and drives for entrance gates, garage doors, blinds and awnings.[11] Somfy also produces other home automation products such as security devices. Somfy is a member of the home automation committees Matter, Thread Group, and the Connectivity Standards Alliance.
- **Schneider Electric** (Build Phase vendor that participated in Design Phase at no cost to the CEC) Microgrid Solutions team brings together industry leading technology with decades of experience helping customers implement power distribution, control systems, and on-site generation solutions that focus on user/prosumer outcomes, including power resilience, critical power, economic optimization, electrification, and decarbonization.[12]
- **UC Davis Center for Regional Change (CRC)** provided land use sustainability and social equity research support for this Design Phase project. Launched in 2007, the CRC is a catalyst for innovative, collaborative, and action-oriented research. The CRC brings together faculty and students from different disciplines, and builds bridges between university, policy, advocacy, business, philanthropy, and other sectors.[13] The CRC's goal is to support the building of healthy, equitable, prosperous, and sustainable regions in California and beyond. The CRC is supported and housed within the UC Davis College of Agricultural and Environmental Sciences. The CRC's past projects include Decarbonizing California's Transportation Sector by 2045, Bay Area to Central Valley Migration and its

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[9] SkySource. n.d. "Our Story." Available at https://www.skysource.org/ourstory.

[10] ElectricFish. 2024. "Our Team, Values & Mission." Available at https://www.electricfish.co/about.

[11] Somfy. 2024. "About us." Available at https://www.somfysystems.com/en-us/discover-somfy/about.

[12] Schneider Electric. 2024. "Company profile." Available at https://www.se.com/us/en/about-us/company-profile/.

[13] UC Davis Center for Regional Change. 2022 (April). "About Us." Available at https://regionalchange.ucdavis.edu/about-us.

Impacts, San Joaquin Valley Healthy Homes Project, Climate Smart Transportation and Communities Consortium, and the Inclusionary Housing Database (in progress with team member, California Coalition for Rural Housing).

- **California Coalition for Rural Housing (CCRH)** provided support for community engagement with a perspective on adaptation project design elements for other geographies in the state for the Design Phase project. Through advocacy, organizing, research, and technical assistance, CCRH works to make the case for rural housing improvement and strengthening the capacity of the nonprofit and public sectors to provide affordable housing and related facilities.[14] CCRH created the first ever database of California jurisdictions with these policies in the late 2000s, which now includes more than 200 inclusionary housing, as well as housing impact and commercial linkage fee, programs throughout California. UC Davis CRC and CCRH partnered to transform this database into an interactive and searchable online database. For nearly 45 years, with support from more than 15 federal grants and 10 state research contracts, CCRH has provided training and technical assistance to local governments, Native American tribes, and community-based organizations on community-driven affordable housing and community development.

During the Design Phase, ConSol assembled a Technical Advisory Committee (TAC) consisting of the following participants:

- Erika Bumgardner – City of Woodland
- Melanie Mathews – Woodland Research & Technology Park
- Lon Hatamiya – The Hatamiya Group
- Conrad Asper – PG&E
- Karen Glitman – Center for Sustainable Energy
- Vance Jarrad – North State Building Industry Association

ConSol prepared the TAC meeting presentation and hosted a successful TAC meeting on January 25, 2023.

Selected Energy Technologies

The ConSol team's concept integrates the following key emerging energy technologies within a tiered resilience strategy:

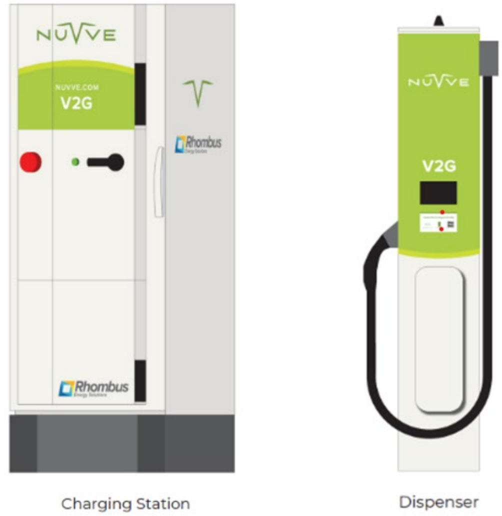
1. Nuvve's bidirectional charging stations to enable building power backup and grid service provision from the batteries in the complementary bidirectional EVs.
2. Envoy's EV car sharing program provides all residents with equitable access to affordable, on-demand, zero-emission vehicles.
3. SkySource's award-winning wood-to-energy deployed water (WEDEW) biomass power generates up to 50 kilowatts (kW) of power any time of day, providing a consistent power source to back up critical energy needs and using locally sourced biomass materials.

[14] California Coalition for Rural Housing. 2024. "About Us." Available at https://www.calruralhousing.org/about-us.

4. Swell's rooftop solar PV generation, parking lot canopy integrated bifacial PV generation, and centralized building battery energy storage.
5. ElectricFish's combined EV direct current fast charger (DCFC) units with integrated battery energy storage for faster charging capability and additional backup power.
6. Somfy's automated indoor window shades and controls for greater occupant comfort and utility bill reduction through HVAC energy savings.
7. Schneider Electric's proven microgrid controls for building and end-user load energy management and monitoring through grid-smart building controls.

Nuvve bidirectional charging stations feature an intelligent charging software system to enable both V2G resilience as well as demand response services (Figure 1). These V2G chargers are intentionally paired with Envoy's community-shared EV fleet, which is also bidirectionally capable. The project would install Nuvve's four bidirectional EV chargers, allowing the four Envoy community-shared EV car batteries to be used to optionally supply additional power to the buildings during peak hours, demand response events, or power outages. Twenty percent of all parking spaces will be Level 2 (L2) EV charging stations that respond to grid and building demand signals and are controlled by smart energy management software. All remaining parking spaces will feature a dedicated electrical circuit to support future build-out of L2 charging stations. The pre-installed vehicle chargers will reduce the key upfront cost of residential EV charging access and coupled with the time-of-use rate-based smart charging capabilities of the chargers, reduce the cost of charging EVs within the community.

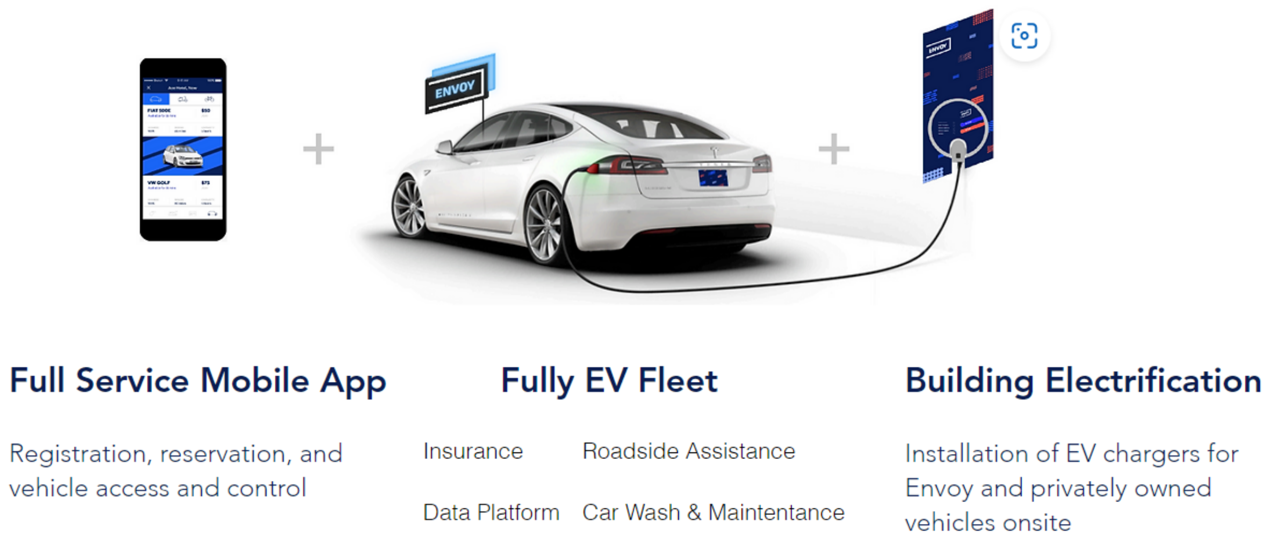
Figure 1: Nuvve Vehicle-to-Grid Bidirectional Charging Station



Source: Nuvve

Envoy's EV car sharing program would optionally provide all residents and non-residential visitors with equitable access to affordable and zero-emission vehicles (Figure 2). Envoy is a technology and mobility service company offering on-demand EVs as an amenity to the ConSol team's proposed multifamily community. Envoy equips real estate owners and operators with a new and innovative way to enhance the lifestyle of their tenants, members, and guests by providing a Mobility as an Amenity™ service, a platform that offers technology to reserve and access vehicles, driver insurance, maintenance, EV chargers, electric fleet, fleet maintenance, full-service mobile app, customer support, and robust analytics. Specific to this project, Envoy will offer affordable housing residents discounted pricing for the shared EV fleet. Envoy's pricing structure can be updated as conditions change and set in hourly intervals that will encourage use of the vehicle chargers during specific periods in the day and in response to grid support needs.

Figure 2: Envoy Electric Vehicle Car Sharing Service



Source: Envoy

The non-residential portion of the development would benefit from SkySource's WEDEW's carbon negative biomass power generation. SkySource's award winning WEDEW is a wood-to-energy deployment using local biomass, such as almond and cashew shells that would otherwise be discarded, as feedstock to generate 50 kW of indefinite critical and priority load power (Figure 3). WEDEW is a carbon negative technology that sequesters carbon in the ground. This innovative use of biomass aids in local forest management, reduces wildfire risk, and produces a bio-byproduct that will be returned to the soil as natural fertilizer. Specifically, WEDEW's byproduct is biochar, which can be mixed with soil to sequester GHGs from the atmosphere for hundreds of years. During a sustained power outage, the WEDEW can generate dispatchable power to complement on-site solar and energy storage to directly power residential and non-residential building areas.

Figure 3: SkySource Wood-to-Energy Deployed Water Biomass Unit

Source: David Hertz Architects (aka SkySource)

These emerging technologies would be coupled with on-site solar and load resilience through stationary battery energy storage deployed behind-the-meter of common/shared area loads, provided by Swell Energy. Swell's rooftop solar PV and centralized building level battery system would be enhanced by bifacial PV panels on the parking lot canopy integrated solar, capturing additional solar power generation from ground reflectance (Figure 4). Tier 1 critical load circuits would be prewired and routed to each residence and would be directly powered by microgrids during grid outages. Tier 2 priority loads in common/shared area loads would also be powered by the microgrid, which would provide multiple layers of critical and priority load resilience by the system design. The stationary storage in a combination of Swell's building level battery, ElectricFish battery-integrated DCFC units, and optionally the Nuvve and Envoy bidirectional electric vehicle supply equipment (EVSE) and EV fleet would also facilitate site peak load reduction and optimize demand response grid service capabilities during normal grid operation. Applicable innovative all-electric applications in the non-residential portion include the V2G charging stations, availability of EV car sharing, and applications of the WEDEW unit.

Figure 4: Swell Bifacial Photovoltaic Parking Canopy

Source: Swell Energy

ElectricFish, a company introduced to ConSol during the CEC's Technology Showcase, would provide two combined EV DCFC units coupled with integrated battery energy storage (Figure 5). This technology would be an innovative feature to the community, bringing a high-speed EV charging option up to 350 kW that can also provide backup power to the buildings, with each of the two units housing 350 kilowatt-hour (kWh) of energy storage. The total 700 kWh of energy storage provided by the two ElectricFish units would increase project-wide energy storage by 60 percent, allowing power to be backed up to the buildings for extended time during an outage.

Figure 5: ElectricFish Electric Vehicle DC Fast Charger

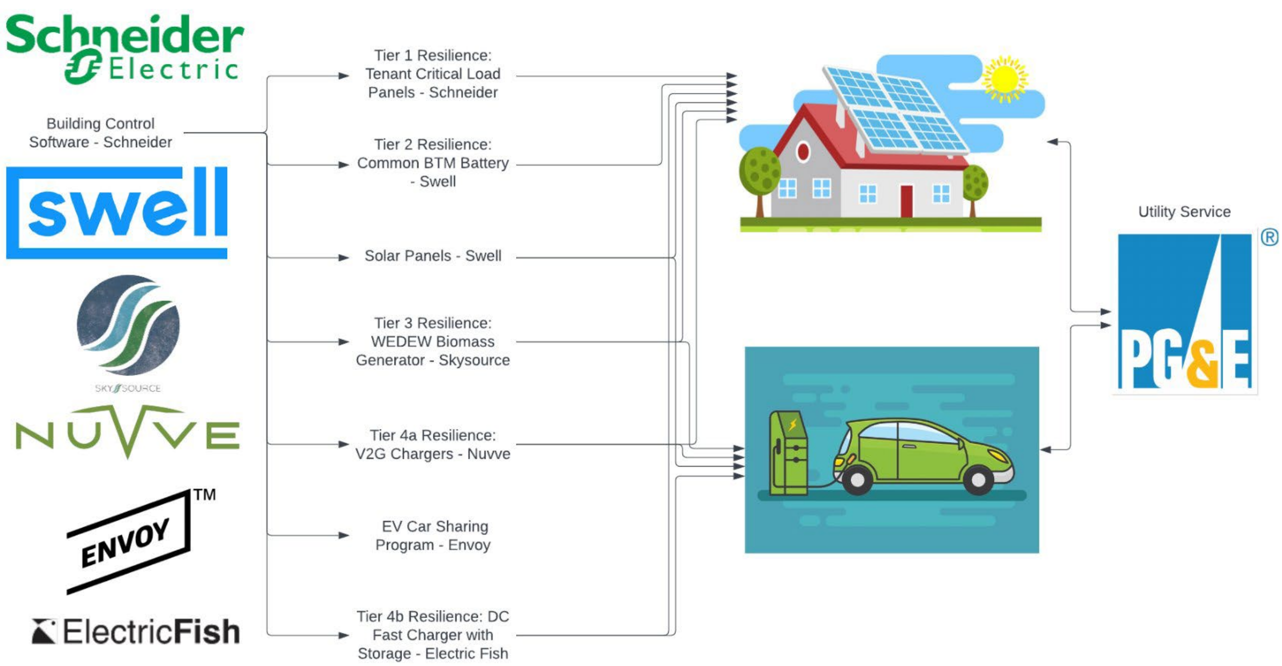
Source: ElectricFish

As an additional amenity feature for residents, Somfy would supply internal automated window shading units with the physical hardware (shade material, motors, controls) and automation software required for advanced control of the window shades. The shades can optionally operate on either a predetermined optimal schedule or based on sensors detecting environmental thresholds such as sunlight and room temperature. These automated shades would be installed on the west-facing windows of the mixed residential and commercial buildings to enable maximum energy savings by minimizing solar heat gain in warmer summer months during the afternoon and early evening. Residents would have the ability to selectively override the automated shades at any time or rely upon the automated or environmental conditions-based schedule. This automated shading technology would provide occupants with both improved comfort as well as utility bill savings from reduced HVAC energy usage.

Finally, Schneider Electric would design and provide building end-user load energy management and residential energy usage monitored through grid-smart building controls. The chosen control system for this project uses the "QBiX-Pro-WHLA8265H-A1," an industrial computer capable of using IEEE 2030.5, OpenADR 2.0b, and CTA-2045b protocols for building control. The CEC's Market Informed Demand Automation Server rates database responds to application programming interfaces requests with data in XML or JSON formats.

The ConSol team's proposed suite of technologies would allow the site to "island" from the PG&E grid utility, if necessary, during a power outage and reduce non-essential loads to extend backup power duration to critical loads in each unit and in common areas (Figures 6 and 7).

Figure 6: Energy Technologies Overview



Source: ConSol

Figure 7: Site Plan and Technology Integration

Source: BSB Design

Key Project Milestones

During the Design Phase, the project team completed critical milestones including the following:

- Design of the overall site plan
- Design of the building
- Incorporation of energy technologies into the site and building design
- Preparation of the Baseline and Optimized Use Cases
- Preparation of the Controls Hierarchy Diagram Design
- Preparation of the Building Funding Plan showing preliminary funding sources
- Preparation of the Technology Funding Plan identifying technology funding sources
- Community Outreach and Design Integration
- Preparation of the Draft Measurement and Verification Plan
- Woodland Research & Technology Park City Council Approval
- California Environmental Quality Act (CEQA) approval – Final Environmental Impact Report certified September 2023 including the project site (No additional CEQA approvals are required for this mixed-use affordable housing project.)
- Preparation of the initial site plan and preliminary designs to support entitlement process

The remaining critical milestones that would be completed during the Build Phase include the following:

- Entitlement of 3.3-acre site for site specific use
- Finalization of funding sources
- Preparation of site and construction drawings
- Coordination of infrastructure to site
- Buildout of on-site infrastructure
- Construction commencement (project construction estimated to start April 2026)

The following tasks outline activities and products that would be critical to accomplish should the project be built out in collaboration with the CEC.

TASK 1 TECHNOLOGY INSTALLATION AND COMMISSIONING

The goal of this task is to procure, install, and commission the emerging technologies on-site. The goal is to ensure that the construction, installation, and implementation are functioning per the project specifications and requirements.

Products:

- Delivery of Emerging Technology Infrastructure Plan (Draft and Final)
- Installation Summary Report (Final)
- Commissioning Plan (Draft and Final)
- Post Commissioning Handover Materials and User Guides (Final)

TASK 2 MEASUREMENT AND VERIFICATION

The goal of this task is to provide measurement and verification of the advanced energy features to demonstrate project performance and zero-emission operations.

Products:

- Final Verification Report (Draft and Final)

TASK 3 EVALUATION OF PROJECT BENEFITS

The goal of this task is to report the benefits resulting from this project.

Products:

- Kick-off Meeting Benefits Questionnaire
- Midterm Benefits Questionnaire
- Final Meeting Benefits Questionnaire

TASK 4 TECHNOLOGY/KNOWLEDGE TRANSFER ACTIVITIES

The goal of this task is to ensure the technological learning that results from the project is captured and disseminated to the range of professions that will be responsible for future deployments of this technology or similar technologies.

Products:

- Project Case Study Plan (Draft and Final)
- Summary of TAC Comments
- Project Case Study (Draft and Final)
- High Quality Digital Photographs
- Two-page marketing brief of emerging technologies

Architectural Designs, Aesthetics, and Functionality

Novel Features and Form Factors

The project team carefully incorporated the emerging energy technologies and, to the greatest extent possible, these technologies would be sited in appropriate locations that enhance the building's overall aesthetics and functionality. For example, the SkySource WEDEW biomass generation container would be located at the southeast corner of the site to minimize conflict with the remainder of the development and minimize impact on the building residents. The WEDEW biomass generation container would also be located strategically near one of the entrances to the project site, allowing for easy access for vehicles bringing organic biomass feedstock materials to be upcycled as fuel. The container is designed attractively, and its low-key signage would indicate its capability to produce electricity from these locally sourced biomass materials.

The building and parking PV structures were sited to maximize the amount of PV power generated. The siting of the building also maximums the effectiveness of the Somfy motorized window shades and blinds. The Somfy shades are also attractive and available in different styles and finishes.

The ElectricFish's battery-integrated DCFC units would be located conveniently in the middle of the parking lot to provide easy accessibility for drivers charging their vehicles. These chargers are visually attractive, offer exceptionally high charging speeds up to 350 kW, and their presence would tell residents and visitors this development is intended to be highly sustainable. The Envoy shared EV fleet would embody the ethos and practice of a community-based zero-emission transportation future. Much of the additional emerging technology would be blended into the existing building and area architecture, maximizing intentional visibility and the demonstration of clean energy technologies, such as the rooftop and carport bifacial PV structures, interior automated window shading, and highly visible and accessible EV charging units (Figures 8, 9, and 10).

Figure 8: Aerial View Renderings

Source: BSB Design

Figure 9: Exterior Elevation

Source: BSB Design

Figure 10: Vignettes

Source: BSB Design

Architectural Design Features to Improve Sustainability and Aesthetics

Cognizant of the local climate, the design team incorporated passive design features to maintain comfortable residential temperatures, including the following:

- The orientation of the building and parking shade structures maximizes sustainability by maximizing PV production.
- Somfy motorized window shades and blinds significantly reduce energy usage.
- The incorporation of a higher glazing standard reduces energy usage.
- The use of one-inch thermal break foam reduces energy usage as well as provides the ability to create design features.
- A tree canopy with a goal of 50 percent coverage provides shade throughout the entire parking lot.

Design Strategies for Integrating Conventional and Emerging Energy Technologies

End-Use Energy Efficiency

Domestic Hot Water

The baseline construction for an all-electric code compliant home in Climate Zone (CZ) 12 features a 50-gallon, 3.42 Uniform Energy Factor Northwest Energy Efficiency Alliance Tier 3 Heat Pump Water Heater (HPWH) that is significantly more efficient than gas or electric resistance heating. To improve upon that, a 3.88 Uniform Energy Factor Northwest Energy Efficiency Alliance Tier 4 HPWH was selected for the high savings scenario.

Cooking

Induction stove tops were selected given the small (5 to 10 percent) increase in efficiency above electric resistance stovetops and the increased heating speed during use. With an induction stove, the cooktop surface itself is not heated, reducing the chance of accidental burns from the stove. A factor of this decision that may be potentially significant to tenants is that not all cookware, such as aluminum, copper, and glass can be used with an induction stove. The cookware must be ferrous or magnetically responsive to function on an induction stove.

HVAC

The HVAC systems to be used in this building are all high-efficiency heat pumps. The baseline technology considered was a 15 seasonal energy efficiency ratio (SEER) heat pump; whereas, the high savings scenario incorporated up to 22.7 SEER for the heat pumps installed for one-bedroom apartments. Two-bedroom apartments and the common areas use a different line of heat pumps that offers up to 22.5 SEER. These models feature greater heating efficiency at colder temperatures than the baseline heat pumps, mitigating some of the winter peak issues attributable to morning heating loads that would otherwise require higher-energy-consuming resistance heating.

Process/Miscellaneous Load

Designers have little control over plug loads that can be used within a project. To encourage efficient usage at the plug level, every unit would be provided smart power strips that allow tenants to monitor their power usage. Appliance loads would be addressed by providing each unit with an ENERGY STAR-rated refrigerator. Peak loads for appliances are also mitigated by the design decision to have a shared laundry room as opposed to in-unit machines. The automated shading provided to west-facing rooms adds a minor load when the motors are used, but this drawback would be far outweighed by the benefit of reduced unit-level HVAC costs.

Renewables and Storage

Solar installed on the rooftop and parking canopy would reach 371 kW. Swell would be providing bifacial PV panels for the car parking canopies, allowing them to generate energy from both sides of the panels.

The battery energy storage system (BESS) would provide 1,170 kWh of storage that can be delivered at 360 kW. This would be supplemented by two ElectricFish units (350 kWh each at 100 kW) and four V2G EVs capable of storing 60 kWh each. This totals 2,110 kWh energy storage.

The SkySource WEDEW unit offers up to 50 kW of power generation that is net carbon negative, given the production of biochar in the pyrolysis process. A quantity of 0.84-kilogram (kg) CO2e is sequestered per kg of biomass input based upon biochar associated sequestration. This technology would be key in helping the project reach its carbon negative goal.

When these generation and storage assets are combined with Schneider’s building controls, the proposed building can adapt to changing conditions and achieve long duration resilience to power outages (unlimited resilience duration and power delivery for Tier 1 critical and Tier 2 priority loads).

Load Flexibility, Grid Interactions, and Residents’ Engagement

Demand Flexibility (Load Shedding and Load Shifting)

Schneider Electric’s contribution to the project involved building control software and hardware that enables load shedding and load shifting. The main load shifting feature would be HVAC pre-cooling. This would allow the HVAC system to run for additional time during off-peak hours in exchange for reduced HVAC usage during peak hours, when energy is more expensive and carbon intensive. The California Building Energy Code Compliance for Residential Buildings (CBECC-Res) software does not facilitate simulation of this kind of technology, and so this technology was not incorporated into the energy modeling.

Somfy's automated shading technology would be incorporated into west-facing windows to reduce HVAC costs. However, CBECC-Res does not facilitate selectively using this technology on only one face of the building. As such, the contribution from this technology was not incorporated quantitatively into the energy modeling.

Load shedding would be performed in response to grid conditions and the amount of energy stored in the central building battery system and ElectricFish DCFC battery units. Initially, during a power outage, load shedding would be accomplished by loosening HVAC setpoints (decreasing heating setpoint and increasing cooling setpoint), lowering hot water heating setpoints, and throttling down output from vehicle chargers to increase islanding duration. If the total battery storage would reach critically low levels, then an additional tier of load shedding would be used that shuts off power to everything except the "critical load panel" prewired in each tenant unit, which would enable each tenant to keep power running for their refrigerator and select plug loads for charging phones/laptops and operating personal medical devices. Up to 25 percent of simulated electrical loads, which account for Tier 1 critical load (10 percent) and Tier 2 priority load (25 percent), including EV charging, could be sustained in perpetuity with energy storage, solar, and biomass generation.

Upon restoration of grid power, the microgrid would automatically reconnect to the main grid and restore full power for all energy loads.

Microgrid Design Strategy

ConSol's project specific performance metrics set a minimum target performance of 24 hours resilient backup power and a goal target performance of 48 hours resilient backup power. This mixed-use design achieved an unprecedented milestone of unlimited Tier 1 (10 percent) critical load and unlimited Tier 2 (25 percent) priority load resilient backup power through the design and capabilities of the community microgrid. During normal grid operations, Schneider's microgrid and building load controls would coordinate with Swell's GridAmp platform to enable the site to participate in a VPP or other load aggregation such as a demand response program. By participating in such a program through the investor-owned utility or independent system operator, the community would be able to earn ongoing revenue as well as take part in any rate arbitrage that may be available depending on their rate plan. Additionally, the community would contribute to grid security for the surrounding area.

The microgrid would island in the event of an outage, continuing to power the building from its first layer of resilience using the centralized 1,170-kWh battery system, which would recharge from the 371-kW rooftop and parking canopy bifacial solar when available and the 50-kW biomass generator power when solar would be unavailable. The second layer of resilience would be the additional 700-kWh energy reserve in the battery-integrated 350-kW DCFC units. Finally, the third layer of 240-kWh energy resilience would be available from the batteries in the fleet of four bidirectional EVs coupled with bidirectional EV chargers. During an outage, the Tier 1 and Tier 2 loads would be prioritized so grid services would be deferred until the grid is restored.

Schneider's microgrid and building load controls platform would coordinate and optimize all site energy assets to maximize site bill savings, provide grid services, and ensure the community would remain fully Tier 1 critical load and Tier 1 priority load resilient during grid outages.

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

Electric Vehicle Charging and V2G

Envoy would provide four Nissan Leaf EVs (or similar) that can take advantage of the bidirectional chargers provided by Nuvve. These four vehicles would provide at least 240 kWh of energy that could be used for backup power. These four vehicles would have access to 100 kW EV chargers capable of providing V2G/vehicle-to-building (V2B) power. The storage capacity of these vehicles was not incorporated into the quantitative energy analysis, given the uncertainty on whether they would be used or not. The two ElectricFish DCFC units would be able to provide energy back to the building at 100 kW from each of their 350 kWh of storage. The project would feature 130 parking spots, and 20 of those spots would be covered by L2, 7.2 kW units.

The projected charging load was based upon the assumption that on average each ElectricFish unit would charge two 60 kWh EVs to full every day, and that the 24 other chargers would use 10 kWh a day, based on a 30-mile daily use assumption and 3 miles/kWh efficiency.

Envelope

Table 1, an excerpt from the Energy and Emissions Performance Workbook, indicates the conventional envelope changes that were altered in the high savings scenario to improve efficiency. The R16 exterior wall sheathing, triple-pane windows, and R-60 ceiling insulation would make the building envelope more efficient to operate.

Table 1: Envelope Base Case Versus High Savings

Envelope	Base Case	High Savings
Exterior Walls:	2x6 studs with R-21 cavity insulation	2x6 studs with R-21 cavity + R16 Sheathing
Windows:	Window area: 18% of Wall area	Window area: 18% of Wall area
U-factor	0.3	0.2
SHGC	0.23	0.21
Cathedral Ceilings:	R-49 insulation	R-60 insulation

SHGE = solar heat gain coefficient
Source: ConSol

The high savings scenario also features an energy saving automated shade control and heavier interior shades, which could save up to 5 percent on heating and cooling energy use if installed on all windows in the project. However, the project was planned to only use this technology on west-facing windows. CBECC-Res does not allow the modeler to be this specific about window treatments. As such, this technology's contribution was excluded from the main analysis on energy savings.

Advanced Construction Planning and Practices

Advanced Planning, Design, and Construction Methods

ConSol technology partners and builder/architect team explored several areas during the Design Phase, including advanced planning, design, and construction methods to pursue for this project. For example, roof-located HVAC equipment would be designed in a way to facilitate a flat, open area to streamline the time and cost of installing the solar. The conduit/wire chase way would be straight vertically from the roof to the main electrical room to minimize the run. The design would include an electrical closet or covered space on the roof that would be protected from the environment and have excellent airflow by junction boxes, inverters, and disconnect switches installed on the north side of the building to minimize heat loading. The energy storage equipment would be installed on the ground floor, in the main electrical room where the common area electrical bus and utility meters would be located with easy access to critical load panels and electrical infrastructure.

The team also reviewed the new construction design details, including building orientation, roof slope, and shading to ease installation, maximize performance, and facilitate maintenance of the solar arrays. Optimal roofing materials would be reviewed and selected to minimize the cost of the solar installation and operating efficiency (minimizing heat). Further, at the time of building construction, minimizing the amount of non-solar rooftop equipment would maximize the available area for installing the solar PV system. Cost savings would be achieved by the builders installing any required penetrating hardware for the solar when the roof is installed. Where the PV electrical equipment (including the inverter, other balance of system components, and safety equipment) would be located at the north side of the building, and how the equipment would be configured, would be integrated into the roof design process.

The design team used Rivet software, which integrates architectural design with the structural, mechanical, electrical, plumbing, and engineering considerations. This allowed for an integrated approach to design and engineering and was critical in efficiently integrating the new energy technologies into the building design and construction.

Construction Time and Cost Savings

During the Design Phase, the team analyzed, tracked, compared, and capitalized on cost and time savings from advanced planning and design techniques based on referencing as-built costs and schedules from relevant team members' past projects. For example, designing the rooftop equipment installation, including the HVAC, to provide a flat, open area was projected to streamline installation of the solar arrays and thus yield construction time and cost savings.

Strategies and Materials to Reduce Embedded Emissions

The development team would strive to achieve the highest building sustainability level possible through carefully considered design and construction methods. Eco-friendly materials (recycled, low volatile organic compounds) would be used for key components of construction (for example, flooring, countertops, doors, roofing, windows, water flow, and exterior building envelope). Rooftop- and carport-mounted solar PV systems and solar thermal systems for hot water would be implemented. A predominantly local subcontractor team would be used to reduce emissions from travel and fabrication. Similar methods were used to reach a Leadership in Energy and Environmental Design Gold sustainability level of new construction on the 16 Powerhouse mixed use project in Midtown Sacramento by the team's builder/ architect group. The team would use the Embodied Carbon in Construction Calculator (EC3) to evaluate and optimally select building materials.

The Woodland Research & Technology Park Plan Area, through its recently adopted development policies and standards, would play an important role in furthering the City of Woodland's GHG reduction goals. The plan strives for zero net energy consumption as outlined in the city's 2035 Climate Action Plan. The city's Climate Action Plan provides strategies and tools for addressing GHG emissions from development and aims to reduce Woodland's GHG emissions by 2020 and 2035, which is consistent with the targets of the State of California.

Market Transformation

Broader Adoption of Emerging Energy Technologies

The project plan fully aligns with the zero energy goals/CALGreen Tier 1 and GHG reduction goals of the local community, as well as the California Roadmap to Decarbonize California Buildings.[15] Specifically, the proposed design would address recognized pathways to accelerate decarbonization of new buildings by doing the following:

- Increasing awareness and interest among customers and builders: For customers, a user-friendly interface, automated, and cost-effective energy management that was tested during community charrettes would exponentially increase consumer interest in the benefits of clean energy consumption. From a builder's perspective, this project would be fully coordinated between local government and private sectors with a collective goal of 100 percent decarbonization. The implementation of the proposed project design would serve as a case study for future builders and developers to create efficient, cost-effective, and exciting designs that deliver occupant comfort, decrease costs, and advance California state housing and clean energy initiatives. To promote broader awareness and adoption, the project team would coordinate project tours with the California Building Industry Association's 3,500+ member companies.
- Improving availability of decarbonization solutions: This project would bring to market some of the most cutting-edge designs in decarbonization and energy efficiency and integrate these technologies as a holistic solution set. The project would serve as a demonstration of how these important objectives can be effectively and affordably accomplished, thereby stimulating wider adoption. A key project deliverable would be to share insights, knowledge, and lessons learned to public sector and industry stakeholders to drive greater awareness of these solutions.

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[15] Building Decarbonization Coalition staff. 2019. *A Roadmap to Decarbonize California Buildings*. Available at https://www.gridworks.org/wp-content/uploads/2019/02/BDC_Roadmap_final_online.pdf.

This project would demonstrate the efficacy, scalability, and ease of adoption of several solutions and economic opportunity interventions, including but not limited to the following:

- Mixed-use residential housing within easy access to a research park location
- Strategic alignment with continuing education and higher education
- Multi-tiered resilience and energy load management and safety with significant end-user control
- EV sharing as a community amenity, grid resource, and resilience layer
- Expansive and varied EV charging options for residents and visitors alike

Transition of One-Off Bespoke Model to a Scalable Model

The project team tailored this specific design solution to the predominantly agricultural nature of the Woodland community. Great importance was placed on the sustainability elements of the project that were chosen not only for their production capabilities, but also positive byproducts such as soil enrichment. Each commercially available and pre-commercial technology selected for the project was orchestrated in a novel, scalable, and resilient manner through energy automation and controls. The project approach was designed for technical and economic reproducibility, leveraging the selected technologies suitable for this community while designing for flexible alternate distributed energy resources depending on the climate, topographies, community, and space constraints of future projects. Once all incentives are accounted for, the cost to the developer to build the proposed design would only be about $315,000 more than the minimally Title 24-compliant baseline design.

The true innovation of the proposed project is the emphasis on the implementation of flexible load management controls that would maximize use of the on-site clean energy. The project would provide vital technology integration and demonstration data that would be studied, analyzed, and disseminated by the project team's consortium of university, new construction builder, local business, city, county, and regional public and not-for-profit partners to create new best practices to achieve goals identified by the CEC.

Ownership and Operation Financing Strategies

During the Design Phase, the project team sought out additional sources for funding/ incentives and cost savings from federal, state, utility, and other programs.

Swell's financing products were determined to be effective financing tools for Swell deployed battery storage and solar generation systems to take advantage of state incentive programs, such as the Self-Generation Incentive Program and Solar on Multifamily Affordable Housing, and federal incentive programs such as Investment Tax Credit. Additionally, the central battery system could be a source of grid services revenue as a part of utility VPP programs. The combination of the above would result in bill savings for residents and bill savings for the building owner for the common area electrical meter of the development. Incorporating the Self-Generation Incentive Program, Solar on Multifamily Affordable Housing, Investment Tax Credit and other incentives, Swell is able to offer a combination of competitive lease, loan, power purchase agreement, direct purchase, and/or VPP options for both the building owner and residents to receive the lowest possible cost of electricity. The building owner would have the option to decide which financial transaction pathway is most economically beneficial. ConSol's calculations show that residents will pay on average $35 per month electricity bills as a result of Swell's on-site PV solar power generation, energy storage, and the balance of microgrid system component operations that optimize for both economics and resilience.

The Envoy EV car share program would enable residents full access to EVs without the upfront and ongoing cost of ownership. A special discounted rate would be provided for these affordable housing community members, and the Envoy car share program would simultaneously generate an estimated $3,000 revenue per month for the building owners and eventually recoup the capital expense. The ElectricFish 350-kW DCFC units and the 20 additional L2 chargers on site could optionally be pay-for-use by community members and/or visitors, generating further revenue to improve the economics, scalability, and replicability of this combined approach in other new construction affordable housing communities in California.

Plug-and-Play Standards

The team would use open standards, including OpenADR 2.0b, to provide a plug-and-play, scalable solution. In addition, the Envoy community-shared EVs coupled with Nuvve's 100-kW V2G bidirectional chargers, and the expanded EVSE access with two ElectricFish 350-kW DCFC units and 20 additional L2 EV chargers, would be plug-and-play amenities for the residents. The microgrid and building load controls energy automation by Schneider Electric and the automated window shading by Somfy would be "beyond" plug-and-play since they would operate automatically for the benefit of tenants.

New Technology Adoption Contingency

ConSol's team of technology partners are leaders in their respective fields, with demonstrated success deploying and advancing solutions for solar, storage, automation controls, microgrids, demand response, grid service programs, load management, multi-technology integration, EV charging, and EV car sharing. Furthermore, ConSol's team of builders and architects are veterans in constructing innovative, energy efficient mixed use, and other properties under California's stringent building codes. In addition, the maturity of key technology elements including solar, storage, and EV charging benefit the scalability, market transformation, and plug-and-play needs of the project. These components are well vetted in multiple applications across the globe and have multiple manufacturers. Throughout the Design Phase, ConSol led risk identification and quantification for adopting each technology. ConSol engaged external advisors and stakeholders, including PG&E, to provide feedback and document results at each milestone.

Community Engagement

Community Input

ConSol's Design Phase partners, the CRC, and the CCRH led community engagement activities related to the design development phase. The project team completed the following community engagement activities and incorporated the resulting feedback into the final design:

- Public meetings with the City of Woodland staff members, Planning Commission, and City Council.
- The Woodland City Council's unanimous approval of the ConSol's community design on September 5, 2023.
- Follow-up neighborhood/stakeholder meetings consistent with Woodland Research & Technology Park Specific Plan community outreach and entitlement process 2020-2023.
- Development, marketing, and implementation of the community engagement survey.
- Development and implementation of stakeholder interviews with local government officials and community groups.
- Development and implementation of the Public Community Forum held on June 12, 2023.

The team's key major activities derived from the successful community engagement activities included the following:

- Successfully responded to the community's input regarding the need for larger family units.
- Redesigned the buildings to include both one- and two-bedroom apartments, which allows the team to market the two-bedroom units as "family units."
- Redesigned the project to be more competitive in obtaining affordable housing funding.
- Redesigned a portion of the units to provide a "live-work" space for the residents.
- Designed and incorporated a community room and children's play area.
- Designed and incorporated community spaces for identified needs such as a rural health clinic, educational and vocational training, workspace, classes for residents and community members, and a potential childcare facility.

The CRC and CCRH conducted a community engagement survey, held one-to-one interviews with representatives from the Woodland community, and held a community-based focus group to solicit feedback regarding the design and integrated technologies. The questions in the survey were developed to get a baseline for the level of understanding that Yolo County residents have for potential energy efficiency and other green features that the project team considered, including in the planning and design phase as well as behaviors and decision-making that further informed the design. Most notably, the survey captured feedback surrounding the topic of apartment types and spaces in the community. The initial findings showed that community members were interested in units for families rather than individuals.

Based on the community feedback, the design team reconfigured the apartments to include both one- and two-bedroom units, rather than studio and one-bedroom units, addressing the market and community need for affordable family and individual units.

Additional findings from the surveys, interviews, and focus groups included the following, which the project team worked to provide solutions for in the design:

- More than half of the respondents wanted places to work, including co-working areas, office spaces, and live-work spaces. Co-working space and live-work units were incorporated into the project.
- There was interest in community rooms and children's outdoor play areas. A community room and children's play area were included in the project.
- Nearly 75 percent of respondents had experienced power outages lasting one day long. Less than 10 percent of respondents had experienced power outages lasting more than one day. Tremendous energy resiliency was built into the project, capable of delivering unlimited Tier 1 critical loads to each residential unit and unlimited Tier 2 priority loads to the common areas.
- More than half of the respondents named costs as the barrier to having all the energy efficiency features they would like. The project design incorporated high-energy-efficiency amenities, including induction range tops, triple-pane windows, Somfy's automated interior window shading, minimum 16 SEER heat pumps with communicating thermostats, Northwest Energy Efficiency Alliance Tier 3 or 4 demand response-capable heat pump water heaters with thermostatic mixing valves for thermal storage, and ENERGY STAR-certified heat pump space heating and cooling.
- The largest number of respondents were interested in hybrid or EVs. However, there were several popular options, including carpooling, biking, using Transportation Network Companies such as Uber or Lyft, transit, and micro-mobility options. Affordable community EV car sharing through Envoy will be available to all project residents, in addition to two 350-kW DCFC units from ElectricFish, four 100-kW bidirectional V2G chargers from Nuvve, 20 additional L2 EV chargers throughout the property, and all remaining parking spaces pre-wired for future EVSE installation.
- The Woodland community has a broad and diverse housing need, with more than 50 percent Hispanic population that includes families, farmworkers, and an aging population. The project is 100 percent affordable housing, and more than 50 percent of the units are two-bedroom, specifically designed for families. This complex was designed specifically with 59 one-bedroom and 71 two-bedroom units to address this need.

Professionals and practitioners interested in the detailed survey findings are encouraged to reach out for a copy of the interim project reports and project deliverables. Project deliverables, including interim project reports, are available upon request by submitting an email to pubs@energy.ca.gov.

Addressing Gentrification

All 130 of the multifamily residential units were designed to be affordable to a range of low- and very low-income (40 percent to 60 percent area median income) households, being 50 percent low-income units and 50 percent very low-income units. This project is consistent with the City of Woodland's recently adopted General Plan that requires additional affordable housing in the city. The 130 affordable housing units proposed for this project would provide more than 80 percent of the city's goal of 160 affordable units for the entire Woodland Research & Technology Park.

Envoy's EV car sharing program would provide all residents with equitable and affordable access to zero-emission vehicles. Envoy's car sharing platform is accessible via an iOS/Android app to provide on-demand EVs, and potentially electric bicycles and electric scooters in the future.

Numerous community and government stakeholders have already expressed interest and voiced support for this project, including the following:

- City of Woodland
- Yolo County
- Yolo County Housing Authority
- Legal Services of Northern California
- Sacramento Housing Alliance
- Woodland Research & Technology Park
- Woodland Chamber of Commerce
- Yolo County Board of Realtors

In Yolo County, 9,756 low-income renter households do not have access to an affordable home. Furthermore, 80 percent of extremely low-income (15 to 30 percent area median income) households are paying more than half of their income on housing costs compared to just 1 percent of moderate-income households. Asking rents for multifamily rental homes have increased by 15 percent between 2018 and 2022.

Also, state funding for Yolo County decreased 26 percent and federal funding decreased 52 percent for housing production and preservation from fiscal year 2008-09 to fiscal year 2018-19. Jurisdictions in Yolo County are behind in meeting their fifth cycle Regional Housing Needs Assessment Allocation production goals for all income groups.

This project is consistent with the city's identified needs for affordable housing at a location already designated for this type of use. The City of Woodland, along with all other California cities and counties, is required to adequately plan to meet the housing needs of everyone in the community. The city is currently updating the Housing Element for this next eight-year span. The city's Regional Housing Needs Assessment Allocation target for the 2021-2029 planning period is 3,087 new residential units. Of these, 34.4 percent (1,062 units) are allocated to very low-income and low-income households. This proposed development would address approximately 10 percent of this allocation.

The Draft Housing Element also specifically addresses two Fair Housing issues that the city intends to address, including disparities in access to opportunity and displacement risk, with a variety of implementation programs that complement this proposed affordable housing development. During the community engagement process, the CRC and CCRH identified specific community needs and ways the development could meet these needs in collaboration with civic and community partners, such as the City of Woodland, Yolo County Housing Authority, Legal Services of Northern California, Yolo County Health and Human Services Agency, UC Cooperative Extension, Yolo Food Bank, and The Bike Campaign, among others.

Positive Impacts on Local Community

This project is consistent with the City of Woodland's General Plan and the Woodland Research & Technology Park Specific Plan for this site. The project co-developer, The Hodgson Company, as developer of the Woodland Research & Technology Park, has already participated in extensive public outreach, including participating in more than 20 community meetings as well as numerous Planning Commission and City Council meetings. Through this outreach, the city has identified the needs and visions of the community and included them in both the recent adoption of its General Plan as well as the adoption of the Woodland Research & Technology Park's Specific Plan. Similar outreach for public input was conducted to determine uses for the non-residential spaces. The residents and commercial users of this project would be able to enjoy the myriad benefits of a master-planned community that emphasizes walking, biking, connectivity, and sustainability. The project would be part of a master-planned mixed-use plan that would create more than 5,000 new well-paying jobs through the development of a research park campus emphasizing advanced technologies.

In addition to the importance of providing 130 affordable housing units to the Woodland community, the project would provide walkable and bikeable proximity to the projected 5,000 new jobs in the Woodland Research & Technology Park. The Woodland Research & Technology Park is focused on sustainability, energy efficiency, and cutting-edge technology. The local community would also benefit from reduced emissions and better air quality through its design as an all-electric development, with Title 24-compliant solar plus energy storage from Swell, the inclusion of Envoy's EV car sharing program, powered by Nuvve V2G charging stations, ElectricFish's DCFC units, Somfy's automated window shading, and SkySource's WEDEW biomass generation technology.

Workforce Development

The project team's proposed mixed-use development is situated within The Woodland Research & Technology Park, an approved 351-acre scientific research park and residential community consisting of 2.2 million square feet of commercial, office, and retail buildings intended for local job creation (Figure 11). It is estimated that up to 5,000 jobs will be created by the Woodland Research & Technology Park, providing employment opportunities for residents in the mixed-use development and in the surrounding community. This mixed-use, affordable housing project would feature space for educational and vocational classes provided in conjunction with UC Davis, Woodland Community College, and the local school district. This training would be focused on jobs related to agricultural technologies and practices needed in Woodland and surrounding communities. The 130-unit community would also include live-work units on the ground floor of the building. This would allow residents the opportunity to work and live in the same location without needing to rent office space. The community would also provide spaces for identified needs such as a rural health clinic, educational and vocational training, workspace, classes for residents and community members, and a potential childcare facility. All these commercial uses could also provide additional job opportunities for the community.

Figure 11: The Woodland Research & Technology Park

Source: BSB Design

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

The community would have 371 kW of rooftop and bifacial parking canopy solar PV, 1170 kWh of centralized building battery energy storage, 50 kW of dispatchable biomass power generation, two 350-kW DCFC units with 700-kWh additional battery energy storage, four 100-kW bidirectional V2G EV chargers, four bidirectionally capable community-shared EVs, 20 additional L2 EV chargers, parking with all parking spaces prewired for future EV chargers, interior automated window shading, smart thermostats and HPWHs that are all demand response capable, and a central microgrid and building loads control platform to efficiently and economically optimize the operations of all these site amenities. Each resident will have access to the Envoy community-shared EV fleet, demand responsive in-unit smart thermostats and heat pump water heating, and Somfy's automated window shading capable of both demand response and environmental condition-based operation.

Affordable housing financing from the city's affordable housing funding program was planned to be used for this $64 million project. In addition, California's Building Initiative for Low-Emissions Development Program, Self-Generation Incentive Program, and Solar on Multifamily Affordable Housing Program; the Investment Tax Credit of the Federal Inflation Reduction Act; the Federal High-Efficiency Electric Home Rebate Act; and other incentives would amass to deliver more than $4.7 million in capital cost savings for the advanced clean energy and energy efficiency technologies.

CHAPTER 3: Results

Design Challenges

Technical Barriers and Challenges

One of the major challenges in developing the mixed-use multitenant building design was in designing and packaging the innovative and unconventional technologies incorporated into the architecture and design plans. For example, the WEDEW biomass unit has design requirements expanding beyond its physical footprint on the property. Depending on frequency of use of the biomass generator, a truck would also need to visit regularly to drop off feedstock. The design team strategically positioned the WEDEW unit to accommodate the truck traffic for safety and efficiency. The WEDEW would also be positioned near a secondary entrance to the development to minimize the impact of commercial vehicle traffic on the parking lot. For the WEDEW unit to provide a consistent source of backup power generation, the device must be filled with 50 kg of locally sourced biomass every hour to provide 50 kW of power. This would require dedicated staff to feed the machine on a timely schedule. Failure to do so can result in less available backup power generation.

Another challenge was in the packaging of the solar equipment. With 371 kW of solar in the specifications for the proposed design, some creativity in the packaging was required. Dual-sided PV structures, which feature a higher wattage per square foot, would be installed on the parking canopies in addition to conventional PV structure installed on the roof. The solar panels do not generate as much energy during months with high heating loads. Given that, the microgrid would be less resilient to power outages during winter months. A full state of charge on the battery system would allow riding through a single day, but multi-day islanding would be exclusive to summer months.

One of the most difficult design challenges was in sizing the batteries to meet the resilience goals of the project. Ensuring that Tier 2 loads could be met indefinitely was a major priority. Even without access to renewable generation, the battery system could run 25 percent (Tier 2 loads) of building loads for more than 3.5 days. Once renewable generation was added to the battery's resilience calculation, the building was projected to sustain Tier 2 loads indefinitely.

The main drivers to meet the performance metrics goals included stakeholder input, cost-effectiveness, resilience, energy efficiency, and demand reduction. The types of units planned for construction were chosen due to community feedback. Initially, studio and one-bedroom units were planned. However, community stakeholders identified apartments suitable for families as a major need, so two-bedroom units were incorporated into the design.

The technology and envelope features incorporated into the design were based on meeting and exceeding resiliency, efficiency, peak reduction, and cost reduction goals. The design takes full advantage of a range of state and federal incentives that mitigate the cost of big-ticket items such as the 2+ MWh of battery storage, 371 kW of solar, high-efficiency HVAC, and the 50-kW biomass generator. The design pushed further above code requirements in areas that are well served with incentives. For example, there were no available incentives for above-code windows. As such, the design only used skinny triple-pane windows. Had sufficient incentives been available, more advanced options (R10+) may have been an option. On the other hand, significant incentives were available for above-code heat pump units and the price (to the builder) is below installing baseline code compliant heat pumps.

The outcome of the challenges and ensuing decisions was a cutting-edge design that pushes industry boundaries along a variety of design parameters, including envelope, HVAC efficiency, self-generation, EV charging, battery storage, and microgrid resilience. How far boundaries were pushed in each direction was primarily informed by the availability of additional state and federal funding and tax credits. The high degree of efficiency and energy self-generation resulted in low energy bills ($25 per unit per month). This was a high priority for the design, given that the project would be entirely inhabited by low-income residents. Residents will also have access to affordable EV transportation options and access to a range of EV charging options.

As the project has not been built yet, an analytical process was required to evaluate the cost and benefits from this concept design project. This process required thorough investigation of technology capital cost (and cost defraying through grants), energy savings as evaluated via CBECC-Res and ConSol's proprietary Load Profile Generator Excel workbook. The Load Profile Generator tool uses CBECC-Res output and allows for freely adjusting self-generation capacity (solar and biomass), EV charging loads, and battery capacity. This tool allowed for experimentally determining the sizing for self-generation and energy storage required to meet resilience goals. The financial savings from energy efficiency, self-generation, and on-site energy storage were rigorously evaluated by applying time-of-use rates to the hourly energy consumption values estimated from the CBECC-Res and the Load Profile Generator workflow.

Market and Policy Barriers

One of the market barrier challenges during the Design Phase was the inclusion and design of revenue-producing spaces with two or more uses to meet the Solicitation definition of mixed-use establishments. Using the community-based feedback during the Design Phase, the project team focused on designing the revenue-producing spaces to include the following:

1. Community room space(s) such as:
    a. Rural health clinic
    b. Educational/vocational training classrooms for residents and potentially other community members
    c. A childcare facility
2. Work-live units as ground floor units on the west side of the larger building

Another market barrier challenge that the project team encountered was the option of designing the plans with an in-unit battery provider for another tier of backup power. ConSol ultimately made the decision to forego this idea because of the inability for the provider to produce enough units within the project's proposed timeframe. It was also discovered that a lower quantity of larger batteries in a storage space is generally more cost effective.

The project team also encountered several policy barriers. The project team and its subcontractor partners identified that the California Public Utilities Commission's recent net energy metering (NEM) 3.0 decisions will have direct and as-yet-unknown impact on the energy economics of the community. This topic would continue to be monitored and evaluated during a build-out. The project chose to model the building performance using NEM 3.0 values for a conservative analysis based on the uncertainty of NEM 2.0.

The interconnection rights that the project site utility provider may or may not be able to provide was another uncertainty and policy barrier the project discovered during the Build Phase competition presentation. The CEC reviewers brought up the challenge that the utility provider may not allow the project to interconnect in the way assumed in the energy usage and storage simulations. Discussing this issue with the utility provider is more suited to a "Build Phase" conversation.

Lastly, another challenge was encountered during the energy use modeling phase of the proposed mixed-use development. ConSol has a long history of using CBECC's residential software for modeling single family and multifamily housing. However, the most recent updates to CBECC 2022 forced all multifamily housing modeling to be done in the commercial version of CBECC. As a result, ConSol used an earlier version of CBECC-Res 2022 that retained multifamily modeling capabilities.

Energy and Emissions Performance

Version 0.5 of CBECC-Res 2022 was the primary tool used in developing the project models. This software version was one of the final versions that retained the ability to create multifamily residential models within CBECC-Res. Small tweaks (HVAC temperature setpoints and shading control) were made to the text files of the model, which were subsequently run in the California Simulation Engine (CSE), version 0.906.0. The model output was then run through ConSol's Load Profile Generator Excel workbook, which allows modification of solar, battery, biomass generators, and EVSE factors to extend energy models simulated in the CSE. Most process loads used the default assumptions incorporated into the CSE models developed in CBECC-Res. A 7.5 percent reduction on cooking loads was used based on the choice of induction stoves.

The control strategies for the solar system plus batteries were based on a 4:00 p.m. to 9:00 p.m. peak schedule. First, energy from solar would be stored throughout the day and conserved until it could be used during peak hours. Any excess electricity that could not be stored in a battery would be self-consumed on site. Excess renewable energy that could not be stored or self-consumed would be sent to the grid. During peak hours, the building would attempt to only use renewable generation and stored battery energy. This strategy would reduce kWh consumed from the grid by about 85 percent during peak hours.

The proposed building features 130 units (59 one-bedroom, 71 two-bedroom). A limited number (about 10) of these units are designated as "live-work" units, which would allow residents to operate small businesses from their home. The ground floor of the building would also feature two larger-scale commercial spaces. Possible uses for these spaces include a childcare facility, technology skills training classrooms, community computing rooms, and community event space. The building incorporates significant investments into building envelope efficiency, energy efficiency technology, EV charging and car sharing, energy generation, and energy storage. These would combine to make the community resilient to power outages.

As seen in Table 2, an excerpt from the Energy and Emissions Performance Workbook, the proposed design would have positive impacts on site energy use and associated emissions. The most dramatic impacts on site energy use intensity would be in space heating (18.3 percent reduction), space cooling (10.4 percent reduction), and domestic hot water (5.4 percent reduction). The 3.6 percent reduction in Process (Cooking/Appliances) would be due to the incorporation of induction cooking in the design.

Table 2: Baseline Design Versus Proposed Design Energy Use Intensity by End-Use

End-Use	Unregulated? Y/N	Site Energy Use Intensity (kBtu/sf/yr)			GHG Emissions Intensity (kg CO2/sf/yr)		
		Baseline	Proposed	% Improvement	Baseline	Proposed	% Improvement
Space Heating	N	2.30	1.88	18.3	0.131	0.105	19.8
Space Cooling	N	1.83	1.64	10.4	0.064	.058	9.4
Indoor Fans (IAQ Vent)	N	0.53	0.53	0	0.024	.024	0
Domestic Hot Water (including pump)	N	2.23	2.11	5.4	0.090	.084	6.6
Indoor Lighting	N	0.96	0.96	0	0.053	.053	0
Receptacle	Y	5.55	5.55	0	0.269	0.269	0
Process (Cooking/ Appliances)	Y	5.88	5.67	3.6	0.232	0.224	3.6
Other Lighting	N	.21	.21	0	0.012	0.012	0

Source: ConSol

As described in Table 3, an excerpt from the Energy and Emissions Performance Workbook, the proposed design would generate about 429,000 kWh more than the baseline design. This self-generation, along with energy usage reductions in the proposed design, would enable long-term islanding during outages.

Table 3: Proposed Renewable Electricity Generation Systems Overview

Technology Type	Rated Electricity Generation Output Capacity (kW)	Annual Electricity Generation (kWh)		Avoided GHG Emissions (Metric ton CO2)		
		Baseline Design	Proposed Design	Baseline Design	Proposed Design	% Improvement
Biomass Pyrolysis	Proposed - 50 kW	0	219,100[4]	0	184[5]	Undefined
Photovoltaic System[6]	Baseline - 242 kW Proposed - 371 kW	394,410	604,628	12.7	19.5	34.8

Source: ConSol

Table 4, an excerpt from the Energy and Emissions Performance Workbook, presents a description of the on-site energy storage design. The modeling assumptions included the following:

- Storage durations are assuming on-site generation is not contributing. Full permanent backup is available for Tier 1 and Tier 2 loads when combined with on-site generation.
- When combined with on-site generation, the batteries are capable of sustaining Tier 1 loads indefinitely.
- When combined with generation and storage, Tier 2 loads can be sustained indefinitely.
- ElectricFish specifications are 2x 100 kW, 360 kW from 3x 120 kW VPort units (2x V120-468-480 and 1x V120-234-480).

Table 4: On-site Storage Summary

Technology Type	Rated Capacity (kW)	Energy Storage Duration (Tier/1/2/3)[7]
Lithium Ion Batteries (2) ElectricFish 350[2] @ 100kW each (1) VPort Building Battery @ 360kW (4) Nuvve V2G Chargers @ 100kW each	960 kW[10]	Tier 1[8] (10%) Duration - 8+ days assuming full charge Tier 2[9] (25%) Duration – 3.5+ days Tier 3 (100%) Duration – 20 hours

Source: ConSol

Table 5, an excerpt from the Energy and Emissions Performance Workbook, indicates the EV charging options that would be available per the proposed design. Six Level 3 charging stations would provide rapid charging that would enable most EVs to approach full capacity in less than an hour. The remaining Level 2 charging stations would enable overnight charging for 20 additional EVs.

Table 5: Electric Vehicle Stations

Model	Output Rating	Level (1,2,3)	# of stations	# of stations with grid- or building-interactive capability
Electric Fish 350[2]	350[11] kW	3	2	2
100 kW V2G EVSE	100 kW	3	4	4
7.2 kW Grid Responsive EVSE	7.2 kW	2	20	20

Source: ConSol

Table 6, an excerpt from the Energy and Emissions Performance Workbook, describes projects regarding peak energy demand. It was assumed that the draw from the grid would be restricted to 100 kW per unit and that only 350 kW would be available when drawing upon stored energy.

Table 6: Peak Demand

(1)	(2)	(3)	(4) = [(2)+(3)]/(1)
Highest Peak Demand in a Year (kW)	Peak clipping due to on-site solar and storage on the highest peak day in the year (kW)	Peak clipping due to load management on the highest peak day in the year (kW)	% Peak reduction from on-site solar, storage and load management
272.10	236.4	35.7	100%

Source: ConSol

Table 7, an excerpt from the Energy and Emissions Performance Workbook, shows projections regarding energy consumption during peak hours. The related analysis was restricted to 4:00 p.m. to 9:00 p.m. Peak winter heating could cause morning total load to reach 367 kW. These hours have lower carbon intensity than peak afternoon hours, so they were not prioritized for peak offsetting. The high level of solar and energy storage in the proposed design would allow the project to readily mitigate impact of high air conditioning usage during hot summer afternoon/evenings. The proposed project would achieve an 85 percent reduction in grid drawn power during peak hours through a combination of efficiency, on-site generation and storage of electricity, and load management through HVAC pre-cooling.

Table 7: Energy Consumption During Peak Hours (4:00 p.m. to 9:00 p.m.)

(1)	(2) = (3) + (4) + (5)	(3)	(4)	(5)	(6) = [(4)+(5)]/(2)
Annual electricity consumption (kWh)	Annual consumption during peak hours (kWh/year)	Annual Grid Purchase during peak hours (kWh/year)	Annual load reduction from onsite biomass, onsite solar and storage during peak hours (kWh/year)	Annual load reduction from load management during peak hours (kWh/year)	% Peak reduction from onsite solar, storage and load management
867,107	292,134	43,935	238,683	9515	85%

Source: ConSol

Table 8, an excerpt from the Energy and Emissions Performance Workbook, indicates that without any solar, biomass, energy storage, or pre-cooling, it would cost $122,000 annually to power the development during peak hours. Adding the proposed generation and storage to the project cuts the annual peak hours energy bill to $19,100.

Table 8: Electric Bill Reduction due to Peak Management

(1)	(2) = (3) + (4) + (5)	(3)	(4)	(5)	(6) = (4) + (5)	(7) = (6)/(2)
Annual electricity bill ($/year)	Expected annual electricity cost during peak hours ($/year) before solar, storage, and load shifting	Cost of purchasing from grid during peak hours ($/year)	Avoided grid electricity purchases due to solar, biomass and storage ($/year)	Avoided grid electricity purchases due to load management ($/year)	Total bill reduction caused by onsite solar, storage, and load management ($/year)	% Bill reduction compared to baseline bill
$81,609	$122,011	$19,124	$102,089	$798	$57,751	84.3%

Note: Peak hours are defined as 4 PM-9 PM; The electric bill reduction should combine energy charge reduction and demand charge reduction (if applicable).

Source: ConSol

Table 9, an excerpt from the Energy and Emissions Performance Workbook, provides estimates of the savings on electric bills when the project incorporates the efficiency and on-site generation measures from the proposed design. The baseline building would entail costs of about $139,300 annually ($125,700 for residents and $13,600 for non-residential tenants) to serve the estimated demand for electricity. By comparison, the proposed building would only cost about $61,500 to serve the estimated electricity demand, resulting in a $77,800 (about 56 percent) bill reduction relative to the baseline.

The modeling assumptions included the following:

- This proposed design does not incorporate the above code EVSE, to compare the performance of a structure with the same amenities.
- The modeling assumes a 30-year time frame and only counts loads that are present in both the baseline and proposed designs.

Table 9: Estimated Residential and Non-Residential Electricity Bill

Total Estimated Residential Space Electricity Bill

Baseline	Proposed Design[13]		
First-Year Bill ($)	First Year Bill ($)	First-Year Saving ($)	Percentage Reduction (%)
$125,704	$54,801	$70,903	56.4%

Total Estimated Non-Residential Space Electricity Bill

Baseline	Proposed Design		
First-Year Bill ($)	First-Year Bill ($)	First-Year Saving ($)	Percentage Reduction (%)
$13,578	$6,649	$6,929	51%

Baseline	Proposed Design		
Lifetime[14] Saving($)	Lifetime Bill ($)	Lifetime Saving ($)	Percentage Reduction(%)
$4,178,460	$1,843,500	$2,334,960	55.8%

Note: If there are different types of non-residential units, please report an average number from the non-residential units. Or present them individually by adding more rows.

Source: ConSol

Costs and Benefits Performance

The incremental design changes in equipment and envelope for the proposed building are displayed below in Table 10, an excerpt from the Zero-Emission Cost-Benefit Analysis Report. Note that the capital cost, energy savings, and cost savings benefits for Somfy's automated window shading technology were not incorporated because CBECC-Res was not able to model the installation of this technology only on the west-facing side of the building. Note that the rightmost column of Table 10 does not consider incentives that would apply to the whole project for reaching overall efficiency goals.

Table 10: Capital Cost of Equipment and Envelope Features

Category	Baseline Per Unit Cost	Baseline Capital Cost	Baseline Capital Costs – with Incentives	Proposed Per Unit Cost	Proposed Capital Costs	Proposed Capital Costs After Incentives	Incremental Cost Increase No Incentives	Incremental Cost Increase – with Incentives	Incentivized Incremental Cost Increases per Square Foot
Windows	$18.67/sf - double glazed	$338,618	$338,618	$28.47/sf - triple glazed	$516,360	$516,360	$177,743	$177,743	$1.44
Wall Insulation	$0.87/sf - R21 Batt	$87,838	$ –	$2.47/sf - R21+ R16.7	$249,379	$41,379	$161,541	$41,379	$0.34
Ceiling Insulation	$1.32/sf - R49 Cellulose	$39,805	$ –	$1.65/ sf - R60 Cellulose	$49,756	$49,756	$9,951	$49,756	$0.40
Heat Pumps 1.5 ton - 59 units	$3,394/15 SEER unit	$200,246	$200,246	$4475 / 22.5 SEER unit	$264,025	$ –	$63,779	$(200,246)	$(1.63)
Heat Pump 2 - tons 71 units	$3476.31/ 15 SEER unit	$246,796	$246,796	$5,145 / 22.5 Seer unit	$365,295	$ –	$118,499	$(246,796)	$(2.00)
Heat Pump 3 tons - 6 units	$5511/15 SEER unit	$33,066	$33,066	$5,992 / 23.9 unit	$35,952	$ –	$2,886	$(33,066)	$(0.27)
Solar	$859,214 for 242 kW solar	$859,214	$429,607	$1.32 million for 371 kW solar	$1,317,225	$574,763	$458,011	$145,156	$1.18
WEDEW		$ –	$ –	$604,000/50 kW unit	$604,000	$265,300	$604,000	$265,300	$2.16
ElectricFish		$ –	$ –	$270,000/unit	$540,000	$ –	$540,000	$ –	$ –
BESS		$ –	$ –	$1.1 million for 1170 kWh/360 kW system	$1,113,284	$47,514	$1,113,284	$47,514	$0.39
Building Controls		$ –	$ –	transformers, meters/data	$840,000	$588,000	$840,000	$588,000	$4.78

Category	Baseline Per Unit Cost	Baseline Capital Cost	Baseline Capital Costs – with Incentives	Proposed Per Unit Cost	Proposed Capital Costs	Proposed Capital Costs After Incentives	Incremental Cost Increase No Incentives	Incremental Cost Increase – with Incentives	Incentivized Incremental Cost Increases per Square Foot
				loggers, Controls System, etc.					
EVs				4 vehicles and associated software, hardware, signage, branding materials, etc.	$527,390	$369,173	$527,390	$369,173	$3.00
EVSE	Level 2 Uni Directional - $1,000/ unit	$7,000	$7,000	Bidirectional - $23,500/unit, Basic Level 2 Uni Directional - $1,000/unit	$114,000	$68,600	$107,000	$61,600	$0.50
Total		$1,812,582	$1,255,333		$6,536,666	$2,520,844	$4,724,084	$1,265,511	$10.28

Source: ConSol

In Table 11, an excerpt from the Zero-Emission Cost-Benefit Analysis Report, the additional whole project incentives are incorporated into the rightmost column of the Capital Cost Summary. Overall, the proposed project would cost about $315,000 more to build than the baseline design. However, this incremental cost would be recovered with a simple payback period of approximately four years based on the designed site energy operating expense savings of about $78,000 per year versus a baseline Title 24-compliant building. Some of the incentives used to arrive at the displayed costs were the Self-Generation Incentive Program, the Solar Investment Tax Credit, and the Investment Tax Credit for Energy Property. More details on applied incentives are in the Technology Funding Plan Design Phase deliverable.

Table 11: Capital Cost Summary

Total Incremental Cost - No Incentives	Total Incremental Cost - Tech Specific Incentives Only	Total Incremental Cost - Whole Project and Tech Specific Incentives
$4,724,084	$1,265,511	$314,629.91
Per Square Foot		
$38.38	$10.28	$2.56

Source: ConSol

The increased incremental cost was balanced against a variety of benefits, including reduced electricity bills, Demand Side Grid Support Program participation, resilience value of ensuring critical and priority loads can be met during power outages, and CO_2 mitigation. Over 30 years, the project would have a lifecycle cost of negative $2.26 million. This could be alternatively stated as the project having a net present value of $2.26 million.

ConSol approached affordability by taking advantage of incentives wherever possible. The entities providing these incentives wanted to increase the amount of these technologies deployed. The value these entities would get from the deployment of this technology could be approximated by the size of the incentive they offer. If they are considered stakeholders in the project, the value they perceive from technology deployment should also be considered in the net present value calculation for the project.

Table 12, an excerpt from the Zero-Emission Cost-Benefit Analysis Report, shows the incremental cost per unit with and without incentives, the resident lifecycle cost, and the societal lifecycle cost associated with CO2 emissions of the project. The proposed design would have a highly beneficial negative societal lifecycle cost given that the design is carbon negative (USEPA, 2024; Eco Cost Savings, 2024).[16] The lifecycle value of emissions avoidance relative to baseline construction would be $1.53 million. Certain lifecycle costs, such as increased mortgage payments and increased property tax values, would get passed on to the owner. These were not incorporated into the residents' lifecycle costs. However, these costs were incorporated into the calculation of the $2.26 million net present value of the project.

Table 12: Incremental First Cost Per Unit, Resident Lifecycle Cost, and Societal Lifecycle Cost

	Incremental First Cost Per Unit			Residents' Lifecycle Cost			Societal Lifecycle cost (carbon emissions avoidance)		
Incremental First Cost Per Unit ($/Unit)	Standard	Proposed	Proposed w/Incentives	Standard	Proposed	Savings	Standard	Proposed	Savings
Standard	0	$36,339	$2,420.23	$3,177,783	$474,477	$2,703,307	$226,514	$(1,300,268)	$(1,526,782)

Source: ConSol

The design team arrived at the proposed design features and construction methods through a series of design meetings with key technology partners and vendors and the architecture team. The design team designed a highly efficient envelope to ensure manageable heating and cooling costs for the proposed building's lifetime. To avoid increasing cost by using 2x8 construction, the team decided to instead use more cost-effective exterior insulation to exceed the baseline R-21 insulation value. Skinny triple-pane windows were specified as they offer above-code insulating value without the high costs associated with R10 windows.

Much of the beyond-code technology improvements incorporated into the design could be heavily subsidized by existing energy efficiency programs such as the High-Efficiency Electric Home Rebate Act, California Energy Smart Homes, the Self-Generation Incentive Program, and the Building Initiative for Low-Emissions Development Program. Once all incentives are accounted for, the cost to the developer to build the proposed design only costs about $315,000 more than the minimally Title 24-compliant baseline design. Some of the highest cost items, such as the central building BESS, ElectricFish combined DCFC units and BESS, and WEDEW biomass generator, are all eligible for the Self-Generation Incentive Program, and costs to the developer could be brought down more than 90 percent with the incentives.

[16] Carbon negativity is achieved through the generation of biochar and displacing gas vehicle use by offering EV charging. Avoided gas vehicle emissions are based on U.S. EPA statistics for average gas vehicles. EVs are assumed to have an efficiency of 0.33 kWh per mile, a conservative assumption given that many EVs use far less energy per mile. Biochar-associated carbon sequestration is based on a proprietary carbon calculator provided by SkySource. Sequestration of carbon in soil and in increased plant growth is incorporated into that carbon value.

Combined with solar, these items enable self-generation and storage that provide high degrees of resiliency, utility bill savings, grid services, and carbon reduction.

The project included a limited amount of high-capacity EVSE. To control costs, 20 of the required 26 EVSE equipped parking spots would have lower-cost 7.2-kW units that can throttle charging based on grid or building signals.

High SEER (22+) heat pump systems were chosen considering the $8,000 limit for heat pump rebates for the High Efficiency Electric Home Rebate Act. None of the planned heat pumps would exceed this cost, so these heat pumps would be effectively free to the project.

Declining technology costs would improve the scalability of the proposed design in the future. The cost curves for many energy technologies indicate declining costs over time. A 2023 study by the National Renewable Energy Laboratory indicated that, by 2026, large scale lithium-ion battery systems like the BESS and ElectricFish in the proposed design will cost 20 percent less than in 2022.[17] Given that the BESS and ElectricFish units are two of the largest line items in the technology budget, this level of cost reduction would help achieve scalability of building designs with large batteries capable of providing grid services and backup power. Solar energy also has a similar declining cost curve. A 2022 study by Lawrence Berkeley National Laboratory estimated that costs for solar will decline by 41 percent by 2035.[18]

Heat pumps are another major line item for technology capital costs. A 2023 study by the UK Energy Research Centre indicated that the total installed cost of a heat pump will decline by 20 percent by 2030.[19]

The EV car sharing service is another major item in the capital costs for the proposed design. The whole car sharing industry is in relatively early stages. As the industry matures, it is likely that economies of scale and competition will put downward pressure on the cost of this service.

Establishing the microgrid is another major component of the project capital costs. Much of the cost of establishing the microgrid is in system integration. Engineers must design a way for all the self-generation, energy storage, and energy loads to coordinate with each other. Historically, this has been a custom build for each microgrid implementation. Some practitioners claim that "modularization" of microgrids will lead to a shorter troubleshooting process.[20] Standardized or pre-packaged microgrid technology would allow for vendors to solve more system integration issues before the technology is installed on site.

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[17] Cole, Wesley and Akash Karmakar. 2023 (June). *Cost Projections for Utility-Scale Battery Storage: 2023 Update*. National Renewal Energy Laboratory. Available at https://www.nrel.gov/docs/fy23osti/85332.pdf.

[18] Bolinger, Mark, Ryan Wiser, and Eric O'Shaugnessy, Eric. 2022. "Levelized cost-based learning analysis of utility-scale wind and solar in the United States." *iScience*, 25(6), 104378. Available at https://www.sciencedirect.com/science/article/pii/S2589004222006496.

[19] Heptonstall, Phil, and Mark Winskel. 2023 (April). *Decarbonising Home Heating: An Evidence Review of Domestic Heat Pump Installed Costs*. United Kingdom Energy Research Center. Available at https://ukerc.rl.ac.uk/UCAT/PUBLICATIONS/UKERC_Decarbonising-Home-Heating_Evidence-Review.pdf.

[20] Howland, Ethan. 2021 (May). "Microgrid Costs, How to Lower Them and What They Mean for the Sector's Growth." Available at https://www.microgridknowledge.com/editors-choice/article/11428010/microgrid-costs-how-to-lower-them-and-what-they-mean-for-the-sectors-growth.

Technology Transfer Plan

ConSol created the Project Case Study to serve as a document for disseminating the technological learning from the Design Phase to various professions involved in future deployments. The objectives of the Design Phase included providing access to clean energy, addressing housing costs, and demonstrating a scalable pathway to sustainable development. The project, situated in Woodland, California, involved a multi-disciplinary team of professionals and practitioners, including subcontractors and a Technology Advisory Committee.

Throughout the Design Phase, ConSol conducted regular meetings and submitted required deliverables to document the planning, design, and integration of technology. Additionally, presentations, webinars, and training events were held to disseminate the project's results to relevant stakeholders. This report's Executive Summary highlights project achievements in sustainability, resilience, and affordability, with a focus on net carbon negative energy design and significant utility bill savings for residents.

The project integrated seven key emerging energy technologies, including rooftop solar PV generation, bidirectional charging stations, and biomass power. Challenges in technology packaging and sizing batteries were addressed creatively to meet resilience goals. Decision-making was driven by stakeholder input, performance metrics, and the availability of incentives, resulting in a design that exceeded industry standards.

The outcome of these challenges and decisions was a cutting-edge design that prioritized energy efficiency, self-generation, and affordability. Analysis of costs and benefits was conducted to evaluate the project's financial viability and energy savings. Tools such as CBECC-Res and a Load Profile Generator were used to assess energy consumption and financial savings rigorously. Overall, the Project Case Study outlined a comprehensive approach to disseminating technological learning and promoting sustainable development in Woodland, California.

CHAPTER 4: Conclusion

When the project team, led by ConSol, set out to pursue this innovative community design, the project team was driven by three goals: sustainability, resilience, and affordability. Unique to the project team's approach was challenging the paradigm that each of these must be tradeoffs. Instead, the project team sought positive-sum solutions where sustainability, resilience, and affordability could coexist. The project team believes that all Californians deserve to truly thrive in their communities and environment.

The all-electric, mixed-use housing community design would use a combination of on-site rooftop and bifacial parking canopy solar PV structures, building-level battery energy storage systems, community-shared bidirectional EVs and chargers, a biomass generator powered by locally sourced organic materials, DCFCs with integrated battery energy storage for resilience, automated window shading for cooling, and a sophisticated controls platform to intelligently manage these advanced assets. The project team continuously improved the design based on new technologies and approaches discovered through CEC programs and discovered that many of these selected technologies were prior or are active recipients of CEC funding.

The proposed 130-unit mixed-use housing community would be located within the Woodland Research & Technology Park Specific Plan, a master-planned community in the City of Woodland and within Yolo County. This plan features an 11-acre linear park, providing a mix of social gathering spaces for residents, employees, and visitors to connect, recreate, work, study, exercise, and relax.

In Yolo County, over 9,000 low-income renter households do not have access to affordable housing.[21] Further, 77 percent of extremely low-income households are paying more than half of their income towards housing costs compared to just 2 percent of moderate-income households who do. The COVID-19 pandemic exacerbated this issue with average rents for multifamily housing increasing more than 15 percent between 2018 and 2022.

Crucial to designing a new mixed-use housing community is listening deeply to the local community and their needs. The project team engaged in multiple community presentations, active listening sessions, and surveys, wherein the community shared their top priorities and concerns as follow:

- More than 50 percent of the respondents wanted places to work, including co-working areas, office spaces, and live-work spaces.
- Community rooms and children's outdoor play areas were noted as a necessity.
- Nearly 75 percent of respondents had experienced power outages lasting a day long.

[21] Greenwald, David. 2023 (May). "Report Finds Yolo County Lacks Affordable Housing, Beds for the Homeless." The People's Vanguard of Davis. Available at https://www.davisvanguard.org/2023/05/report-finds-yolo-county-lacks-affordable-housing-beds-for-the-homeless/.

- More than half of the respondents named costs as the barrier to having all the energy efficiency features they would like in their home.
- The largest proportion of survey respondents were interested in hybrid vehicles or EVs, but affordability was a concern.
- The Woodland community has a broad and diverse housing need, with a more than 50 percent Hispanic population that includes families, farmworkers, and an aging population, so multi-bedroom units are critical.

These needs resonated with and validated the project team's three priorities: sustainability, resilience, and affordability.

The ConSol project team is pleased to announce that 100 percent of the apartment units in the project were designed to be affordable for low and very low-income households. The mixed-use multifamily residential community would consist of a four-story building with 130 affordable housing units, including 71 two-bedroom family units and 59 one-bedroom units. In addition, the building will house community-shared and commercial spaces for uses such as a childcare facility, a rural health clinic, educational and vocational training classrooms, a children's playground, a dog run, and a barbeque area for residents.

To provide a viable pathway for the all-electric, 100 percent affordable, mixed-use housing development design to be constructed in the City of Woodland and be ready to scale throughout California, the project team integrated a combination of seven key emerging and established energy technologies into the design. These innovative technologies included the following:

- Swell Energy's rooftop PV and parking canopy bifacial solar photovoltaic PV systems combined with battery energy storage
- Nuvve's bidirectional charging stations to enable optional building power backup and grid service from the coupled EVs
- Envoy's bidirectional-capable EVs as part of a community EV car sharing program, to provide all residents with equitable access to affordable, on-demand, zero-emission vehicles
- SkySource's award-winning WEDEW biomass power generator to provide a consistent power source any time of day to back up critical energy needs
- ElectricFish's combined EV DCFCs and battery energy storage units for faster charging capability and additional building resilience through backup battery power
- Somfy's automated window shades and controls for greater occupant comfort and HVAC energy savings
- Schneider Electric's proven microgrid energy management and grid-smart building controls

The combination of the above technologies and controls enabled the community design to achieve an incredible milestone of unlimited Tier 1 critical backup power to this multifamily community. In terms of measurable savings, tenants would see an approximate $546 of annual utility bill savings per unit (a 56.4 percent reduction), in addition to the net carbon negative energy design, resulting in a reduction of 336 tons of CO_2e emissions annually across the whole project. The combination of high-efficiency heat pumps and envelope improvements result in an 18 percent reduction in space heating, and a 10 percent reduction in space cooling energy use intensity. The project team's strategic design of the combination of incentives and operational cost savings for this design pay for all the advanced clean energy and efficiency features in under four years. Combining these highly sustainable and energy-efficient technologies and incentives to deliver a 100 percent affordable housing community, the project team delivered on all three of the project team's goals: sustainability, resilience, and affordability.

In September 2023, the Woodland City Council unanimously approved the Woodland Research & Technology Park, which includes ConSol's Next Electric Program Investment Charge Sustainable Mixed-Use Community design. This approval validated that the project is highly valued by the community and is consistent with the City of Woodland's recently adopted General Plan and the city's housing plan, which encourages a greater availability of affordable housing.

The ConSol project team is confident that its Sustainable Mixed-Use Community Design would revitalize, energize, and empower the affordable housing community starting in the City of Woodland and would set the stage to accelerate and scale decarbonization in new multifamily residential and mixed-use buildings throughout the entire state of California.

GLOSSARY AND LIST OF ACRONYMS

Term	Definition
BESS	battery energy storage system
BSB	BSB Design
CALGreen	CALGreen, is the nation's first mandatory green building standards code, in effect as of July 1, 2024.
CBECC-Res	California Building Energy Code Compliance for Residential Buildings
CCRH	California Coalition for Rural Housing
CEC	California Energy Commission
CEL	Community Energy Labs
CEQA	California Environmental Quality Act
CO2e	carbon dioxide equivalent
CRC	UC Davis Center for Regional Change
CSE	The California Simulation Engine is a general-purpose building simulation model developed primarily to perform the required calculations for the California Building Energy Code Compliance for Residential Buildings software.
CZ	Climate Zones established for Title 24 energy efficiency standards.
Demand Side Grid Support Program	The Demand Side Grid Support Program will offer incentives to electric customers that provide load reduction and backup generation to support the state's electrical grid during extreme events, reducing the risk of blackouts.
DCFC	Direct current fast charger. This equipment offers rapid charging along heavy-traffic corridors at installed stations.
EC3	Embodied Carbon in Construction Calculator. This program is a free and easy-to-use tool that allows benchmarking, assessment, and reductions in embodied carbon, focused on the upfront supply chain emissions of construction materials.
EPIC	Electric Program Investment Charge
EV	electric vehicle
EVSE	electric vehicle supply equipment
GHG	greenhouse gas
HPWH	heat pump water heaters. HPWHs use electricity to move heat from one place to another instead of generating heat directly.
HVAC	heating, cooling, and air conditioning
kg	kilogram

Term	Definition
kW	kilowatt
kWh	kilowatt-hour
IEEE	Institute of Electrical and Electronics Engineers
L2	Level 2. L2 equipment offers faster-rate AC charging by using 240-volt (in residential applications) or 208-volt (in commercial applications) electrical service. It is common for home, workplace, and public charging. L2 chargers can charge a battery EV to 80 percent from empty in 4 to 10 hours and a plug-in hybrid electric vehicle in 1 to 2 hours.
MWh	megawatt-hour
NEM	net energy metering
PG&E	Pacific Gas & Electric
PV	photovoltaic
SEER	seasonal energy efficiency ratio
SHEG	solar heat gain coefficient
Swell	Swell Energy
TAC	Technical Advisory Committee
Transportation Network Companies	Transportation network companies provide prearranged transportation services for compensation using an online-enabled application or platform (such as smart phone apps) to connect drivers using their personal vehicles with passengers.
UC	University of California
V2B	vehicle-to-building. Bidirectional vehicles can provide backup power to buildings or specific loads, sometimes as part of a microgrid, through V2B charging, or provide power to the grid through vehicle-to-grid charging.
V2G	vehicle-to-grid. Bidirectional vehicles can provide backup power to buildings or specific loads, sometimes as part of a microgrid, through vehicle-to-building charging, or provide power to the grid through V2G charging.
VPP	virtual power plant
WEDEW	wood-to-energy deployed water is a versatile, self-contained, sustainable energy-water generator.

References

Bardis & Miry. n.d. "Bardis & Miry Development." Available at https://www.bardismiry.com/.

Bolinger, Mark, Ryan Wiser, and Eric O'Shaughnessy. 2022. "Levelized cost-based learning analysis of utility-scale wind and solar in the United States." *iScience*, 25(6), 104378. Available at https://www.sciencedirect.com/science/article/pii/S2589004222006496.

BSB Design, Inc. 2024. "About." Available at https://www.bsbdesign.com/about/.

Building Decarbonization Coalition staff. 2019. *A Roadmap to Decarbonize California Buildings*. Building Decarbonization Coalition. Available at https://www.gridworks.org/wp-content/uploads/2019/02/BDC_Roadmap_final_online.pdf.

California Coalition for Rural Housing. 2024. "About Us." Available at https://www.calruralhousing.org/about-us.

California Housing Partnership. 2023 (May). *Yolo County 2023 Affordable Housing Needs Report*. Available at https://sachousingalliance.org/wp-content/uploads/Yolo-County_Housing-Report_2023.pdf.

City of Woodland staff. 2017 (May). *General Plan 2035*. City of Woodland. Available at https://cityofwoodland.gov/563/General-Plan-2035.

City of Woodland staff. 2023 (September). *Woodland Research & Technology Park – Specific Plan*. City of Woodland. Available at https://www.cityofwoodland.gov/585/Documents.

Clean Coalition staff. 2023. "VOR123: Value-of-resilience." Available at https://clean-coalition.org/disaster-resilience/.

Cole, Wesley, and Akash Karmakar. 2023 (June). *Cost Projections for Utility-Scale Battery Storage: 2023 Update*. National Renewal Energy Laboratory. Technical Report Number: NREL/TP-6A40-85332. Available at https://www.nrel.gov/docs/fy23osti/85332.pdf.

Community Energy Labs. 2022. "The Future of Building Performance." Available at https://communityenergylabs.com/solution/.

ConSol, Inc. 2022. "About Us." Available at https://www.consol.org/about.

Eco Cost Savings. 2024 (February 29). "Electric Car kWh Per Mile List [277 kWh/Mile Listed]." Available at https://ecocostsavings.com/electric-car-kwh-per-mile-list/.

ElectricFish. 2024. "Our Team, Values & Mission." Available at https://www.electricfish.co/about.

Emery, Ashley, and Erik Lyon. 2023 (July). *Demand Side Grid Support (DSGS) Program Guidelines, Second Edition*. California Energy Commission. Publication Number: CEC-300-2023-003. Available at https://www.energy.ca.gov/publications/2023/demand-side-grid-support-dsgs-program-guidelines-second-edition.

Energy Star. 2022. "2021-2022 Residential Induction Cooking Tops | ENERGY STAR." Available at https://www.energystar.gov/partner_resources/products_partner_resources/brand-owner/eta-consumers/res-induction-cooking-tops.

Envoy. n.d. "Car Sharing Platform | Car Sharing App." Available at https://www.envoythere.com/about-us.

Greenwald, David. 2023 (May 25). "Report Finds Yolo County Lacks Affordable Housing, Beds for the Homeless." *The People's Vanguard of Davis.* Available at https://www.davisvanguard.org/2023/05/report-finds-yolo-county-lacks-affordable-housing-beds-for-the-homeless/.

Heptonstall, Phil, and Mark Winskel. 2023 (April). *Decarbonising Home Heating: An Evidence Review of Domestic Heat Pump Installed Costs*. United Kingdom Energy Research Center. Available at https://ukerc.rl.ac.uk/UCAT/PUBLICATIONS/UKERC_Decarbonising-Home-Heating_Evidence-Review.pdf.

Hertz, David. 2023. *WEDEW Carbon Sequestration Calculator.* SkySource.

Hodgson Company. 2024. "About Us." Available at https://www.thehodgsoncompany.com/about-us/.

Howland, Ethan. 2021 (May 25). "Microgrid Costs, How to Lower Them and What They Mean for the Sector's Growth." *Microgrid Knowledge.* Available at https://www.microgridknowledge.com/editors-choice/article/11428010/microgrid-costs-how-to-lower-them-and-what-they-mean-for-the-sectors-growth.

Interagency Working Group on Social Cost of Greenhouse Gases. 2021 (February). *Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990*. Available at https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethane NitrousOxide.pdf.

Nuvve. 2024. "Our Story." Available at https://nuvve.com/our-story/.

Schneider Electric. 2024. "Company profile." Available at https://www.se.com/us/en/about-us/company-profile/.

SkySource. n.d. "Our Story." Available at https://www.skysource.org/ourstory.

Somfy. 2024. "About us." Available at https://www.somfysystems.com/en-us/discover-somfy/about.

Southern California Association of Governments staff. 2021 (March). *Regional Housing Needs Assessment*. Southern California Association of Governments. Available at https://scag.ca.gov/rhna.

Swell Energy. n.d. "Press Room." Available at https://www.swellenergy.com/press/.

UC Davis Center for Regional Change. 2022 (April). "About Us." Available at https://regionalchange.ucdavis.edu/about-us.

United States Environmental Protection Agency staff. 2024 (May). "Greenhouse Gases Equivalencies Calculator - Calculations and References." United States Environmental Protection Agency. Available at https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references.

Project Deliverables

During the Design Phase, the project team completed critical milestones including the following:

- Design of the overall site plan
- Design of the building
- Incorporation of energy technologies into the site and building design
- Preparation of the Baseline and Optimized Use Cases
- Preparation of the Controls Hierarchy Diagram Design
- Preparation of the Building Funding Plan showing preliminary funding sources
- Preparation of the Technology Funding Plan identifying technology funding sources
- Community Outreach and Design Integration
- Preparation of the Draft Measurement and Verification Plan
- Woodland Research & Technology Park City Council Approval
- CEQA approval – Final Environmental Impact Report certified September 2023 including project site. (No additional CEQA approvals required for this mixed-use affordable housing project.)
- Preparation of the initial site plan and preliminary designs to support entitlement process

During the Design Phase, the project team completed the following technical Project Deliverable Products:

- Community Survey(s) (draft and final)
- Summary of Initial Key Stakeholder Engagement and Action Items
- Additional Community Engagement Activities Plan
- Baseline and Optimized Use Cases (draft and final)
- Summary of Use Case Simulation Findings
- Functional Hierarchy Diagram (draft and final)
- Measurement and Verification Plan (draft and final)
- Building Funding Plan (draft and final)
- Technology Funding Plan (draft and final)
- Initial Project Benefits Questionnaire
- Annual Survey(s)
- Final Project Benefits Questionnaire
- Documentation of Project Profile on EnergizeInnovation.fund
- Documentation of Organization Profile on EnergizeInnovation.fund
- Project Case Study Plan (draft and final)
- Project Case Study (draft and final)
- High Quality Digital Photographs (Site Renderings)
- Conceptual Design and Engineering Report
- Energy and Emissions Performance Model Report
- Emerging Technologies and Strategies Report
- Zero-Emission Cost-Benefit Analysis Report
- Community Engagement Plan

- Concept Video
- Presentation Materials
- Build Phase Amendment Package

Project deliverables, including interim project reports, are available upon request by submitting an email to pubs@energy.ca.gov.

ENERGY RESEARCH AND DEVELOPMENT DIVISION

Appendix A: Conceptual Design Renderings

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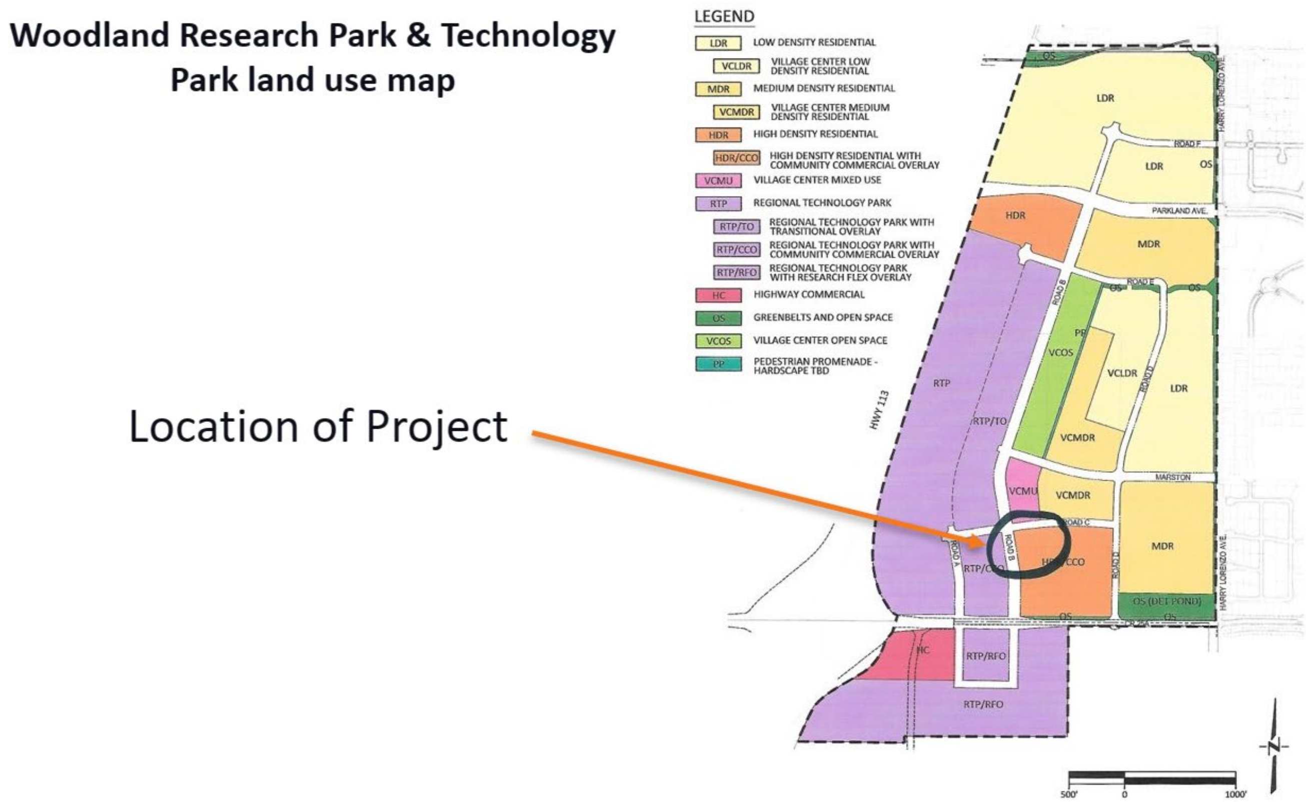
Appendix A
Conceptual Design Renderings

Figure A-1: Woodland Research & Technology Park Land Use Map



Source: The Hodgson Company

Figure A-2: Site Design

Source: BSB Design

Figure A-3: Conceptual Exterior Elevation – Southeast

Source: BSB Design

Figure A-4: Conceptual Exterior Elevation – Northwest

Source: BSB Design

Figure A-5: Conceptual Exterior Elevation – Northeast

Source: BSB Design

Figure A-6: Conceptual Exterior Elevation – Southwest

Source: BSB Design

Figure A-7: Conceptual Exterior Elevation Vignette – View #2

Source: BSB Design

Figure A-8: Conceptual Exterior Elevation Vignette – View #4

Source: BSB Design

Figure A-9: Conceptual Exterior Elevation – Playground and Electric Vehicle Car Sharing Section

Source: BSB Design