

Zero Net Energy Multifamily Case Study



OVERVIEW

Location: Issaquah, Washington

Project Size: 13,400 SF

Number of Units: 10

Construction Type: New

Completed in: 2011

Building Type: Multifamily

Climate Zone: 4C

Total Costs: \$3,034,000 (land excluded)

Hard costs: \$180/SF (land excluded)

Soft costs: \$46/SF

Measured Energy Stats

21 - 22 = -1

BUILDING'S
TOTAL EUI

RENEWABLE
PRODUCTION RPI

BUILDING'S
NET EUI

Site Energy Use Index (EUI) kBtu/SF/year

The Energy Equation: **the building energy use minus the renewables production equals the net energy of the building.** Buildings may be 'Getting to Zero' and have a net EUI above zero. If renewable production exceeds energy use its net EUI is below zero (negative) and it is creating surplus energy.

nbi new buildings
institute

For more information:
newbuildings.org/zero-energy



Photos: Ichijo USA

zHOME MULTIFAMILY COMPLEX

Overview

The zHome multifamily complex was the first zero net energy project of its kind in the United States. Completed in 2011, zHome is a pioneering demonstration of sustainability. The complex is made up of 10 units and a shared community area. The design approach of the project centered on energy efficiency, but also included a focus on reduction of water use, locally-sourced and recycled products, and minimization of storm water discharge. Launched as a market catalyst to bring sustainable housing to everyday people, zHome has proven to be a strong example of successful sustainability at the multifamily scale. Since the project was completed, more than 100 multifamily projects¹ have either achieved or are pursuing zero net energy performance.

The project was a joint venture between the City of Issaquah and the builder, Ichijo USA. The City provided the property with the intention of building a project that would serve as both an affordable housing project and a sustainable demonstration development. In exchange for providing the land free of charge to the developer, the City of Issaquah required that the zHome project meet strict sustainability guidelines, including zero net energy performance. The developer was also responsible for absorbing market risks during a tough economy. To promote the sustainability of the project, one of the 10 housing units was also reserved as a model unit that would serve as an education center for up to five years.

¹ Source: Internal NBI research; will be published in 2016 Getting to Zero Status Update

Team/Owner Details:

Builder: Howland-Ichijo USA

Land: Port Blakely Communities

Architect: Vandervort Architects

Energy Engineer: Stantec

Structural Engineer: Harriot Smith Valentine

Low Impact Development: 2020 Engineering

Civil: Core Design Inc.

Landscape Architect: Dar Webb Landscape Architects

Interior Design: LH Design

Part of the design process included evaluating and outlining the path to zero net energy to ensure the feasibility and means of reaching this ambitious energy target. Upon completion, zHome was certified by *Built Green*. This certification reflects the sustainable successes of the project in terms of energy efficiency, waste minimization, indoor air quality, and responsible site management.

Planning & Design Approach

From the outset, zHome was intended to be a zero net energy project. In fact, the contract between the city and the developer stipulated zero net energy performance as an obligation. To achieve this bold goal, an integrated design team composed of the architect, mechanical engineer, energy code specialist, and project managers came together to ensure a successful overall zero net energy design with minimal cost premiums.

Aside from zero net energy, other design goals aimed to make zHome a demonstration project to better catalyze the sustainable multifamily housing market. By designing an easily replicable building at market costs, future iterations of zHome projects can be developed with reduced design costs.

Other long-term considerations were taken into account when designing zHome, including: life cycle costs, durability, maintainability, and retrofit readiness. As a demonstration project, the benefits of not only the energy and water savings, but also these less tangible sustainable practices are highlighted and promoted for their market value.

As with most high performance building projects, the design team made full use of a preliminary energy model to inform design decisions. The model helps to evaluate the relative impacts and benefits of different massing, orientation, envelope, passive features, and other design strategies. The team for zHome established baseline models for the typical one, two, and three bedroom homes. With the baseline energy usage for each of the homes established, the design was optimized to lower energy consumption and incorporate renewable energy as needed to cover the anticipated energy usage over the course of a modeled year.

To provide clean renewable energy, the design team considered both small-scale wind generators and solar photovoltaic (PV) panels. Both were evaluated in-depth at the project site: wind flows were evaluated and solar availability was modeled on-site. While solar availability was sufficient, the low average wind speed of 4 mph at the zHome site was too low to enable cost-effective small-scale wind energy generation. The team decided to use solar PV panels exclusively.

Energy Efficiency Strategies & Features

The zHome design strives for minimal energy consumption as the first step toward zero net energy. This approach is not only the more sustainable route, it is also the most cost effective. Energy efficiency has long been considered the “first fuel” due to its low cost and high return on investment. Further, energy efficiency is often a passive solution, requiring little to no maintenance to realize the energy benefits. Only after all cost-effective load reduction and energy efficiency measures are incorporated into the design are renewable energy systems designed and installed.

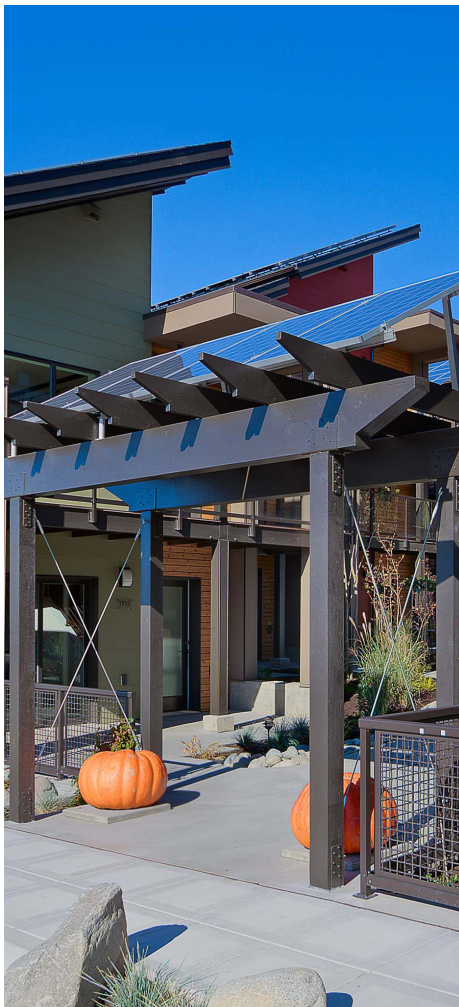


Photo: Ichijo USA



Photo: Ichijo USA

Awards & Certifications:

2012 U.S. Department of Energy
Builder’s Challenge

2012 Northwest Energy Star Project of
the Year

2011 Residential Project of the Year in
North America

2009 Smart Partnership Award

The effectiveness of the energy efficient design is validated in the energy consumption data. The energy consumption from all of the metered homes (eight of ten homes were metered) was far below the city average of 2,764 kWh. The all-electric zHome units averaged 612 kWh of energy consumption per month, an approximately 78% reduction. The primary energy efficiency measures employed are:

- High performance appliances
- R-38 Wall insulation
- R-60 Ceilings
- R-55 Structurally Insulated Panels (SIP Roof)
- U-0.30 Double paned low-e, argon filled windows
- 0.20 Air changes per hour
- Ground source heat pumps
- Low flow water fixtures (reduce hot water consumption)
- LED lighting
- Daylighting
- Smart switches to cut standby power loads

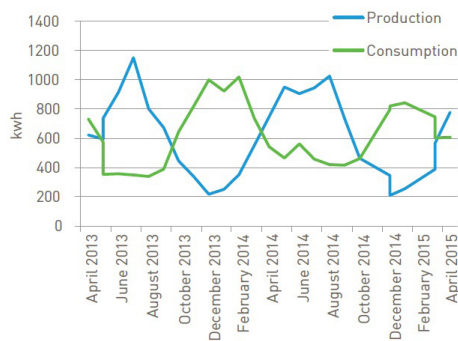


Figure 1: Total Average Solar Production vs. Total Average Energy Consumption (Source: Built Green)

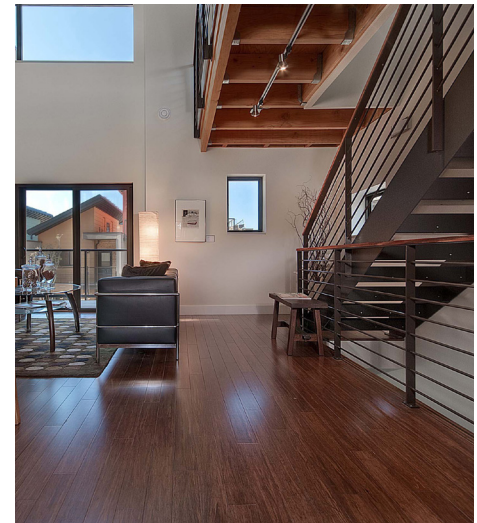
Renewable Energy Generation

Each unit has its own individual solar photovoltaic array. The arrays are sized to meet the anticipated loads of the unit. The average array capacity for the units is 6.6 kW. To reach zero net energy, the zHome dwellings rely directly on the grid to handle over- and under- production, essentially using the grid as a battery. As seen in Figure 1 below, the buildings export energy to the grid in the summer and import energy from the grid in winter. These buildings are net-metered, which means that the exported electricity is purchased by the utility at retail rates. Residential scale energy storage with batteries was deemed cost prohibitive at the time and was not included².

² In 2016, the most common battery on the market costs \$3,000 for 6.4 kWh of capacity (not installed) – approximately enough for a single-family home.



Photos: Ichijo USA



Only after all cost-effective efficiency options were implemented, and the buildings were ultra-efficient, were renewables added.

What are “Hard” and “Soft” Costs?

- Site Costs**
 - Land*
 - Land cost
 - Commission and fees
 - Title insurance
 - Transfer taxes
 - Surveys
 - Demolition
 - Site work

- Hard Costs**
 - Building*
 - Foundations
 - Enclosure
 - Interior finishes conveying
 - HVAC and plumbing
 - Electrical
 - Interiors*
 - Tenant work
 - Art work
 - Furniture, fixtures and equipment
 - Telephone & data communications system

- Soft Costs**
 - Development Costs*
 - Design fees
 - Taxes and levies
 - Insurance
 - Owner’s administration
 - Leasing commissions
 - Interim finance
 - Moving costs

Financing & Cost

The total cost of the project was \$3,034,000 including soft costs of \$622,000 and hard costs (excluding land which was donated by the City of Issaquah) of \$2,412,000.

To make informed design decisions based on cost-effectiveness, the design team estimated the cost of on-site renewable energy generation. This generation cost was then used to evaluate the cost-effectiveness of different energy efficiency measures. Using the energy model, the incremental cost of energy savings from adding additional insulation, increasing envelope tightness, specifying equipment with even greater efficiency, and other parameters was compared to the cost of generating that same amount of energy. This is the point at which increasing the efficiency of the buildings becomes more expensive than adding renewable energy generation, due to diminishing returns. Only after all cost-effective efficiency options were implemented, and the buildings were ultra-efficient, were renewables added. Over the course of several meetings, the design team used this method to select the final key parameters (envelope, leakage, equipment, etc.) for the project.

Occupant Engagement & Behavior

The role occupants play in any building is a substantial contributor to energy use – but in a multifamily building like zHome occupant impacts are even more important. Naturally, people spend many hours at home, which amplifies occupant effects. These effects, as well as increased control over the HVAC system, frequent energy intensive activities such as cooking and laundry, and many other factors combine to produce large variability in energy usage per capita in the zHome units. The personal differences in schedules, personal comfort levels, and interest in energy conservation are highlighted in the energy consumption results for the various units. The monthly energy consumption per person for the eight metered zHome units ranged from 187 to 364 kWh. The most energy intensive unit uses nearly twice as much energy as the least energy intensive unit.

As building codes get more stringent and building systems become more efficient, a larger share of total energy use in buildings is being used by plug-in devices, including appliances, computers, hand-held devices, etc. Given that occupants now have relatively high control over the total energy usage of a multifamily



Photo: Ichijo USA

building, it is very important for design teams to encourage residents to conserve energy. There are a variety of ways to achieve this, both directly and indirectly. Direct approaches include education, usage feedback, and other solutions that target occupant behavior by communicating with the occupant in one way or another.

Table 1: Demand Side Energy Conservation Strategies at zHome

Direct	Indirect
Energy feedback monitors	Heat recovery ventilation
Phantom load switch outlets	Natural ventilation
Educational sessions	Extensive daylighting
	LED lighting
	High efficiency appliances

Indirect approaches to reduce occupant-driven energy consumption include: automatically resetting controls, specifying high-efficiency equipment and lighting, incorporating energy recovery systems, and other design aspects which encourage occupants to save energy (e.g. daylighting and operable windows for cross-ventilation). In contrast, occupants in commercial buildings seldom have access to a thermostat or operable windows and commercial HVAC schedules are usually preset. Table 1, above, highlights the various strategies used in the zHome project to address these occupant-driven loads. The educational sessions coupled with the energy feedback monitors allow the residents to learn what impact their behavior has on their consumption. This encourages residents to take advantage of daylighting, natural ventilation, and phantom load switches as tools to minimize their consumption.

As seen in Figure 2, the overall per capita net energy consumption has steadily declined in the zHome units during the measured period of April 2013 to May 2014.³ Living in a building which is striving for resource conservation may influence occupants to monitor their energy usage and conserve more.

³ More analysis would be needed to determine what share of this energy reduction is attributable to weather patterns. However, the data suggest that part of the reduction in energy use is due to a behavioral shift in the occupants over time.



Photo: Ichijo USA

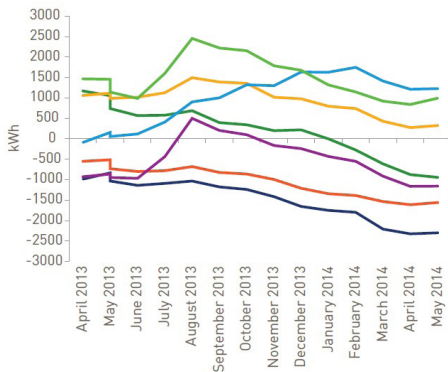


Figure 2: Net Energy Usage by Unit from April 2013- May 2014 (Source: Built Green)

For More Information

“zHome Reaches the Stars: A Built Green Emerald-Star Case Study,” King County, 2012.

“zHome Case Study,” International Living Future Institute, 2013.

“zHome: Setting a National Net Zero Energy and Green Building Precedent,” Built Green, 2015.

zHome Website: <http://z-home.org/index.php>

Successes

The zHome project has successfully demonstrated that zero net energy performance on a residential scale is achievable, despite the challenge of increased impacts of occupant behavior. zHome units use 60-80% less energy than a typical home in the area. Indirect solutions rooted in passive efficiency, coupled with direct solutions which center around occupant engagement have kept notoriously variable and unpredictable occupant-driven loads relatively low. zHome has performed at zero net energy for the past two years, showing that the project has maintained its ambitious high-performance goals over time.

Lessons Learned

- As with most zero net energy projects, establishing early project goals and embracing a fully integrated design process is crucial for success.
- High-performance projects need an educated design team and builder who are familiar with the latest technologies and sustainable best practices.
- Informed design choices were made using energy models and renewable energy costing to ensure that all cost-effective efficiency measures were included before layering in renewables.
- The zHome project, through its delays due to the economy, benefitted from a fresh evaluation of available materials on the market. Project specifications were revised to take include some of the new materials.
- Occupant-driven energy use was reduced by both direct (e.g. education and feedback) and indirect (e.g. operable windows, daylighting and natural ventilation) approaches.