Mutual Housing CALIFORNIA

MUTUAL HOUSING AT SPRING LAKE

A ZERO NET ENERGY RENTAL HOUSING COMMUNITY

Key Statistics

Location:
2170 Farmers Central Road
Woodland, CA 95776
Yolo County

Completed: March 2015

Energy Climate Zone: 12

Homes: 62

Site Size: 3.28 Acres

Density: 18.9 units per acre

Unit Mix:
1-Bedrooms (Flats) 12
2-Bedrooms (Flats) 20
3-Bedrooms (Flats) 12
3-Bedrooms (Townhomes) 10
4-Bedrooms (Flats) 6
4-Bedrooms (Townhomes) 2

Annual Solar Production:
334,295 KWH

Incremental Cost to Achieve ZNE: 8%

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Principal Photography: Frank Domin
Design & Digital Imaging: Art101.com

Executive Summary

Design & Development Team

Owner/Developer:
Mutual Housing California

Architect:
Kuchman Architects PC

General Contractor:
Sunseri Construction

Energy Consultant:
Redwood Energy

Mechanical Engineer:
Alexander Scheflo & Associates

Structural Engineer:
Harris & Sloan
Consulting Group, Inc.

Civil Engineer:
TSD Engineering, Inc.

Landscape Architect:
Deering Design

Electrical Engineer:
Up Light Electrical Engineering

HERS Rater:
Davis Energy Group

Photovoltaic System:
Everyday Energy

Mutual Housing at Spring Lake in Woodland, California, is the first rental housing community in the nation to receive a ZNE certification. The property is certified as a 100% Zero Energy Ready Home by the U.S. Department of Energy. This 62 home Low Income Housing Tax Credit – supported development provides healthy, affordable housing for agricultural workers and their families in a region with limited viable housing options for this population.

Mutual Housing California, the property's nonprofit developer, learned valuable lessons throughout the conceptualization, design, construction, and first year of operations for this innovative housing community. Relying on its experience in sustainable development and a survey of the targeted population, the development team arrived at the Zero Net Energy (ZNE) goal for this project – "The amount of energy used on site by residents and the common areas will be offset by on-site solar generation on an annual basis."

The design and construction team was challenged to build a financially feasible development with building envelope, HVAC, mechanical, lighting, and plug load packages for which the projected energy use could be offset by an on-site solar panel system. The community opened in March 2015 and successfully houses 62 agricultural worker households in an affordable, sustainable community. It did not quite reach its ZNE goal in its first year of operations.

Valuable lessons throughout the process included the value of having the owner lead as the "ZNE Champion" as well as the value of having an energy consultant on the design team, the importance of correctly marketing the concept of ZNE, the need for monitoring both the specialized installation and ongoing maintenance of ZNE components, and the importance of ensuring staff knowledge sharing to inform future operations and new developments.

Project Overview

Developer

Mutual Housing California, formed in 1988, is a nonprofit California corporation with a mission of developing, operating, and advocating for sustainable housing that builds strong communities through resident participation and leadership development. Mutual Housing has been a leader in green building since 2002, when it became the first developer in the Sacramento region to include solar photovoltaics for resident benefit in a multifamily residential property. Mutual Housing is committed to decreasing the use of fossil fuel, lowering the carbon footprint of its housing properties, and providing healthy living environments for households of modest means while helping them live within their limited budgets. In 2013, Mutual Housing was named a NeighborWorks® Green Organization by NeighborWorks® America after an extensive review process which recognizes comprehensive green efforts and policies throughout an organization that has embraced a sustainable business culture.

Local Demographics and Land Use Considerations

Mutual Housing at Spring Lake is located in the City of Woodland, the county seat of Yolo County, where agriculture is among the leading industries. In 2015, Yolo County had an estimated 5,900 agricultural workers employed in the fields, packing houses, and processing plants, with an average hourly wage of about $12. A majority of these workers live and work in the community year-round and have a difficult time finding suitable housing that they can afford.

The City of Woodland's General Plan calls for more energy efficient and agricultural worker housing. The City has a mixed income housing policy for new single-family housing subdivisions, including the Spring Lake subdivision. The Spring Lake Specific Plan was approved in 2001. When completely built out, Spring Lake will contain more than 4,000 housing units (primarily single-family homes) as well as schools, parks, city services, and commercial development. In early 2015, single-family homes in the Spring Lake subdivision carried selling prices from mid-$300,000 to mid-$500,000.

Under the mixed income housing policy, developers of single-family homes must sell a portion of the homes to low income households at an affordable sales price, or they must pay into a low income housing fund to support the development of affordable housing. After saving this parcel in the Spring Lake subdivision from down-zoning by the former owner who had plans for additional market-rate single-family homes, Mutual Housing California utilized the low income housing fund to develop this site.

Building this community at this site helped to ensure economically inclusive development. Further, the site location met principles of sustainable development due to its proximity to existing infrastructure as well as being within walking distance to public transportation, shopping, a school, a neighborhood park, and related community amenities.

Community Vision

Completing construction and lease up of 62 affordable, sustainable homes in Mutual Housing at Spring Lake was the realization of a long-held Mutual Housing goal of creating housing for agricultural workers and their families in the region. The rationale for pursuing leading-edge green goals in this effort was validated when Mutual Housing first reached out to the target constituency in the early stages of planning. A Mutual Housing survey of local agricultural workers about their housing concerns revealed that while the most commonly mentioned concern was high rental housing costs, the next most commonly mentioned concern was high utility bills.

With this in mind, Mutual Housing set out to design and construct the homes in a manner that would bridge the "Green Divide." The goal was to bring the health and economic benefits of sustainably developed housing to a population that has traditionally suffered some of the unhealthiest housing conditions and jobs in the country.

Supported by a community organizer on the nonprofit staff who helps facilitate the formation of resident councils and other leadership building activities, Mutual Housing at Spring Lake residents take an active role in decision-making in their community. Common space in the attractive community building includes space for resident activities, financial education and peer lending circles, leadership training, health education, college planning, other educational and recreational programs, and a computer learning lab with laptops available for residents to use at home. It also houses staff offices and a laundry room. In addition to the community room, Mutual Housing at Spring Lake also features public art by regional artists, a children's play area, and scattered community gardening areas. All ground floor apartments are fully adaptable for those residents with physical disabilities.

Top: Children's play area.
Above: Community building interior.

"Marsh Madness" – an 8 1/2-foot metal sculpture by Steve Cook mirrors wildlife at local marshes.

Certifications Received:

- U. S. Department of Energy – Zero Energy Ready Homes
- U. S. Green Building Council – LEED Platinum
- Build It Green – Green Point Rated
- Enterprise Green Communities
- Energy Star for Homes

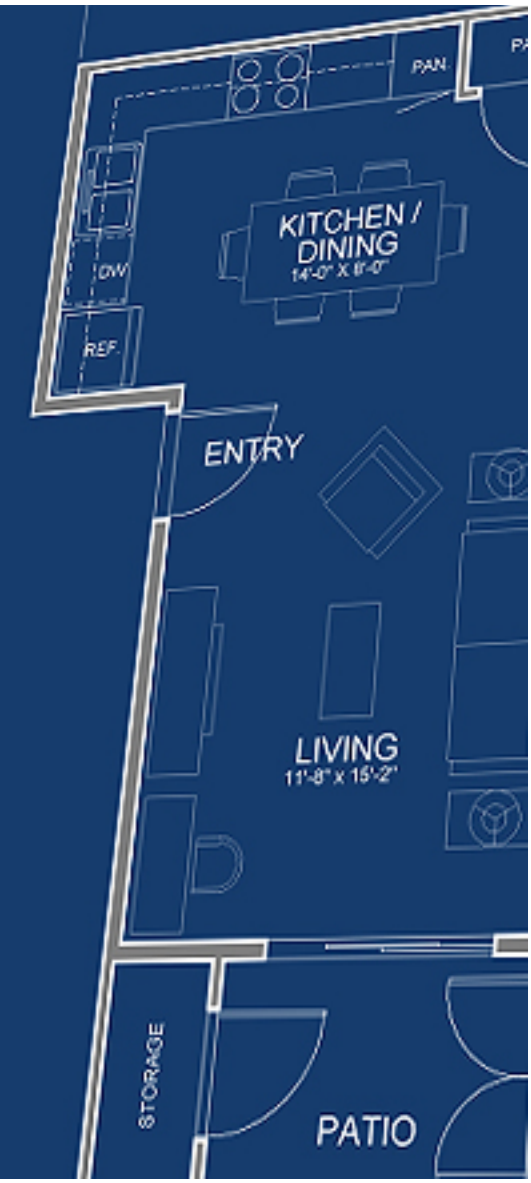
Mutual Housing asserts that the Green Divide will only be closed if low-income and non-English-speaking households are connected with affordable access to green technology. Only then can we expect this constituency to embrace and become leaders in the green revolution. The organization proactively links its commitment to maximizing its sustainable building efforts with its green education and leadership development efforts.

Design Overview

Design Team

Mutual Housing relied on a trusted team to help design and build this ZNE development. The project team included Mutual Housing as the sponsor and developer, the architect and design consultants, the general contractor and key subcontractors, the energy consultant, and the Home Energy Rating System (HERS) rater. Mutual Housing had previously worked with many of these same partners in achieving high levels of sustainability at many other Mutual Housing developments.

The design process began with a full-team charrette to lay out the overall project sustainability goals and establish key points of coordination between the team members. Mutual Housing California, as the developer, set the stage for these discussions by mandating maximum feasible sustainability and Zero Net Energy design.



Blueprint from a typical 2-bedroom floor plan at Mutual Housing at Spring Lake.

The members of the design team continued this collaboration at several meetings held during conceptual design, design development, and while completing final plans and specifications. For certain aspects of the plan, particularly related to HVAC and hot water systems, there was a steep learning curve as alternative combinations for efficiency measures and on-site generation were proposed, analyzed, and evaluated for occupancy comfort as well as cost impacts, both at installation and over time.

Problem-solving by this team continued throughout construction. Preconstruction meetings were held with all subcontractors, as well as coordination meetings with subcontractors, the energy rater, and inspectors from the sustainability certification programs, to ensure that all energy efficiency requirements and unique construction methods were understood and followed.

Zero Net Energy Definition

With the goal of creating a Zero Net Energy affordable housing community, one of the first steps was for the team to adopt a common definition of ZNE. Some proponents of ZNE consider only the extent to which on-site photovoltaics offset electrical energy used in the buildings, without considering consumption of energy produced by other sources such as natural gas. Others maintain that true ZNE requires consideration of all sources of energy to be consumed on-site.

Top: Community building.

Above: Resident green leaders volunteer to monitor energy usage.

Internal discussion led Mutual Housing to adopt the latter definition of ZNE, given the greater greenhouse gas reduction results it could provide. The concern then became the limited availability of feasible technologies to offset natural gas consumption, along with the perceived risks of using new technologies. After further consideration, the simple solution became eliminating natural gas as an energy source. Ultimately, the team adopted the following definition for ZNE:

The amount of energy used on site by residents and the common areas will be offset by on-site solar generation on an annual basis.

The team's early decision to make it an all-electric community, with no natural gas, provided a clear pathway to achieve the determined ZNE goal. On-site electricity usage from plug loads, lights, appliances, and mechanical systems can be directly offset by electricity generated from solar panels. There is no need to offset the use of natural gas due to the all-electric design. All-electric strategies are thus the most fool-proof way of achieving zero-net carbon, pushing buildings toward more complete sustainability since they eliminate on-site fossil fuel emissions.

The key to meeting the stated goal of a ZNE community was clear to team members: Design and build a community with the lowest possible energy consumption, then utilize solar panels to offset the predicted electricity usage.

Typical electric HVAC and hot water heater closet at Mutual Housing Spring Lake.

HVAC and Hot Water Systems	
Heating & Air Conditioning System	Daikin Altherma inverter driven heat pump; SEER 13, HSFP 11
Heating & Cooling Distribution	Ducted
Water Heating System	Daikin Altherma heat pump with tank Energy Factor 2.4
Duct Location & Insulation	Conditioned space – dropped soffits or buried ducts
Duct Leakage	8-21 cfm @ 25 PA
Mechanical Ventilation	ENERGY STAR exhaust fans per ASHRAE 62.2
Energy Star HVAC Contract Checklist	Yes
Return air pathway vents at bedroom	Yes

Designing for Efficiency

The buildings in Mutual Housing at Spring Lake were designed to exceed California 2008 Title 24 energy conservation requirements by between 36 and 40 percent. This was accomplished by exacting attention to several different means of achieving energy efficiency throughout the development.

Heating, Cooling, and Hot Water

Decisions about heating, cooling, and hot water systems are critical in residential ZNE building design because those systems use a large portion of total energy consumed. At Mutual Housing at Spring Lake, those systems account for approximately 45 percent of the total energy demand. While Woodland has mild winters, with the temperature rarely dipping below freezing, summer temperatures often exceed 100 degrees. Thus, air conditioning and passive cooling were important considerations.

To achieve a cost effective, energy efficient, and durable solution appropriate for the local climate, the design team specified an innovative heat exchanger and pump system that supplies domestic hot water and hydronic heating and cooling without using natural gas. To provide indoor heating, the system extracts heat from the outside air (which it can do even when outside temperatures are as low as 5 degrees) and transfers it inside the residential unit. In the summer, the system works in reverse to provide cooling by drawing heat from within the unit to the outside. The same system works to extract heat from the air and transfer it to the hot water tank, which also has a back-up heating element that kicks in when needed.

The general principle of electric heat pump systems is that it is easier to move heat than to create it. These heat transfer systems use approximately 25 percent less electricity than conventional systems that use electricity to generate their own hot or cold air. This makes them a practical, efficient solution for eliminating the need for natural gas. To limit inefficiency for heat exchanges in these systems, a critical feature of building design is that all ductwork must be properly installed, sealed, and positioned in conditioned spaces with insulation.

Insulation

- High-density R-21 fiberglass batt in walls
- High-quality installation and insulated corners
- R-44 to R-49 blown fiberglass in attic
- 18" raised heel trusses or rigid insulation at attic perimeter
- Vented attic
- 30 pound felt and radiant barrier on roof sheathing
- Certified-cool composition shingles
- Cool roof ratings: solar reflectance 0.26 & thermal emittance of 0.91
- Double-paned, low-e, argon-filled windows

Quality Insulation Installation (QII).

Building Envelope

A critical area in ZNE design is planning for an energy-efficient building envelope, which includes decisions about framing details, insulation for the walls and attic, attic design and roofing materials, and selection of windows and foundation. It also includes making provision for air-sealing the buildings and providing for ventilation.

Insulation materials are rated according to how much insulation they provide – the higher the insulation factor, the greater degree of insulation. The wall and attic insulation installed at Mutual Housing at Spring Lake had R ratings which exceed the requirements of the local building code. It was installed pursuant to high quality standards (including insulation of corners even when not required by code) and was subject to ongoing in-process third-party inspections. In key locations with more exposure to wind, wall insulation was enhanced through the use of house wrap to supplement standard OSB sheathing. Using raised heel trusses is a framing strategy that was used to increase the depth of insulation at the perimeter of the attic. Where that detail was not possible due to building design, rigid insulation was added between trusses at some top plates.

General contractor, architect, and developer staff on site.

Indoor air is vented to outside rather than into attic.

Attics that are well-ventilated and well-insulated enhance the energy efficiency of buildings. The buildings in this development have attic ridge vents along with the standard side venting. A radiant barrier on the underside of the OSB roof sheathing reduces radiant heat transfer. Heavier than typical felt was used, and shingles on the roof help reflect heat through the use of lighter colors and embedded reflective material.

Building Envelope	
Exterior Wall Construction	2 x6 R-21 16" oc
Foundation Type	Slab, uninsulated
Attic Insulation	R-49
Roofing Material	Comp shingles, CRRC-certified with radiant barrier
Housing Infilitration – Blower Door Test	2.3 – 4.0 ACH50
Glazing	U-value = 0.29, SHGC = 0.19

Window choices are critical to achieving high levels of energy efficiency, with selection guided by ratings that measure how well the windows keep heat both out and in. For Spring Lake, Mutual Housing selected highly rated dual-pane windows with argon gas installed between the panes for greater insulation.

The foundation for this development is uninsulated slab on grade. In geographies with significant summer heat, as in the California Central Valley, it is considered best practice to leave the slab uninsulated, allowing it to serve as a heat sink during the summer cooling season.

Air sealing throughout buildings is an important means of conserving energy by limiting heat loss. One way to do this is to use house wrap for the entirety of the buildings, including party walls. Instead of that strategy, due to its cost, this project minimized leakage at all wall penetrations and where walls met the ceiling and floor plates with caulking, foam, or fire-resistant putty pads for the fire-rated walls. Air sealing, which can be difficult to accomplish in multifamily buildings, was completed in accordance with Section 8 of the ENERGY STAR Thermal Enclosure System Rater Checklist. To test the effectiveness of the air sealing, the builder completed multiple sequential blower door tests on prototype units following each improvement to identify and remediate problematic leakage points. This continued until leakage was reduced to levels acceptable for certification in the U.S. Department of Energy's Zero Energy Ready Home program.

Other Electric Uses

Conservation Measures:

- ENERGY STAR appliances and ceiling fans
- Centralized laundry facilities
- 100% ENERGY STAR-certified lighting
- CREE 84 lumen/Watt LED screw-based lighting
- Hard-wired fluorescent lighting in kitchens
- LED exterior and interior lighting
- Energy monitors

Another consideration for ZNE design is limiting the amount of energy used by appliances, lighting, and plug loads. ENERGY STAR refrigerators and dishwashers use about 30 percent less energy than standard models and have been installed in all Mutual Housing at Spring Lake apartments. ENERGY STAR clothes washers have been installed in a central location in the community room rather than in individual homes, a strategy known to reduce laundry loads by as much as 40 percent. ENERGY STAR ceiling fans provide energy-efficient ventilation and climate control in the bedrooms and living rooms.

While building code requirements for this development called for at least half the lighting to be fluorescent lighting, which is more energy efficient than incandescent lighting, even greater energy efficiency was accomplished by installing two-thirds LED lighting via screw-based bulbs for a majority of fixtures. While LED is more energy efficient than either fluorescent or incandescent lighting, it is more expensive. Lighting is installed with dimmer

Color coded Nexi energy monitors are installed in every kitchen.

For Mutual Housing at Spring Lake, the design team settled on energy efficiency measures that brought the modeled demand down to 334,000 kilowatt hours per year and the solar system was designed accordingly.

switches and occupancy sensors that turn off lights when rooms are vacant. LED is also used for exterior lighting.

The most unpredictable factor in estimating energy load is resident behavior. Studies have shown, however, that real-time feedback energy monitors result in 10 to 15 percent energy savings in households where they have been installed, compared to households without them. In modeling the energy consumption and sizing the solar panel system for Mutual Housing at Spring Lake, the inclusion of energy monitors reduced the expected electricity demand by a conservative 3 percent with a corresponding 3 percent reduction in the size of the solar panel system.

The color coded energy monitors installed in every kitchen in this development provide a user-friendly means of monitoring energy use that is engaging for residents of all ages. The monitors display both instantaneous and daily electrical usage. A green or yellow illumination means the household is using a limited amount of electricity, while a red or purple illumination represents a high amount.

Designing Renewable Energy Systems

Photovoltaic System

Planning for a ZNE photovoltaic system begins with site layout, building orientation, roof pitch, and window placement to maximize passive solar benefit and potential of the solar array to capture the sun's rays. It continues with locating roof penetrations to maximize available roof space. Once the expected energy load has been determined through computerized modeling, including consideration of proposed measures for energy-efficiency, the solar array can be sized to meet that energy load. If the system size is too large for the space available or too expensive for the

resources available, the design team may have to go through several iterations to balance the cost of energy efficiency measures with the cost of the PV system while keeping available space for the solar array always in mind.

For Mutual Housing at Spring Lake, the design team settled on energy efficiency measures that brought the modeled demand down to 334,000 kilowatt hours per year and the PV system was designed accordingly. Note that the match between energy demand and production is calculated on an annual basis as the solar panels will produce more electricity on longer summer days than during the winter. The solar panels were installed on the south side of each building as well as on solar support structures in parking lots with a combination of south and west facing arrays.

Virtual Net Metering

The most common approach for households to benefit from solar power is to tie directly into a photovoltaic system. However, multifamily developments have struggled with this approach due to its complex and expensive set up that would require an individual photovoltaic system for each home.

To address this situation, the California Public Utilities Commission (CPUC) adopted Virtual Net Metering (VNM), which allows electricity produced by a single solar installation to be credited to the benefit of multiple residents in a building. It is called virtual metering because the system is not physically connected to individual meters. Instead, each household receives a credit on its utility bill calculated as a portion of the total solar generation of the common system. The allocation of these credits is established by agreement between the property owner and the utility company.

Allocations are based on the square footage of the apartment and other usage factors. For Mutual Housing at Spring Lake, VNM was a critical component of the project's ZNE design, since it offered a cost effective and efficient way of providing the residents of the housing community with the opportunity to offset their electricity costs.

Virtual Net Metering

Credited Account	Allocation of Monthly Solar Electricity Generation
1 Bedroom	0.89%
2 Bedrooms	1.17%
3 Bedrooms	1.36 - 1.75%
4 Bedrooms	1.62 - 1.89%
Common Areas	18.42%

Resident green leader tabulates energy consumption.

Photovoltaic System	
Utility Provider:	Pacific Gas & Electric
Solar Installer:	Everyday Energy
Size of System (kW DC):	209
Number of Meters:	6
Number of Inverters:	31
Cost Before Rebates:	$973,351
Cost After Rebates:	$597,182
Percent Generation Applied to Residents:	81.58%
Percent Generation Applied to Common Areas:	18.42%
Expected Annual Solar Production:	334,295 KWH
Expected Annual Solar Production Applied to Residents:	265,765 KWH
Expected Annual Solar Production Applied to Common Areas:	68,530 KWH

Water Conservation

- Drought-resistant landscaping
- A "Smart" irrigation system
- Shower heads: less than 2 gallons per minute (gpm)
- Bath faucets: less than 1.5 gpm
- Kitchen faucets: less than 2.0 gpm
- Toilets: 1.28 gallons per flush (gpf)

Additional Sustainability Considerations

In addition to designing for energy efficiency and renewable energy generation, Mutual Housing at Spring Lake incorporates a number of important measures to support water conservation, resource conservation, and indoor air quality.

Water Conservation

Water conservation is a critical consideration when designing projects in California, a state that has been experiencing significant drought and increasing water prices in recent years. Key water conservation measures included designing water-efficient landscaping and irrigation, installing low flow fixtures, and influencing resident behavior.

The landscaping installed at Mutual Housing at Spring Lake consists largely of California native and drought-tolerant plants with less than one third of the planting area dedicated to turf.

Native plants are naturally suited to the dry summer climate and offer delightful flowers, fragrant foliage, and habitat for beneficial native insects and birds. The irrigation system combines stream nozzles which apply water at about one third the precipitation rate of conventional spray heads with "smart" controllers that track climate conditions and measure soil moisture to avoid unnecessary watering. This type of controller has been shown to save 30 percent of irrigation water use.

The decision to include fruit trees (which are not low-water users) for a local, free resident food source was mitigated by

planting the trees in crushed rock with sub-surface drip irrigation to help minimize evaporation. A sports field with turf (also not a low-water user) was included for recreational purposes. As designed, the irrigation water usage will be nearly 50 percent lower than the limit mandated by the State of California Landscape Water Use regulations.

All installed plumbing fixtures are low-flow, including high-efficiency shower heads equipped with thermostatic shut-off valves designed to combat the wasteful practice of turning on the shower and then walking away until the water reaches a comfortable temperature, which studies show is done by approximately 75 percent of people taking showers. In showers with these valves, the water slows to a trickle automatically when it reaches 95 degrees Fahrenheit and only fully starts again at that temperature when the walkaway user returns and pulls the release valve. This tool is shown to reduce hot water usage by an average of one minute per shower, and also conserves the energy used to heat the water.

While the thermostatic shut-off valves help combat a wasteful practice without significantly changing resident behavior, Mutual Housing's Green Leaders initiative promotes resident education and community-wide conservation efforts at this and every Mutual Housing community.

High efficiency Evolve shower head equipped with thermostatic shut-off valve.

Resource Conservation

- Lumber: engineered and pre-cut
- Insulation: with recycled content
- Framing: more than 16" on center for joists and rafters
- Construction waste: 71% recycled
- Flooring: 75% Marmoleum® and carpet tile
- Cabinets: durable and easy to refinish
- Stormwater management

Lumber used for floor and ceiling joists included engineered material made from smaller rapid-growing trees and sawmill scrap.

Resource Conservation

The design and construction team supported sustainability goals for resource conservation by using environmentally friendly lumber, reducing the amount of lumber used, diverting construction waste for recycling, selecting materials with recycled content and long-term durability to reduce future need for replacement, and managing stormwater runoff during construction.

Lumber used for floor and ceiling joists included engineered material made from smaller rapid-growing trees and sawmill scrap. Use of pre-cut framing and spacing of more than 16 inches on center for ceiling and floor joists and rafters also helped reduce lumber usage. At least three-quarters of the construction and demolition waste, which included concrete, drywall, lumber, cardboard, and carpet, was diverted to a recycling center rather than being sent to a landfill.

Marmoleum® (a brand name linoleum made of all natural linseed oil, recycled wood flour, cork dust, and limestone) and carpet squares were used in all but the bathrooms. Using carpet squares in bedrooms rather than conventional roll carpet helped to minimize construction waste and will reduce on-going replacement costs. Batt insulation with recycled content was used in the walls.

The high-quality durable cabinets installed in kitchens and bathrooms were selected to withstand wear and tear. Cabinets and drawers have no added formaldehyde and contain FSC-certified particle board. The flat fronts on the cabinet doors and drawers allow for easier cleaning and maintenance as well as for efficient refinishing rather than replacement in the future. The expected life of various project components was also enhanced by durability management practices and inspections implemented throughout the construction process.

Several sustainable construction practices were used to prevent erosion around the construction site and to prevent undue impact on storm drainage systems and nearby lakes and streams. These included stockpiling and protecting disturbed topsoil from erosion, controlling the path and velocity of runoff with silt fencing, providing swales to divert surface water from hillsides, using tiers, erosion blankets, and compost blankets on sloped areas and protecting sewer inlets, streams, and lakes with straw bales, silt fencing, and other similar materials.

Indoor Air Quality

- No or low VOC finishes and adhesives
- Low-formaldehyde wood products
- Fresh air intake filters: MERV 8
- Return air pathway vents
- Kitchen fans: outdoor venting
- Bath fans: ENERGY STAR, continuous operation with humidity sensors
- ASHRAE 62.2 ventilation rates
- Non-smoking community

The ventilation system provides high indoor air quality.

Indoor Air Quality

Ensuring the health benefits of Indoor Air Quality (IAQ) was a central goal in creating this new housing for agricultural workers, who often have high rates of asthma due to occupational exposure and substandard housing. The key components of providing for IAQ include limiting the use of indoor pollutants, providing sufficient ventilation to remove pollutants and moisture from the inside, and controlling the entry of pollutants from outside.

One of the most important things a residential builder can do to ensure IAQ is to avoid the use of products that contain formaldehyde and volatile organic compounds (VOCs). Zero-to low-VOC paints, stains, and adhesives were used throughout Mutual Housing at Spring Lake, and interior flooring, doors, cabinets, and trim materials have reduced levels of formaldehyde.

"At a green leaders presentation my wife and I learned how to reuse glass bottles to make beautiful vases and kitchen accessories. We are proud to be part of a community that cares for the environment."

The development also benefits from advanced fresh air mechanical ventilation, as well as operable windows and ceiling fans in every bedroom and living room. High efficiency in-take filters and return air pathway vents were installed in every bedroom door. All kitchen fans vent to the outside. All bathroom fans are equipped with humidity sensors that operate continuously until humidity is reduced to acceptable levels. Control of contaminants from construction dirt and debris was achieved by sealing all permanent ducts and vents until construction was completed. All homes have carbon monoxide detectors.

Because second-hand and even third-hand smoke is widely known to cause respiratory and other adverse health effects, and because it is possible for smoke to permeate through walls and between floors, Mutual Housing opted to ban smoking in all of the residential apartments, as well as in the management office, community room, garden plots, playground, and anywhere within 20 feet of these facilities. In addition to providing a healthier community, this decision reduces the risk of fire and decreases the potential for high maintenance and cleaning costs in apartments that become vacated when smokers move out.

Financing Zero Net Energy

Cost does need to be taken into account when planning a ZNE development. The additional cost to construct the energy efficiency measures required to meet our ZNE goals, rather than the minimum Title 24 standards, was $511,327. The cost for the solar panel system was $973,351, bringing the total ZNE increment to $1,484,678.

Part of this almost $1.5 million incremental cost was paid by rebates, including $32,347 from Pacific Gas & Electric's California Multifamily Housing program which supports energy efficiency measures.

An additional $376,169 rebate from the PG&E New Homes Solar Partnership supported the installation of the solar panels. The combined benefit of these two rebates reduced the hard cost premium for the ZNE energy efficiency measures and renewable energy system down to just about $1.1 million. This represents an 8 percent premium over a similar building without solar panels that would have just met the Title 24 standards.

Incremental Cost for Zero Net Energy

Measure	2008 Title-24 Basecase	Spring Lake Specifications	Base Cost	Actual Project Cost	Incremental Cost
Envelope					
Exterior Wall Construction & Insulation	2x6 R-19 16"oc	2x6 R-21 16"oc	$21,435	$28,121	$6,686
Foundation Type & Insulation	Slab, uninsulated	Slab, uninsulated	Same	Same	$0
Attic Insulation	R-38 attic insulation	R-49	$22,580	$28,276	$5,696
Roofing Material	Comp shingles, CRRC certified, w/ radiant barrier	Comp shingles, CRRC certified, w/ radiant barrier	Same	Same	$0
House Infiltration - Blower Door Test	7 ACH50	4 ACH50	$0	$22,994	$22,994
Glazing	U-value = 0.40, SHGC = 0.40	U-value = 0.29, SHGC = 0.19	$0	$8,600	$8,600
Thermal Enclosure Checklist / Quality Insulation Installation	No	Yes (sealing at top/bottom plates, quality insulation, etc)	$0	$3,400	$3,400
HVAC Equipment					
Heating Type & Efficiency	Single speed heat pump: SEER 13, HSPF 7.7	Altherma inverter driven heat pump: SEER 13, HSFP 11	$141,196	$405,304	$264,108
AC Type & Efficiency					
Heating & Cooling Distribution	Ducted	Ducted	$349,816	$349,816	$0
Hot Water Production		HW storage tank	$0	$86,956	$86,956
Duct Location & Insulation	R-6 ducts located in attic	Conditioned space: Dropped soffits (flats). Burried ducts (townhomes)	$0	No change with Daikin system	$0
Mechanical Ventilation	Exhaust fans per ASHRAE 62.2	ENERGY STAR exhaust fans per ASHRAE 62.2	$17,136	$29,084	$11,948
EnergyStar HVAC Contractor Checklist	No	Yes	$0	$21,867	$21,867
Return Air Pathway Vents at Bedrooms	No	Yes	$0	$28,508	$28,508
Water Heating Equipment					
Water Heater Type & Efficiency	Gas storage: 0.575 Energy Factor. Includes gas line	Altherma heat pump: 2.4 Energy Factor	$67,300	$0	-$67,300
Evolve Shower Heads	No	Yes	$0	$5,464	$5,464
Appliances & Lighting					
EnergyStar Appliances	None	Dishwasher & refrigerator	$0	$6,200	$6,200
Lighting Package	~1/2 fluorescent, ~1/2 incandescent	~1/3 fluorescent fixtures, ~2/3 LED A-lamp bulbs	$81,600	$187,800	$106,200
Solar PV System					
PV System 209.04 kW DC	None		$0	$973,351	$973,351
		Subtotals:	**$701,063**	**$2,185,741**	**$1,484,678**
		Incentives/Rebates:	**$0**	**-$408,516**	**-$408,516**
		Estimated Total Hard Cost Premium:	**$701,063**	**$1,777,224**	**$1,076,161**
				Total Construction Cost:	**$13,970,997**
				Cost Increase:	**8%**

Mutual Housing CALIFORNIA

Uses of Funds	
Acquisition Costs	$1,485,547
Hard Costs	$13,970,997
Soft Costs	$7,017,657
TOTAL	$22,474,201
Sources of Funds	
Conventional Bank Loan	$1,159,000
USDA 514/521 Loan	$5,500,000
City of Woodland Loan	$910,000
HCD - Joe Serna Jr Farmworker Housing Program Loan	$1,000,000
9% LIHTC Investor Equity	$13,290,685
Rebates & Incentives	$408,516
Deferred Developer Fee	$206,000
TOTAL	$22,474,201

Achieving ZNE, though, made the full project more competitive for $5.5 million in funding from the U.S. Department of Agriculture – Rural Development housing program that it would not have been able to obtain otherwise and which was awarded together with a valuable rental subsidy.

ZNE features also made the project eligible for Business Energy Investment tax credits and increased its competitiveness in applying for federal Low Income Housing Tax Credits from the California Tax Credit Allocation Committee.

Resident meeting to discuss electricity usage and zero net energy components.

First Year Operations

Resident Education and Involvement

Mutual Housing at Spring Lake opened its doors in March 2015 and was fully occupied with 62 agricultural worker families by June of that year. Many of the new residents came from sub-standard, older, and/or smaller housing situations and were unfamiliar with many of the energy efficiency features of their new homes, such as smart thermostats, thermostatic shower shut-off valves, ceiling fans, humidistat fans, energy monitors, and virtual net metering. This made resident education key to success in meeting the ZNE goals of this community.

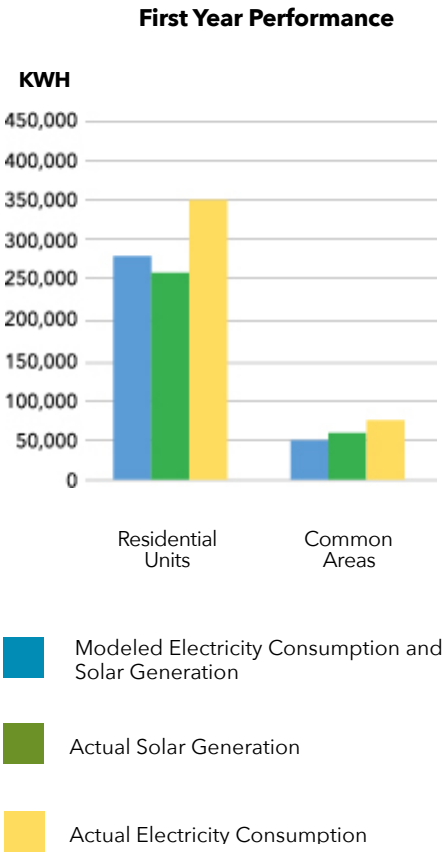
Community outreach and marketing efforts began even before construction and included information on the green goals and energy efficient features of the community. Once residents moved in, they were given a Resident Green Guide that was published in both English and Spanish. The Resident Green Guide provides an overview of the Mutual Housing at Spring Lake green building features and graphically illustrates how to use the energy monitors, thermostats, and shower valves. The guide also includes tips on green cleaning methods, recycling, and pest management.

In addition to providing written materials, staff offered in-person training in both group settings and to individuals in their homes. Residents learned, among other things, how to best operate their air conditioning and heating systems, how to engage with their energy monitors, and how to read and understand their utility bills.

Mutual Housing also hosts ongoing green education for residents through its established Green Leaders program, which focuses on recruiting, training, and offering stipends for residents who agree to plan, lead, and execute green education projects that benefit the community.

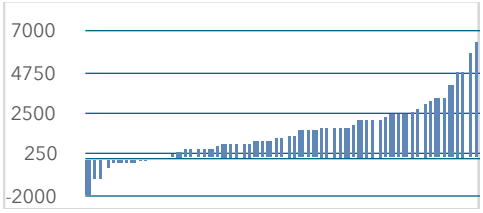
Energy Performance

Mutual Housing at Spring Lake is an all-electric community, where the ZNE goal is for the solar panels to produce as much electricity as is consumed by the common areas and the residential units on an annual basis.



The first side of the equation is the electricity generation. The 209 KW DC system was designed to produce approximately 330,000 KWH of electricity annually. This electricity is fed directly back to the utility grid, then administratively credited to the utility bills for each individual apartment and the common area. The solar panel system produced approximately 96 percent of the expected generation through the first two years. While this solar production is well within an acceptable range, there were a few challenges that affected overall production. First, the solar panels became heavily soiled at times. Cleaning the solar panels boosts production by 6 percent immediately, but the benefits wear off fairly quickly as panels can become soiled again. Second, a few inverters and meters malfunctioned for a variety of reasons, stopping the flow of electrical credits. Periodic visual inspections of the equipment along with the on-line monitoring system allowed staff to identify the issue and bring the system back on-line without too much down time.

First Year Net Energy Consumption Per Household (KWH)



These households consumed ***less*** electricity than they received in solar credits

These households consumed ***more*** electricity than they received in solar credits

The other side of the equation is electricity consumption. The energy model used in the development planning phase predicted the average amount of electricity that would be consumed by a conservation-minded household living at Mutual Housing at Spring Lake. During the first full year of operation (2016), the property consumed approximately 28 percent more electricity (+95,000 KWH) than expected and 33 percent more electricity (+108,000 KWH) than was generated on-site. The common areas and the residential units shared in the over-consumption in different ways.

The electricity consumption of the common areas, which includes site lighting and community room, management office, computer lab, and laundry room uses exceeded the energy model by approximately 22,000 KWH. One potential cause was revealed by analyzing time of use data. This analysis determined that we underestimated the number of laundry loads (dryer use in particular), as well as the electricity draw per load.

The total electricity consumption by the residential units exceeded the energy model by approximately 72,000 KWH or an average of 98 KWH per month for each unit. 42 percent (26 units) of households had actual energy usage that conformed to the energy model very closely. About half the units exceeded the consumption model by a moderate amount. Five units grossly exceeded the energy usage estimates.

Here are a few of the identified reasons for not meeting the ZNE goal in the first full year of operations:

- The energy modeling is based on an *average* household and not all households will conform to the average. Mutual Housing at Spring Lake houses both agricultural worker families and retired agricultural workers. Not all adult members work outside of the home year round.
- Some residents like to keep their apartments cool while others like to keep them fairly warm. Some residents like to enjoy long, hot showers.

Moving forward, Mutual Housing has developed a strategy to work more closely with the resident households using the highest amounts of energy.

- 2015 and 2016 were the hottest local years on record with 25 percent more cooling degree days than a typical year. This resulted in the need for more air conditioning than the engineering model predicted.
- Many residents did not take full advantage of the energy efficiency equipment (such as ceiling fans, energy monitors, shower valves) installed in their apartments.

Moving forward, Mutual Housing has developed a strategy to work more closely with the resident households using the highest amounts of energy, and to continue education and support of all residents toward meeting ZNE goals.

Lessons Learned

It is important to have the owner's representative be the "ZNE Champion" and to work with an architect and general contractor committed to the ZNE goals of the project.

Achieving ZNE goals requires everyone on the development team to push the envelope in designing and building a project with new methods and greater coordination of design, construction, and processes. It is important for the owner's representative to set the stage, define the team goals, and continue to encourage high levels of coordinated communication and problem-solving throughout the design and construction process. This work will be much easier and ultimately much more rewarding if the architect and general contractor can enthusiastically engage in the challenge.

Achieving ZNE goals requires everyone on the development team to push the envelope in designing and building a project with new methods and greater coordination of design, construction, and processes.

It is important to have an energy consultant on the design team.

The energy consultant should be able to introduce the team to equipment and techniques that are not part of typical American construction. Our energy consultant pushed the team to consider new products that otherwise were unknown to the team but helped significantly in successfully meeting the ZNE design goals.

It is important to market and communicate ZNE accurately in order to manage resident expectations.

With great enthusiasm for this new ZNE community, Mutual Housing's initial marketing efforts touted the sustainability benefits of the new development with an emphasis on stating that residents would have very low or no electricity bills. In actuality, this was not necessarily the case for everyone, and especially not on a month-by-month basis.

First, it needs to be clear that the ZNE benefits should be considered and promoted on an annual basis, acknowledging fluctuations in both energy usage and solar credits from month to month. During the winter months, for example, the solar panels produce less electricity due to shorter days, while households use more electricity when heating demand is the greatest. While the total usage and total credits should be about equal over the course of an entire year, households may very well receive sizable electricity bills in months when usage is above the monthly average.

Second, it needs to be clear that while the energy modeling is based on what an average, conservation-minded household would be expected to use each month, not all households will reflect that average. Some households will closely match the model, while others will use more or less. For a household with high electricity usage, that usage will likely exceed the solar allocation each month so that the potential for zero or low energy bills may not be realized even on an annual basis. These households will also jeopardize the likelihood of meeting ZNE goals for the development as a whole. At Mutual Housing at Spring Lake, about 10 percent of the households used much more electricity in the first year than the energy model predicted. A plan should be developed to identify those households early and work with them to support and encourage responsible energy use.

It is important to closely monitor both installation and operation of ZNE building systems.

At Mutual Housing at Spring Lake, there were three noteworthy instances of items not operating as intended:

1) Thermostatic Showerheads. The thermostatic showerheads with shut-off valves were installed with the expectation of

providing an efficient flow rate and cutting down on water waste due to resident behavior. Some households, though, removed the showerheads and installed their own, less efficient ones. After discussions with these residents, Mutual Housing discovered that it was not the flow rate or shut-off valve that was the concern – it was that they needed or preferred a handheld wand. To address this issue, Mutual Housing now makes handheld wands available that work in conjunction with the thermostatic valves.

2) Heat Pumps Systems. The Daikin Altherma heating, cooling, and hot water heat pump system installed at Mutual Housing at Spring Lake is a highly technical system with a variety of settings that can be calibrated for optimal performance. While using this type of system was a major factor in successful ZNE design, ZNE performance was compromised when about 60 percent of the hot water heater temperature gauges were improperly installed. This caused the heaters to run continuously even after the water temperature set point had been reached. Unfortunately, the extra electricity needed to heat the water past 120 degrees came from the auxiliary, less-efficient heat strips rather than from the heat pumps. This situation resulted in excessive electric bills for those apartments where this was occurring. Once this issue was identified and corrected, electricity usage in those apartments dropped significantly.

3) Monitoring Energy Usage. This is a challenge for a multifamily property. Obtaining utility provider releases from each resident is one way to gather the information, however it is time intensive and may be incomplete if residents refuse to sign releases or apartments experience turnover. The most effective way Mutual Housing staff found to track consumption was to periodically read the actual electric meters. Staff could then take these readings in combination with solar production billing to compute ZNE progress.

It is important to provide ongoing staff education and encourage knowledge sharing.

Ongoing education for and collaboration between development, property management, and asset management staff will support the staff's ability to make good decisions in understanding, selecting, and operating new green technologies. This education should contribute to an information loop where lessons learned during operations inform choices made for future developments.

The Fruits of Our Labor Mural

Mutual Housing California commissioned a local art professor and his class to interview the new residents of the community and come up with an image that represents their life journey. The collaborative image, painted on the wall of the community room, depicts the different turns life can take, while displaying the various narratives of community members. The cultivation of the land, the fruits of their labor, and the foundation of a family home are all represented as goals, achievements and healing happening concurrently in full circle. This mural serves as a reflection of the humility, faith, and hope found in the community.

The mother with the child on her back, on the right side of the mural, is holding a bundle of fruits and vegetables that she harvested in the fields. At the center of the bundle lies her heart, el corazón. The harvested vegetables are sprouting from her heart to symbolize the connection the woman feels toward the earth and the fruits of her labor.

The community image portrays the bond that is found at Mutual Housing at Spring Lake. It is through community that people create safety and a place where they can speak up about their problems. In this image on the zarape, unity, safety, respect, and protection come together as one.

"Mutual Housing at Spring Lake uses our natural resources efficiently and makes an immediate, positive impact on our planet."

– Rick Fedrizzi, US Green Building Council Chief Executive Officer

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Founded in 1988

Mission:
To develop, operate, and advocate for sustainable housing that builds strong communities through resident participation and leadership development.

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