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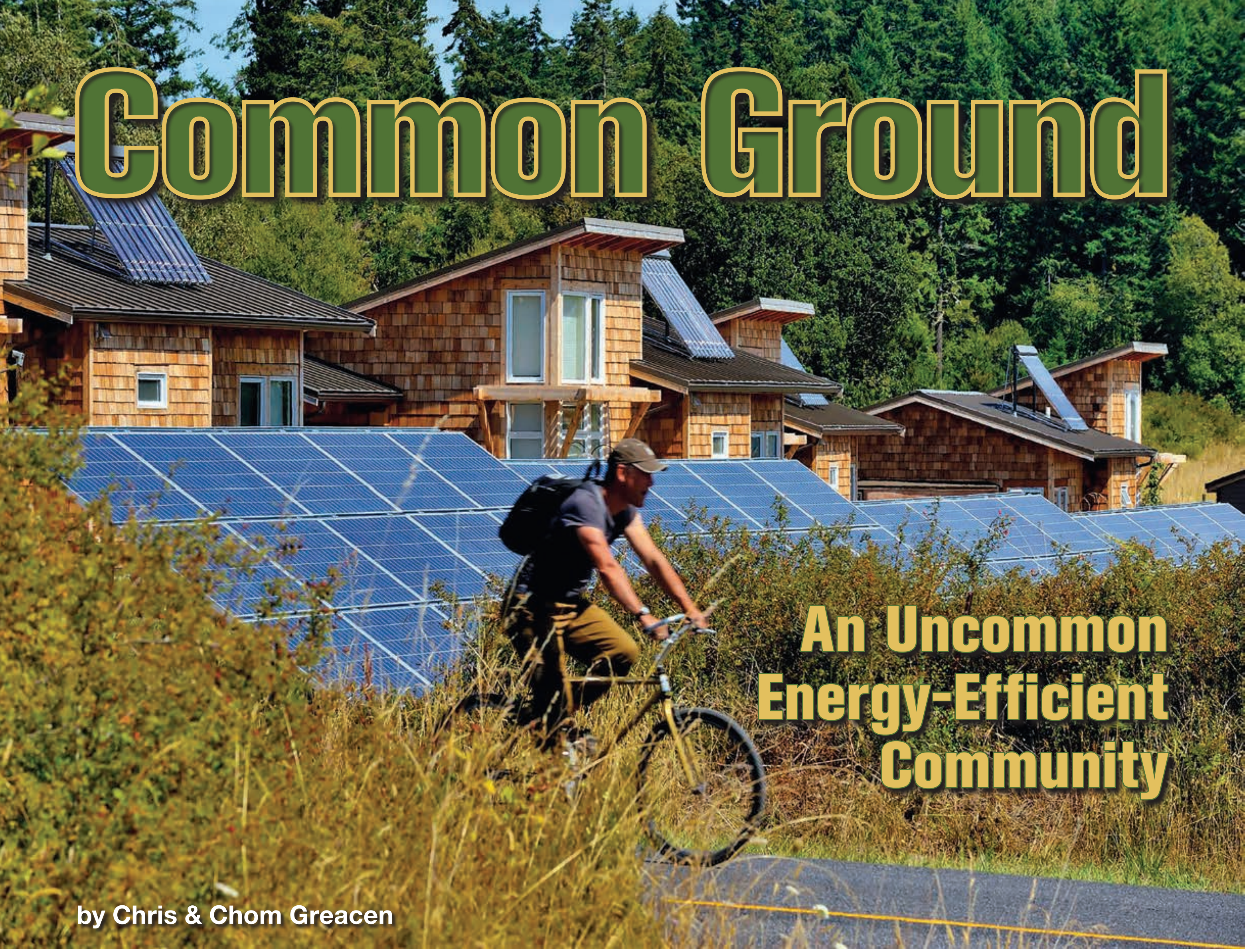
Common Ground



An Uncommon Energy-Efficient Community

by Chris & Chom Greacen

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In 2006, a group of local residents set a goal of creating net-zero-energy (NZE) straw-bale homes as part of the Lopez Community Land Trust (LCLT), an affordable housing project on Lopez Island in rainy Washington State. By 2007, we had architectural drawings and engineering designs. In 2008, we became a part of the resident-builder construction process of 11 homes, and have lived in one of these cozy homes since their completion in March 2009.

Chom Greacen

Project Origins & Objectives

In 1989, home prices on the island rose 189%. Locals found it increasingly difficult to find affordable housing. A group of Lopezians came up with the idea of a community land trust (CLT) housing development as a possible solution. In a CLT, land is held in trust by a nonprofit organization and removed from the speculative real-estate market for perpetuity. The homes are owned by individuals through cooperatives. LCLT homes are allowed to increase their value only 3% (noncompounding interest) per year, thus ensuring permanently affordable housing. There are roughly 250 land trusts in the United States.

By 1992, LCLT had finished seven homes in Morgantown, the first affordable housing project in Washington State. The homes were built with resident sweat equity, working with volunteers, LCLT interns, and contractors. After Morgantown, the LCLT completed Coho (seven homes, 1995); Innisfree (eight homes, 2003); Common Ground (11 homes, 2009); Tierra Verde (four homes, 2012); Salish Way (three homes, 2015); and is working on three additional homes.

Site Design

1 Evacuated-tube solar hot water collectors
2 Potable water tank & pumphouse
3 Rainwater catchment tank & pumphouse
4 Pond for storm-water control & irrigation
5 Rain gardens
6 Bioswale
7 PV arrays

Many who turned to the LCLT for housing did not qualify for traditional mortgages, which usually require excellent credit history and reliable, consistent income history. LCLT negotiated a group mortgage on behalf of the homeowners who formed the cooperative. The cooperative makes mortgage payments to the bank, and each co-op member pays their share of the mortgage to the co-op. Ownership of one share in the cooperative entitles the shareholder to reside in one of the homes. If a shareholder is unable to pay, the co-op tries to work with the shareholder to address the payment issue, taking into account the shareholder's circumstances. A backstop for the first few months of delinquency is to deduct the monthly assessments from the shareholder's equity. Continued nonpayment can be grounds for being asked to leave the cooperative. In that event, the share is sold at full value, but the shareholder receives a reduced amount, reflecting the amount withheld by the co-op for nonpayment.

Built in 2008, the Common Ground community on Lopez Island, Washington, is a showcase of energy efficiency and social collaboration to provide an oasis from rising housing costs.

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The 11 energy-efficient homes use both active and passive solar energy strategies.

Pioneering Affordable Homes

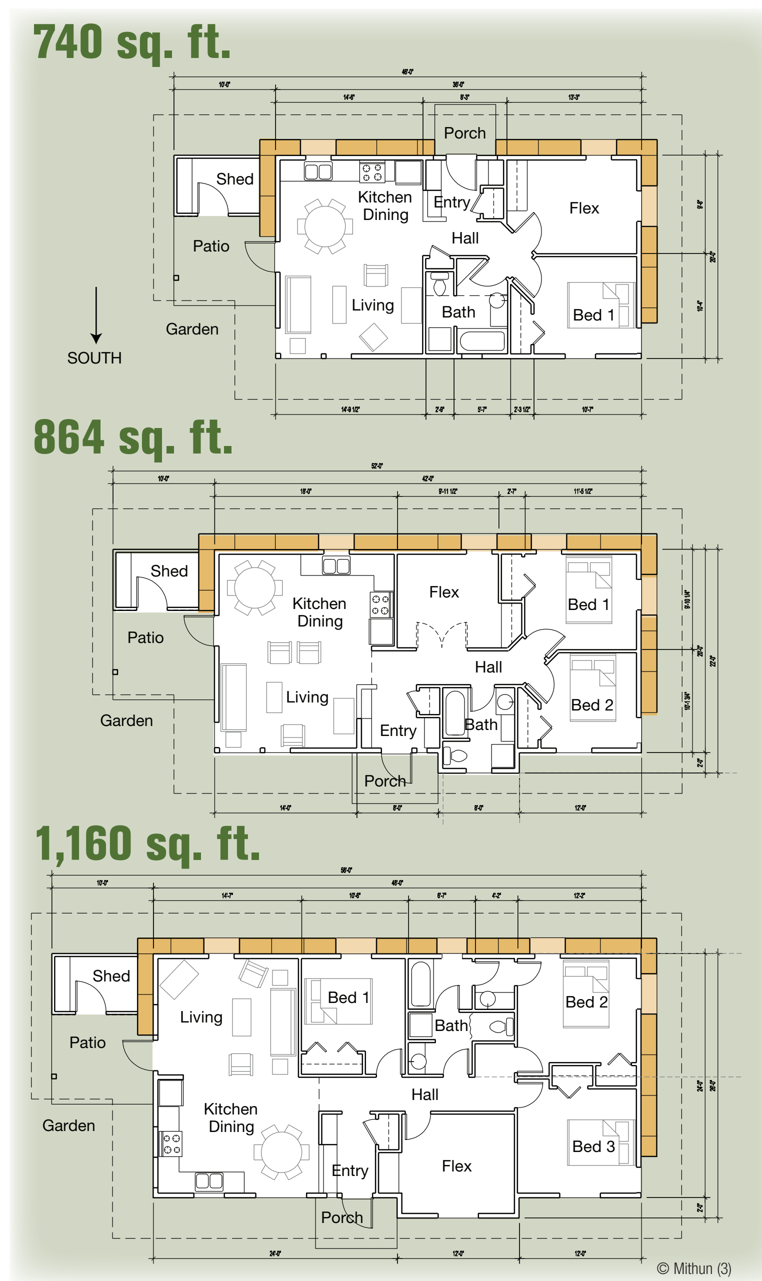
Inspired by a speech by William McDonough, the author of *Cradle to Cradle*, a manifesto calling for transformation of human industry through low-waste and ecological design, LCLT members focused on developing an NZE neighborhood called Common Ground, with a project concept of superinsulated, passive solar, solar-powered, straw-bale homes, with water catchment and permaculture landscaping.

LCLT contracted with solar installer Dana Brandt of Ecotech Energy Systems to further evaluate the NZE concept. Ecotech used recorded data from the three existing LCLT communities of 22 homes and information from existing NZE home projects to estimate the energy requirements for Common Ground homes. Seattle-based architectural firm Mithūn was selected to guide the homes' design. The designs evolved as LCLT and Mithūn made revisions based on available budget, skills, and timeline. The final design called for 11 homes in three different sizes: 740, 864, and 1,160 square feet.

Building Efficiency First

Solar siting and an efficient envelope. With excellent solar exposure from horizon-to-horizon, the homes are oriented with east-west lengths and substantial south-facing glazing for maximum solar gain in the winter. A high south-facing clerestory with operable windows assists with passive, stack-driven ventilation. The floor of each house is a 4-inch concrete slab above a 2-inch layer of R-10 rigid foam insulation. This provides thermal mass for absorbing daytime solar gain. When inside temperatures start to fall, this stored heat is released to heat the space. Several layers of earthen (interior) and lime plaster (exterior) finish over the straw bales provide additional thermal storage.

The north, east, and west walls are nonload-bearing straw bale (timber-frame structure) providing R-34 to R-42—double the level required by local code. The south walls are 2-by-6 studs, with blown in cellulose for R-21. A cathedral



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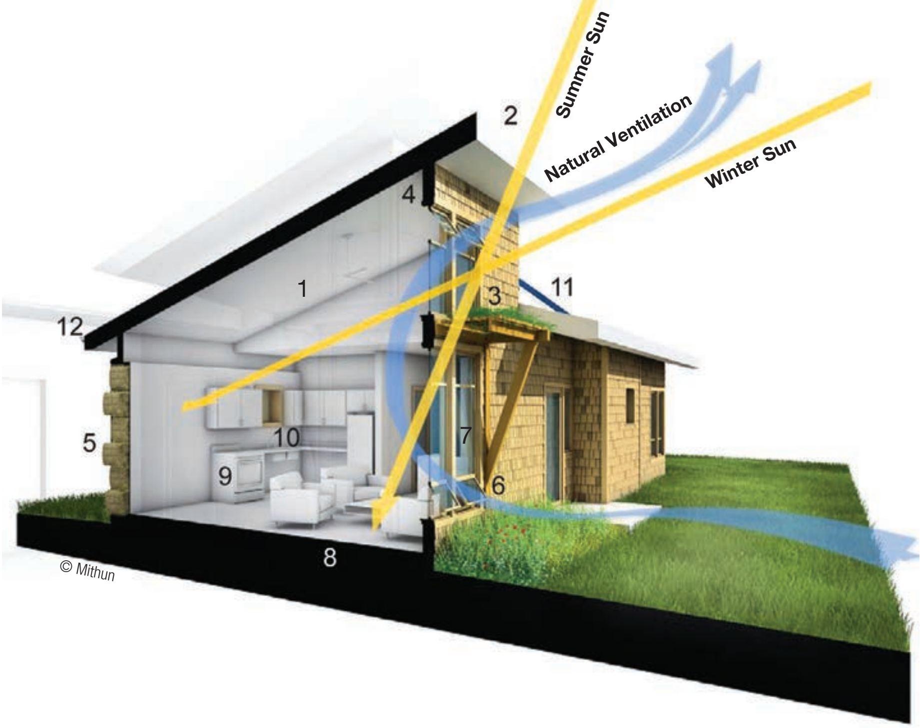

House Systems

1 Home sizes are small to reduce energy and resource use.
2 Overhangs were sized to allow heat gain in winter and provide shading in summer.
3 Vegetated trellis shades lower windows.
4 Superinsulated roof and walls.
5 Straw bales at north, east, and west walls provide insulation.
6 High-efficiency operable windows optimize solar performance, natural cooling, and ventilation.
7 Solar shades on window interiors.
8 Concrete floor provides thermal mass.
9 Energy Star appliances & lighting.
10 Water-saving plumbing fixtures.
11 Rooftop solar water heating system.
12 Rainwater catchment system provides water for toilet flushing, washing machines, and storm-water control.

ceiling above the kitchen and living room is insulated with spray foam for R-50. All other rooms have a dropped ceiling insulated with 14 inches of blown-in cellulose, also R-50. All windows are argon-filled, low-e coated, and double-pane. Windows on the south, west, and east walls have a 0.31 U-factor, an SHGC of 0.61, and a VT rating of 0.63 with double glazing and insulated spacers to maximize solar insolation. The windows on the north walls have a 0.27 U-factor, an SHGC of 0.28, and a VT rating of 0.49 with double glazing and insulated spacers to maximize heat retention.

Space heating & ventilation. Our initial building performance calculations suggested that passive solar gain could provide 40% to 50% of heating needs. At the time, minisplit heat pumps were not available, and ground-source heat pumps were cost-prohibitive, so we chose electric resistance heaters for backup. Since their initial occupancy, five of the homes have been retrofitted with minisplit ductless heat pumps. These work extremely well in the Pacific Northwest, where temperatures hover around 50°F much of the winter, and rarely fall below freezing. Whole-house fans provide supplemental ventilation. We retrofitted our house with a heat recovery ventilator (HRV), which uses a heat exchanger to preheat fresh outside air using outgoing stale air. The homes' performance were tested using a blower door test and infrared camera. During the blower-door test remaining leaks were identified and the house sealed for less than 2.5 air exchanges per hour. (Passive House standards dictate an ACH@50 Pa of 0.6 or less.)

Appliances. Lighting was initially all CFL, but since 2013 has transitioned to LEDs. Refrigerators are Energy Star-qualified models. Washing machines are low-water, front-loaders. All homes were equipped with electric clothes dryers, though many occupants choose to hang their clothes. Kitchens in

Inside, natural, nontoxic finishes help ensure good indoor air quality.

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Thick straw-bale walls offer good insulative value. The earthen plaster walls and concrete floors provide thermal mass.

Evacuated-tube solar water heating systems offset up to 75% of each household's domestic hot water.

most of the homes were outfitted with conventional electric ranges, though two homeowners chose to use propane. Only one house has a dishwasher (added several years ago).

Water systems. Three sources of water serve the LCLT. The first is conventional well water, with a class-A treatment system (chlorinated, with arsenic removed) and a 23,000-gallon storage tank. This is used for all potable water, for the kitchen, bathroom sink, and shower/bath. The second water system is rooftop rainwater catchment, plumbed on separate lines into each house for nonpotable uses, including toilet flushing, clothes washing and outdoor spigots. Water that falls on the metal roofs is collected using gutters and flows to a 34,000-gallon metal storage tank located at the edge of the Common Ground neighborhood. We had hoped to have the rooftop catchment system be the only water source used for all household purposes, but San Juan County required the well and class-A system, which has proven to be a considerable expense for the LCLT. The third system is pond water, collected as runoff from the site via a swale and ditch, which is used for three household gardens. Water is conserved in the houses through the use of low-flow showerheads and low-flush toilets.

The solar water heating system includes an 80-gallon SuperStor tank with built-in heat exchanger and a FlowCon FA glycol pump station. The glycol is heated by rooftop-mounted Thermomax evacuated-tube collectors.

Active Solar Energy

Solar water heating. Twenty rooftop-mounted Thermomax evacuated-tube solar collectors provide up to three-quarters of each household's domestic hot water. When the temperature in the solar manifold on the rooftop exceeds the temperature of the water in the solar storage tank, a pump circulates solar-heated propylene glycol through a heat exchanger built into the lower portion of the HTP brand water tanks. Larger homes have 80-gallon tanks; smaller homes use 50-gallon tanks. A 240 VAC heating element in the uppermost portion of the tank provides backup heating. Thanks to the physics of thermal stratification, this means that the electric element heats the water in the top tank, leaving cooler water at the bottom of the tank that the solar system, when available, can heat.

Starting in early April, several households (ours included) turn off the circuit breaker to the tanks' heating elements to heat entirely with solar. When daylight hours grow shorter in October, we flip on the breaker. But we're convinced that solar-heated showers feel better.

When the CG homes were built, evacuated tubes were the best option for solar water heating. In subsequent years, the price of PV has plummeted, and affordable heat-pump water heaters have become available. In Tierra Verde, built after CG, instead of evacuated-tube collectors, the LCLT elected to add another kW of PV modules and use heat-pump water heaters instead.

This has several advantages. First, it works better with the seasonal availability of sun in our climate. We get a lot of sun in the summer—so much that CG's water tanks need to be monitored to ensure that they don't overheat. Overheating triggers the water tank's pressure-relief valve, losing hot water. This is dangerous, as pressure-relief valves are not designed for routine use, and venting hot water outside—near straw-bale walls—is exactly what they do not need. During the summer, some households, ours included, turn a portion of the evacuated tubes away from the sun to reduce system overheating. During the winter, when the number of sun-hours dwindles, the evacuated-tube systems don't typically generate enough hot water and we have to turn on the tanks' electrical heating element.

Another advantage of using a PV array and heat-pump water heater is that there is less plumbing. Our solar water heaters have worked pretty well, but we have piping and circulation pumps and propylene glycol that needs to be replaced every few years. Wiring takes much less maintenance.

Solar electricity. From its inception, we wanted Common Ground to use renewable electricity. Lacking falling water and biomass, the two options we considered were wind and solar. A comparative feasibility study conducted by A World Institute for a Sustainable Humanity (AWISH) investigated both options, making use of a loaned anemometer mounted on a 100-foot tower. The results of the study were conclusive—we had a good solar site and a marginal wind site. Even in 2007, PV modules would be cheaper for us than wind turbines, and it was a pretty easy choice to go with PV technology.

The utility didn't allow LCLT to install one large community array. Instead, 11 individual 3 kW grid-tied systems were installed, one for each home. This cost more but also triggered a larger subsidy.

Courtesy LCLT (2)

The next decision was whether to have a single, large shared array or a collection of 11 smaller arrays, one for each house. Our preference was one single array and also to have the entire cooperative served by a single utility revenue meter. Installation would be less complex and the system less expensive to install. If Common Ground were to have a single utility revenue meter, we would have had to pay only a single base meter rate, saving about $4,900 annually at today's rates. But the day we were prepping the groundwork for the electricity installation, three yellow utility trucks pulled up, with the general manager of the local cooperative electricity utility, Orcas Power and Light Company (OPALCO), who informed us they had changed their minds. We weren't sure why, but we guessed it had something to do with the $4,900 per year they would gain by having the monthly meter charge from 11 meters instead of one. By then it was too late to appeal. On the bright side, OPALCO offered subsidies for customer-owned, grid-intertied PV systems at $1.50 per watt, peak. The subsidy was capped at $5,000 per system. This helped soften the blow of having to change our plans—we received $49,500 in subsidies from OPALCO after the systems were commissioned.

With help from NW Seed (now NW Spark), a Seattle-based RE advocacy group, a request for bids (RFB) was issued. The RFB instructed companies to submit bids that included cost savings by using local resident and volunteer labor. After reviewing proposals from several companies, Power Trip in Port Townsend was chosen because it met technical specifications, had an attractive price offer, and had a great reputation. Power Trip designed and procured equipment for 11 identical 3.075 kW batteryless GT PV systems. Their bid included labor only to install the first two, which would serve effectively as reference model systems. Washington law allows homeowners to pull their own electrical permits. Making as-needed visits to the professionally installed system to examine how the installers treated certain details, homeowners and interns installed the remaining nine systems.

Each PV system has 15 Evergreen 205 W PV modules feeding a SMA Sunny Boy 3000 inverter. Electricity production is metered with a utility AMR meter that is read remotely by OPALCO. PV production is compensated through Washington State's RE production incentive. For the first few years, we were compensated $0.15 per PV kWh produced, but in 2017, this dropped to about $0.081—OPALCO's quota under the Washington RE production incentive is heavily oversubscribed and is parsed out pro-rata.

OPALCO provides an annualized net-metering, earning monetary credit for surplus solar energy produced during the summer and drawing on these credits when PV production is less than consumption. Homeowners whose homes are net-positive energy producers are compensated by OPALCO for their surplus electricity in July of every year at $0.04 per kWh, a rate roughly equal to the utility's wholesale electricity cost.

Wide-open solar exposure on the site's southern boundary made a ground-mounted array preferable.

Courtesy LCLT

Community members and volunteers worked together to build the straw-bale homes.

Courtesy LCLT (2)

Community & Home Building

Residents put in "sweat equity" to complete the project. We were a diverse crew, ranging in age from early 20s to over 70 years old. For our family, the quota was 26 hours per week, calculated based on the square footage of the home. In addition to future residents, construction labor was also provided by "building partners" (friends and family) of future residents to help meet their respective sweat equity requirements, and by a wonderful cohort of national and international interns. Many of the interns were recently graduated from college and, after four years of sitting at desks, were eager to work with their hands on a sustainable construction project. Others were retirees and folks in career transitions who dedicated several months of their lives to participate in a meaningful project.

Interns boarded in the homes of Islanders, typically exchanging eight hours of additional labor per week at their hosts' homes for a room—all arranged by LCLT. Additionally, the project accepted walk-in volunteers once they had been checked out on tool safety. Professional carpenters worked side by side with the interns and volunteers, providing hands-on training when necessary. Each weekday began at 8 a.m., rain or shine, with a safety talk and discussion of the days' activities. A local restaurant, Vitas, provided hot soup most days at lunchtime, and a local bakery, Holly B's, provided goodies consumed during the workday's two 15-minute breaks. Residents, interns, and volunteers did most of the construction, but LCLT hired contractors for the rough framing, drywall, plumbing, and electrical.

The straw-bale building process was perfect for an untrained volunteer workforce on a budget.

Courtesy LCLT (3)

Straw-Bale Construction in the Pacific Northwest

Straw-bale buildings require "good boots and a good hat." The "good boots" means a foundation sufficiently high off the ground to protect the plaster and bales beneath from rain splatter, and keeping the walls free from moisture from plants. A "good hat" means sufficiently deep eaves to protect the plaster-and-bale walls from wind-driven rain.

Our hat initially wasn't so good. Engineering, architecture, and cost decisions led to relatively small eaves. After three years of residency, water damage was causing mold growth in some straw-bale walls, particularly those exposed to our island's strong southeast winds that bring driving rain. The primary factor was the quality of lime plaster used, which ended up acting more like a sponge and less like a raincoat. Many problem areas were transitions between materials—for example, where lime plaster interfaced with wooden windowsills.

Fixing the problem was expensive, time-consuming, and anxiety-producing. LCLT purchased specialized moisture removal equipment and we drilled dozens of holes in each wall and attached tubes that siphoned moisture from deep in the walls. We built generous awnings over east- and west-facing straw-bale walls. Two of the straw-bale walls had to be completely rebuilt. We have implemented an annual inspection process in spring during which we take moisture readings with a long straw-bale probe, and, over the years, have applied layers of additional lime-wash using a higher-quality lime. The problem that once loomed large seems to have been remedied.

While the straw-bale walls are beautiful—people love the gentle curves in the spaces—they're a lot of work in this climate. Subsequent LCLT building projects chose other insulation materials.

Courtesy LCLT

Cooperation and camaraderie during the building process made for an emotional investment in the community.

"My heart grew three sizes," says one resident of the construction process. The homes were built in concert with each other, with everyone working on each of the homes as needed. Working side by side, we shared stories, music, laughter, and developed a deep trust in each other. When challenges emerged, this bedrock of trust held us together. The alchemy of working together fostered an atmosphere in which everyone's contributions were valued. Those who were highly skilled in the trades often handled more difficult tasks, or accomplished them more quickly. But those learning carpentry were encouraged to move at their own pace, prioritizing safety and following the carpenter's maxim: "Measure twice, cut once."

In CG, NZE Relies on End-User Behavior

We found that user awareness and behavior accounts for huge differences in electricity consumption. After move-in, residents took weekly meter readings of electrical consumption. By sharing this information and nurturing awareness of energy conservation, we achieved the largest reduction in electricity usage among the outlier households with high consumption levels.

The monitoring continues, albeit now on a monthly basis. Despite the initial decline in usage by the largest electricity users, differences remain. Compared to the homes with the lowest usage, the homes with the highest consumption use roughly three times as much electricity each year. This is not due to the number of people in the household: one of the households with the lowest annual consumption has four people. The difference in consumption patterns can be attributed to user behavior. Do you like to keep your house really toasty most of the time? Do you take long baths in the winter? Do you use the electric clothes dryer or hang-dry your laundry?

Notwithstanding the differences between households, our average annual consumption per household is 5,900 kWh—about 47% of the Washington State average and 54% of the U.S. average household electricity use. Our average PV production per 3.075 kW array is about 3,730 kWh per year. As a community, we are not NZE—an average household at Common Ground generates 63% of its own electricity from PV while importing the remaining from the grid—but four CG households have been certified as NZE by the Living Future Institute, with two households meeting the NZE goal year after year.

LCLT Home Stats

Total LCLT homes completed in 2015	42
Local businesses owned or run by residents of LCLT homes	16
Total land trust homes with on-site PV production	20 (48%)
Average monthly LCLT household electricity consumption	492 kWh
PV system size	3.075 kWp
Average annual PV production per Common Ground Home	3,730 kWh
Lowest annual household energy consumption at Common Ground (Nov. 2016 to Oct. 2017)*	2,737 kWh
Highest annual household energy consumption at Common Ground (Nov. 2016 to Oct. 2017)*	8,401 kWh
Number of households that have met the NZE annual goals	2*

*These two households have the same number of occupants (4).

Chris Greacen

Choosing to live in community takes commitment, but the work is empowering and fruitful.

Courtesy LCLT

Smaller Footprints, Larger Lives

Common Ground is about reinventing the American Dream. In the coming years, Americans will do well to shed entrenched habits of consuming stuff. We can embrace these adjustments if we are confident that our country is headed toward a more fulfilling transformation. We believe this transformation is really about revealing what it means to be truly human, not as "consumers," but as friends, neighbors, citizens, and co-creators of a compelling new story that supports a healthy planet and social justice. Our community is about smaller footprints and larger lives.

Resources

Ecotech Energy Systems • ecotechsolar.com • Energy systems design

Mithun • mithun.com • Home design

PowerTrip Energy • powertripenergy.com • PV systems installation