zHome: Setting a National Net Zero Energy and Green Building Precedent

OUTCOMES AND LESSONS LEARNED

Table of Contents

Executive Summary

zHome was the first net zero energy townhome complex in the United States. The project was launched to spur the market toward deep green housing for the average person. As such, zHome was built to rigorous environmental benchmarks of net zero energy use, a 70% reduction in water use, a 90% construction recycling rate and the use of only low- and non-toxic materials among other specifications. All zHome units that went up for sale eventually sold at slightly above standard prices for the time and area, despite going on the market at the tail end of the Great Recession.

Now that the development has been occupied for several years, it is important to check on its outcomes — both those of quantitative performance measures and qualitative homeowner satisfaction. Happily, based on utility data, we have found that zHome achieved its benchmark of net zero energy, and, in fact, releases excess energy onto the grid, producing 3.5% more energy than is consumed. Over a two year span, the eight units for which we have data and the community trellis generated an excess 562.8 kWh of renewable energy for the grid on top of what zHome consumed. When the net energy use is instead calculated on a rolling annual basis, zHome still comes out positive, producing an excess 160 kWh per year on average. Energy efficiency helps make this possible. The highest consuming zHome unit only uses 759 kWh per month, significantly less than the Issaquah average of 838 kWh. Additionally, despite a recent drought, the average zHome resident uses 16.07 gallons of water from the utility per day, which is well under average — depending on the baseline comparison, either approaching or exceeding a 70% reduction.

Interviews with homeowners demonstrated that although adapting to life in a zHome necessitated getting used to new technologies and involved a learning curve, life is comfortable and enjoyable. In fact, zHome owners have become outspoken on the topic of green living after moving into their zHome. Now, after a few years of occupancy, it can be said that zHome met its goals and is a successful demonstration of what the future of green building can entail.

Background

Purpose

zHome was launched as a market catalyst for highly sustainable, climate neutral homes for the everyday person. It is the result of years of collaboration by a coalition of partners led by the City of Issaquah in concert with Port Blakely Communities, King County, Built Green, Ichijo USA, Puget Sound Energy, and the Washington State University Energy Office.

The project was made possible through an innovative development deal brokered by the City of Issaquah in collaboration with Port Blakely Communities, which provided a site for both an affordable housing community (now the YWCA Issaquah Family Village) and the zHome project. For zHome, the builder was given land at no cost in exchange for meeting strict sustainability benchmarks as well as providing for partnership project management costs, absorbing market risk and reserving one unit as an education center for up to five years. The primary benchmarks included: zero net energy use; 60% reduction in water use; locally produced, recycled content; FSC certified and low toxic materials; construction recycling; meeting high indoor air quality standards; and minimal stormwater discharge.

Progress

The design of zHome began in 2007. Detailed design processes were initiated, which included evaluating and then outlining "the road to zero energy" along with other key specifications. However, late in 2008, before final project specifications had been developed, the zHome project was paused due to the market downturn during the Great Recession. During this time, it was impossible to find a builder who was able to take on the challenge when so many businesses were collapsing. In 2010, the project recommenced with a new building partner, Ichijo USA. Ichijo is one of the largest homebuilders in Japan, where they were already well known for their innovative and energy efficient products. Ichijo signed onto the zHome project and was able to use it as an opportunity to enter the U.S. market.

Completion

zHome was certified by Built Green in September 2011. Once construction was completed, tours and educational sessions were held at zHome and the Stewardship Center — a studio unit that was designated as a learning center — was opened. The nine other units sold at standard prices for the market in that time and place. All units sold — and though the sales weren't completed until nearly two years had passed, it is impressive that all units sold despite it being the tail end of the Great Recession.

TABLE 1

Number of Bedrooms	Date Sold	Price Sold for
1	5/6/2012	$485,000.00
1	1/18/2013	$244,000.00
2	8/9/2012	$374,000.00
2	12/31/2012	$365,000.00
2	12/12/2012	$374,000.00
3	5/17/2012	$485,000.00
3	12/14/2012	$475,000.00
3	8/24/2012	$480,000.00
3	12/8/2011	$599,000.00

Lessons learned

The collaborative project planning, management and design process were important to engage key organizations and leverage resources of the various parties involved. At the same time, having a shared vision, clear project goals and team roles, combined with a knowledgeable but flexible team was critical in working through communications strategies, changing project specifications, oversight and other details. The timing of the project around the Great Recession, and its subsequent transition through multiple developers and ultimately a new market player, proved to be significant challenges to the project, particularly in early design and development, which influenced total project timing, momentum and total cost. In the end, however, a very good project team was assembled with a committed builder. The project developed a successful education campaign reaching more than 13,000 people, spurred the development of the Built Green Emerald Star rating level and demonstrated the achievement of zero net energy homes in operation.

Energy

What is net zero?

At its root, the definition of net zero, also called zero net energy, means that a building produces enough clean, renewable energy onsite to entirely cover its energy consumption. Buildings that are net zero may be connected to the electrical grid, but the amount of energy that flows off the grid into the home must be less than or equal to the amount of energy that flows onto the grid as a result of clean energy production. This is the case for zHome and many other developments.

Though the definition of net zero is fairly simple, the measurement isn't necessarily so. Energy use and production fluctuates over time — month by month and year by year. Depending on the time frame chosen, a building that produces more energy than it consumes may in fact be in the opposite situation in a different time period.

It is important to consider seasonal factors when calculating whether a building achieved net zero: in this region, energy consumption is high in the winter, when home dwellers are using their heating systems, while solar production (the common choice for clean energy production) is greater in the brighter summer months. Because of this, any net zero calculations should span at least a year, in year-long increments, in order to balance out the seasonal variation. Additionally, the timespan should be clearly specified for full transparency and clarity.

zHome net zero results

Overall

zHome was conceived as a net zero development. Each individual unit was modeled to achieve net zero through energy efficiency gains with solar photovoltaic (PV) accounting for the remaining energy consumption.

Over the two years for which we have post-occupancy energy data (April 2013 – April 2015), zHome achieved net zero energy use. zHome's net consumption over this two-year period was -562.8 kWh, or in other words, 562.8 kWh was generated above what zHome consumed and was put onto the grid. For perspective, 500 kWh is equivalent to 180 pounds of carbon dioxide emissions in Washington State. These data account for eight of the ten living units and the community trellis (which provides energy for outdoor lighting and the geothermal pumps). Given that the total energy taken from the grid for these units over the two year time period was 162,169 kWh and that 562.8 kWh were generated in excess of what was consumed, this means that zHome exceeded net zero energy by 3.5%, or almost $54 of electricity savings.

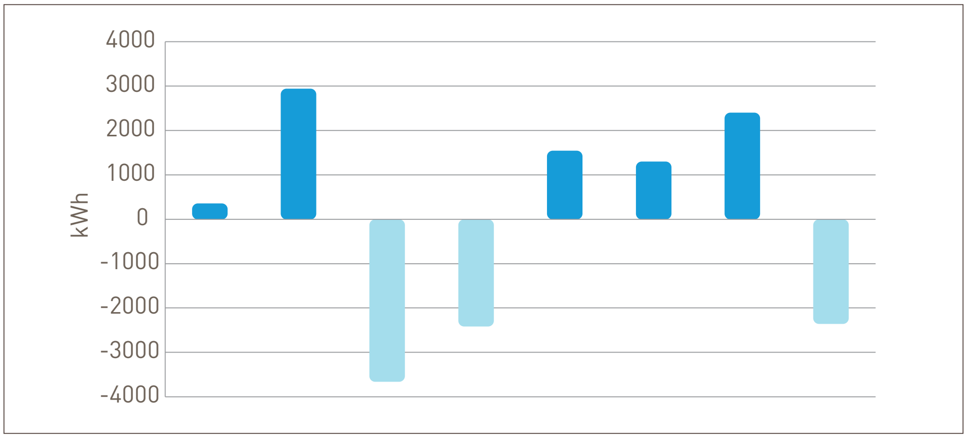
However, there was substantial year-to-year variability. Over the year-long period of April 2013 to April 2014, zHome did not achieve net zero; instead consuming a net of 1,636.4 kWh. This was reversed from April 2014 – April 2015, when zHome contributed 2,199.2 kWh onto the grid. These two years average out to a net production of -281.4 kWh.

Additionally, the data can be examined in rolling years by calculating the net use and production from each month forward for a year. By doing this, we are able to analyze all possible year-long time frames. Over the 14 periods we can apply this calculation, the eight units we have data for plus the community trellis reached net zero or better than half of the time. When averaged, the yearly net consumption is -160 kWh. Given the data, it is a safe statement to say that, overall, zHome achieved its net zero goals.

Unit by unit

Though zHome met net zero on the development scale, there was significant variation unit-by-unit, even though they had been individually modeled to achieve net zero and the PV arrays had been sized accordingly. Over the two-year span of data, three of the units achieved net zero whereas five of the units did not.

FIGURE 1: Net Energy from Grid by Unit from April 2013–2015



In total, across the two-year data period, all eight units combined consumed 111.1 kWh (just over $10 worth) — a very small amount considering the average Issaquah home consumes 838 kWh of electricity per month as well as 65.75 therms of gas (1926 kWh equivalent)[1]. The community trellis generated a net of 673.9 kWh, which adjusts the zHome development to where it is producing more energy than it is consuming.

Individual units experience a fluctuation in consumption year-by-year as well (see Table 2 below), though only one unit reached net zero during the time period of April 2014-2015 and not the previous year.

TABLE 2

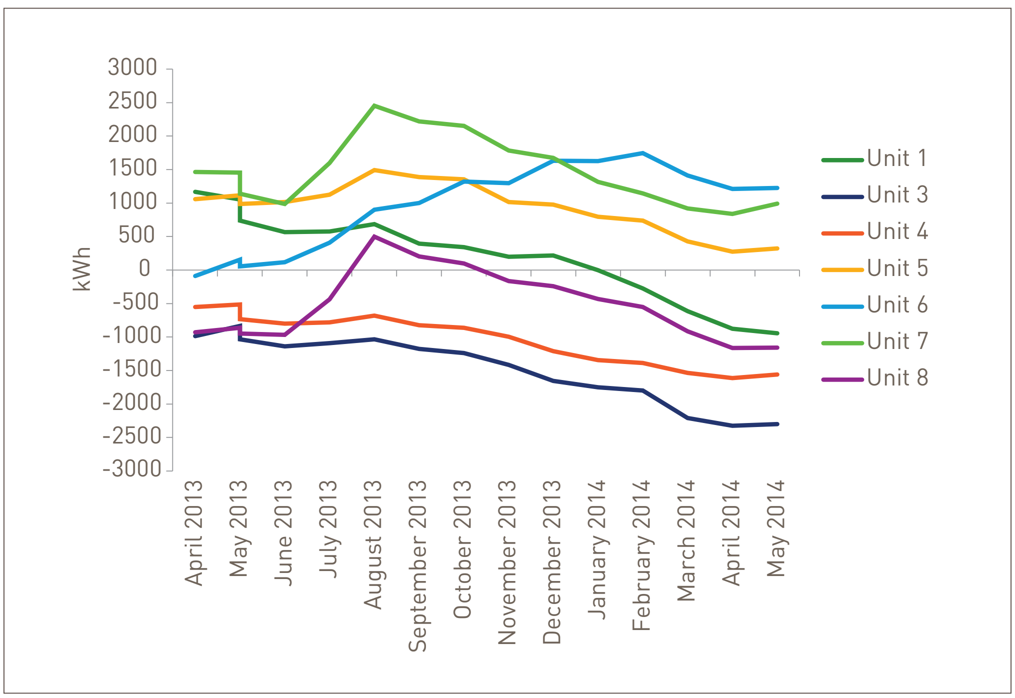
Unit	Net Consumption April 2013-2014 (kWh)	Net Consumption April 2014-2015 (kWh)
1	1,470	-1116
2	2,067	880
3	-1,049	-2,617
4	-546	-1,868
5	1,313	230
6	215	1,083
7	1,696	711
8	-815	2,041
Community Trellis	-2,715	2,041
Total	1,636	-2,199

Interestingly, the eight units, without factoring in the community trellis, managed to perform significantly beyond net zero in the second year, producing a net total of 4,240 kWh during that year.

When years are viewed on a rolling basis, rather than on an April-to-April frame as in Table 2, the outcomes fluctuate. Five of the units reach net zero for at least one year-long period of time. Two of the units achieve net zero during every single year-long time period accounted for (given the time range of the data at hand, we can measure 15 such periods on a rolling basis).

Looking at each unit individually on a rolling basis also allows us to gauge individual behavioral shifts and learning curves. The data show that over time, units trend toward performing more efficiently — either getting closer to reaching net zero or widening the gap between energy produced over energy consumed. This suggests occupants are adjusting to their homes and learning how to utilize them more efficiently. In the future, we can reasonably expect that the performance of each individual unit, and zHome as a whole, will continue to improve. However, it is important to note that we cannot adjust for weather over this time period, which would also have an impact on energy consumption.

FIGURE 2: Net Energy Usage by Unit from April 2013–May 2014



Energy efficiency

The first step toward net zero is creating extremely energy efficient living spaces. In the case of zHome, which was being developed for sale at market rates, cost was a factor that merited strong consideration. The most cost effective way of reaching net zero at the time was to achieve as much energy efficiency as reasonably feasible, and then to install enough PV to account for the remaining projected consumption. Since PV was relatively expensive, energy efficiency was the first step.

How does zHome perform in regard to energy efficiency? Extremely well. Even though there is a disparity between units, not a single unit reached the average Issaquah monthly home electricity consumption of 838 kWh. Additionally, the average home in Issaquah consumes an additional amount of energy in the form of gas (an average of 65.75 therms of gas, or 1926 kWh equivalent), which zHome does not utilize, leading to even greater energy savings.

TABLE 3

Unit	Net Consumption (kWh)	Average Monthly Consumption (kWh)
1	354	631
2	2,947	728
3	-3,666	312
4	-2,414	413
5	1,543	748
6	1,298	738
7	2,407	759
8	-2,358	568

Given these results, it is quite clear that zHome is much more efficient than the average dwelling. Even though there was significant discrepancy between units when comparing net consumption, they all perform quite efficiently. The unit with the highest average consumption is still 10% more efficient than the city average.

These efficiency gains were achieved through both high performing appliances and design elements that induce more efficient occupant behavior. Examples of high efficiency appliances and systems include ground source heat pumps for heat and hot water, R-38 wall insulation and R-60 ceilings, a SIP (structural insulated panels) roof of R-55, low flow water fixtures (which save hot water and thus energy), LED and fluorescent lights, and ENERGY STAR appliances. Homeowner action is what ultimately leads to the amount of consumption; thus design aspects such as black/white switches to prevent phantom loads and ample natural lighting to reduce the need and desire to switch on indoor lights help reduce energy consumption further.

Solar production

The size of each solar PV array was fit to the unit size, with arrays ranging from 4.8 kW to 7.2 kW. All installations performed better than their target. This is true even though the rated yearly production accounted for the estimated solar access of each roof where the panels would be installed.

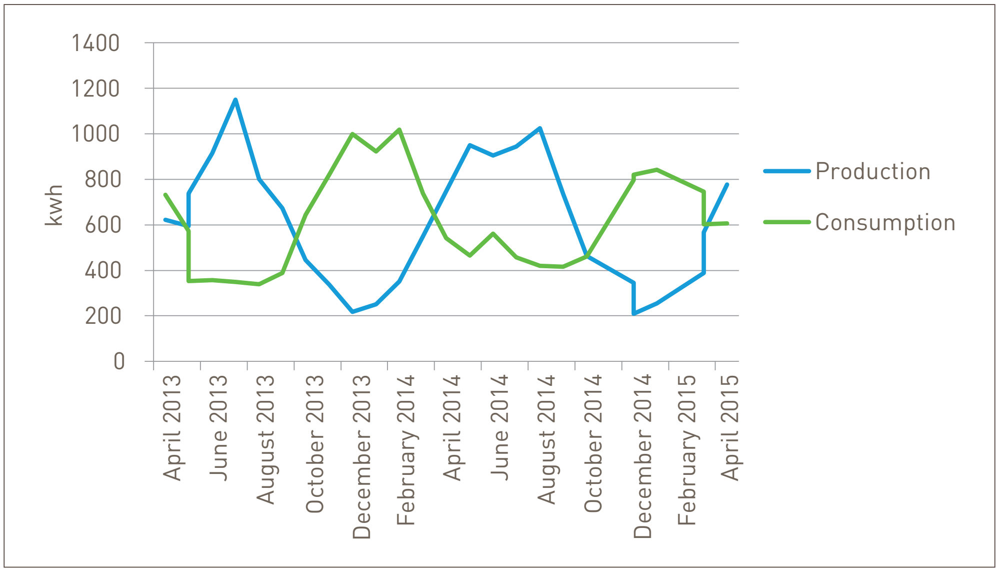
TABLE 4

Unit	PV Rating	PV Rated Yearly Production (kWh)	Actual Average Yearly Solar Production (kWh)
1	7.20 kW	5,959	7,626
2	6.72 kW	6,634	7,954
3	4.80 kW	4,837	5,607
4	5.52 kW	4,733	6,251
5	7.20 kW	7,014	8,514
6	7.20 kW	7,014	8,510
7	7.20 kW	7,014	9,493
8	7.20 kW	7,014	8,275

An interesting implication of the zHome data, despite — or even because of — the high performance of the solar panels, was the need to develop far better energy storage systems as PV becomes more widespread. Since energy must be consumed when it is generated in the absence of storage, there is a disparity between when the solar panels are producing energy and when the homeowners are consuming it. In the case of zHome, if the solar panels are producing more energy than is needed by the dwelling, the excess energy flows onto the electric grid and will be used at some other location. Conversely, if energy is being consumed at a time when the panels are not producing, such as during the night, energy will be pulled from the grid rather than from the panels. In the end, it all balances out since zHome achieved net zero.

The same disparity between consumption and production that occurs on an hourly basis also occurs in a more prominent way across seasons. In the winter, homes typically consume more energy in the Pacific Northwest as they meet their occupants' heating needs. At the same time, solar panels are not producing as much energy due to the overcast weather. In the summer, homes consume less energy — not needing heat and with many (zHome included) lacking air conditioning. This is the time of year when solar panels are producing at their best. The zHome data illustrate how energy consumption and production are almost perfectly in opposition to each other over the year.

FIGURE 3: Total Average Solar Production vs. Total Average Energy Consumption



Once solar has penetrated the market thoroughly and becomes more widespread, excess energy will be produced with no one to use it at that given point in time, which will create an opportunity for the deployment of energy storage technology.

Batteries are generally cost prohibitive right now; for example, Tesla's new, much publicized battery (Powerwall) that will store 7 kWh per day costs suppliers $3,000. However, as demand for storage increases, the price will fall.[2] This market penetration and cost curve has already been demonstrated by solar PV technology.[3] As solar PV continues growing in popularity, one can assess that battery storage will not be far behind.

Models vs. reality

Given that zHome averages a yearly net production of 160 kWh per year and exceeds zero net energy by 3.5%, the models that predicted zHome would reach net zero were incredibly close to the mark, especially given that energy modeling is imperfect. Though zHome's yearly average is close to net zero, in reality, its year-to-year numbers vary, with a 3,835.6 kWh difference between the two full years we have data for. What accounts for these yearly fluctuations, and for the discrepancies between reality and models?

Apart from the intricacies inherent in modeling complex systems such as buildings, the main element that leads to differences between models and reality is human behavior. Within zHome units of the same size, which were built and modeled to the same specifications, there are differences in energy consumption that stem from the differences in occupant behavior.

TABLE 5

Unit	BR	Average Monthly Consumption (kWh)	Per Person Monthly Consumption (kWh)
1	2	631.19	315.60
2	2	728.09	364.04
3	1	312.39	N/A - Occupancy Varied
4	1	413.19	206.60
5	3	747.77	186.94
6	3	737.96	245.99
7	3	759.44	189.86
8	3	567.70	283.85
Community Trellis	N/A	466.04	N/A

Habits related to energy consumption can vary between people for a very wide variety of reasons. Differences in energy education, individual schedules and how much time is spent at home and when, the types of activities they tend to do at home, how conscientious they are of their energy use and how much they care, how much control they have over their home (one zHome unit is being rented out), and variations in personal comfort levels are a few examples. In addition, mechanical flaws — be it due to lack of education regarding system maintenance or actual malfunction — could potentially account for some of the higher per capita energy consumption.

In addition to these factors, one aspect that is difficult to measure and account for is that of the rebound effect. "The rebound effect is a postulate that people increase their use of products and facilities as a result of this reduction in operating costs [due to energy efficiency], thereby reducing the energy savings achieved."[4] In other words, if someone knows they are using less energy and spending less money when using an appliance, they are more likely to use it with greater frequency, mitigating the energy savings that would have been reached with normal usage. It is incredibly difficult to know what the rebound effect measures at, and it varies by product, but a survey of different studies suggests the direct rebound effect is 10% or less.[5] Though this demonstrates that energy efficiency gains are still made, it does pose challenges for modelers and can lead to discrepancies between projected and actual savings.

Conversely, as demonstrated with Figure 2, occupant behavior changes over time and generally becomes more efficient as residents become accustomed to their new home and its equipment. Further, upon moving into a high-efficiency development that champions environmentally-friendly behavior, residents may begin to pay attention to their behavior in a way they hadn't been previously as obvious or important to them.

Accounting for individual habits and behavioral shifts is near impossible. Additionally, given the time frame, it is not possible to parse out how much of an impact weather had on consumption changes. Happily, the models for zHome were, to the modelers' credit, extremely close to reality.

Water

Though building a zero net energy development was the primary goal of the zHome project, reducing water use was an important aspect of the project as well. A goal of reducing water consumption by 70% was set. In addition to water-saving fixtures, such as efficient faucets and toilets, rainwater is also collected in cisterns (cisterns vary in size from 1,100 to 1,700 gallons) and then used for flushing toilets and doing laundry. After zHome was developed and Built Green's Emerald Star certification was finalized (largely based on lessons learned from zHome) a water efficiency gain of 70% was approved for the Emerald Star criterion as well. How does zHome actually perform?

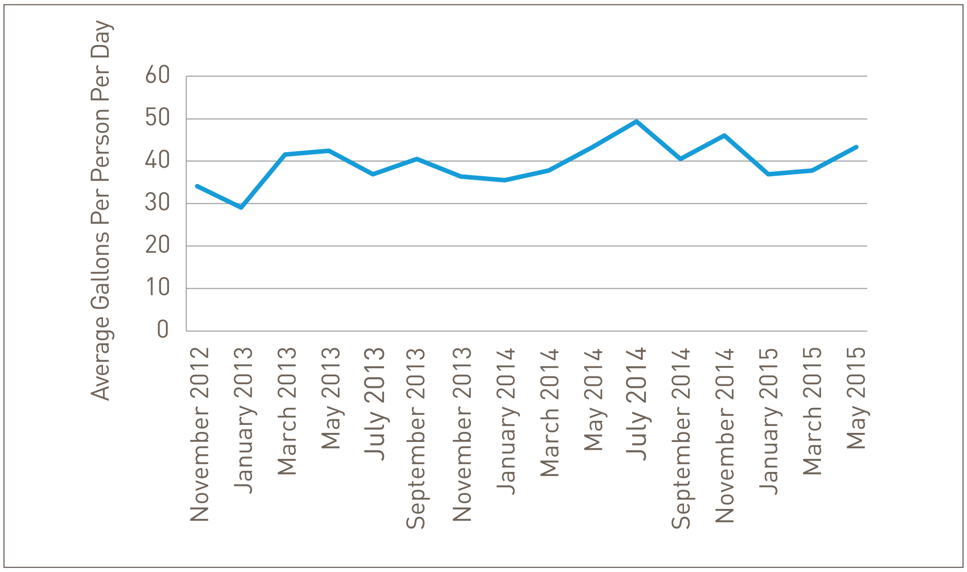
Consumption

Average water consumption in the Issaquah area is 47.9 gallons per person per day.[6] The Emerald Star checklist uses a baseline water consumption of 67 gallons per person per day — from which a 70% reduction must be made.

zHome water consumption comes both from the water utility and from rainwater harvesting. Analogously to our energy calculations, water consumption from the rainwater harvesting system will not count toward household consumption like water from the utility does. Unlike in the case of measuring energy use, however, we do not know exactly how many gallons per day of rainwater are used since that is not tracked by the utility. But, it is possible to estimate these numbers based on research on toilet and clothes washer use (which zHome utilizes rainwater for).

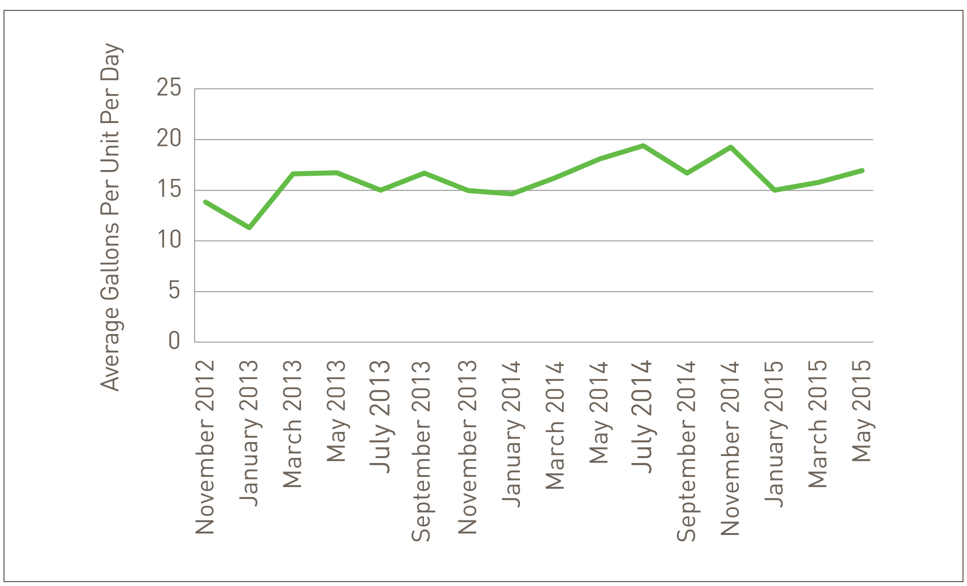
According to over two years of utility water data (from November 2012 to May 2015), average per person water consumption across the nine units we have water data for was 16.07 gallons per day from the utility. Estimated rainwater consumption is 11.46 gallons per person per day,[7] leading to a total per capita per day consumption of 27.53 gallons — well below the average consumption of 47.9 gallons per day in Issaquah.

FIGURE 4: zHome Per Capita Utility Water Consumption



Given that toilet flushing and laundry water comes from rainwater harvesting, rather than from the utility, these low averages can be expected. Additionally, though there is not a huge amount of variation, the reliance on rainwater harvest to keep the average utility consumption low can be seen in the slightly upward trend. Due to the drought the region has been experiencing, rainwater cisterns may run low or empty, at which point more water will be needed from the utility.

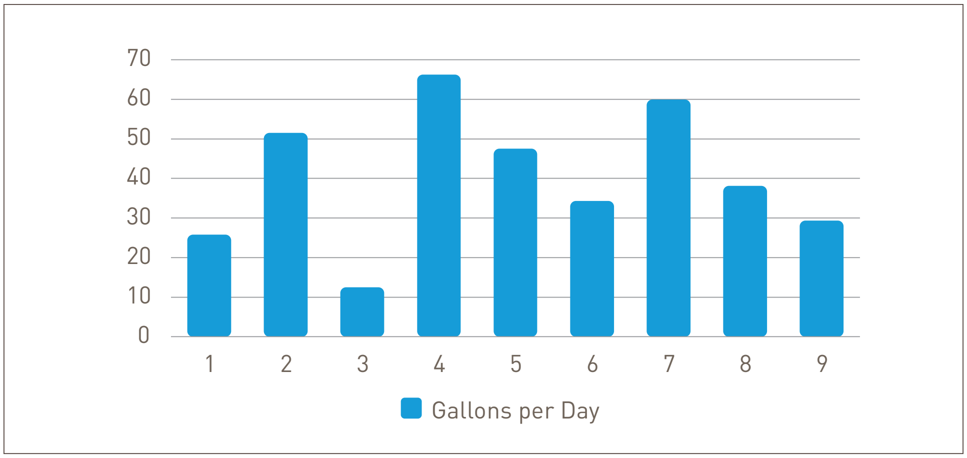
FIGURE 5: zHome Per Unit Utility Water Consumption



The trend and variability in water consumption over time as shown in Figure 4 is confirmed by Figure 5, which looks at average unit consumption rather than average consumption per person. Again, there is a slight upward trend, which is perhaps indicative of the drought. We are unable to determine if the trend would be even more drastic if occupants had not made adjustments to living in their zHome, as was demonstrated by their energy consumption generally decreasing over time as they learned how to more effectively operate their units.

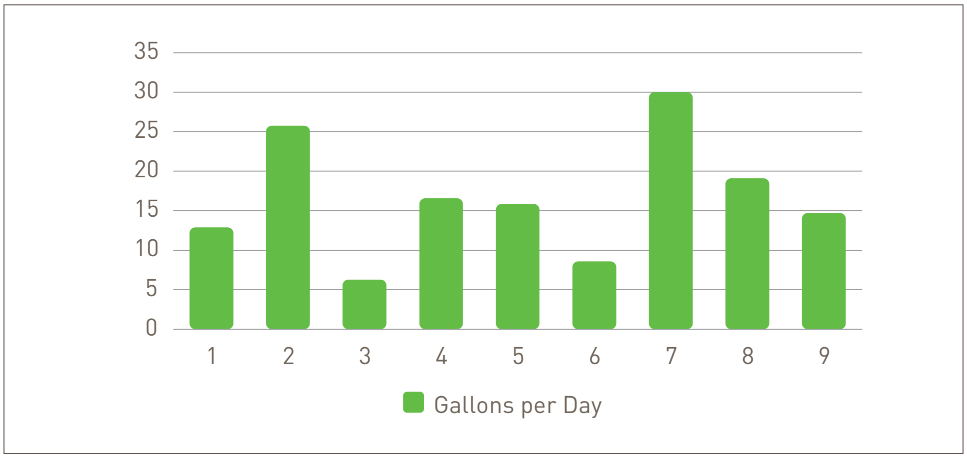
Though the variability over time is not extravagant, there is significant variation by unit.

FIGURE 6: Average Per Unit Water Use



The range in average utility water use per unit varies from 12.52 gallons per day (unit 3) to 66.23 gallons per day (unit 4) — over a fivefold difference. However, unit size accounts for some variability: unit 3 is a one-bedroom unit whereas unit 4 is a three-bedroom.

FIGURE 7: Average Per Person Water Use



When unit size is somewhat equalized based on the number of occupants, the units perform differently, but there is still a significant spread between low and high utility water users. Unit 3 remains the lowest consumer at 6.26 gallons per person per day, while unit 7 is the highest consumer at 30 gallons per person per day. However, even the highest usage is still significantly below the average of 67 gallons per person per day that is used as a baseline on the Emerald Star checklist or the Issaquah average of 47.9 gallons per person per day.

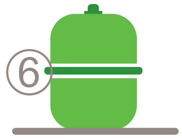
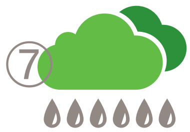
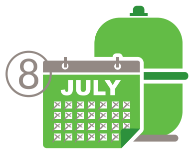
Based on these data, it is clear that a combination of water efficient fixtures and rainwater harvesting has been very effective in reducing utility water usage. In fact, the average per person per day utility water usage is only 24% of the 67 gallons per person per day Emerald Star benchmark — a reduction of 76%. When comparing zHome's utility water use to the Issaquah average, zHome nets a reduction of about 67% — even in a time of drought. In this area, zHome achieved its goal of significant water savings.

Satisfaction

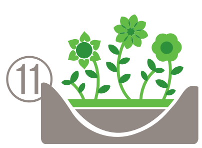
In addition to quantitative water data, a homeowner survey focused on water was conducted in order to gain some qualitative insight on how homeowners viewed their fixtures, rainwater harvesting system and landscaping.

		STRONGLY AGREE	AGREE	NEUTRAL	DISAGREE	STRONGLY DISAGREE
1	The toilets work well	●●●●	●●	●●●		
2	The bathroom faucets work well	●●●●	●●●●	●		
3	The showerhead works well	●●●●●●	●●	●		
4	The clothes washer works well	●●●●	●●●●	●		
5	The dishwasher works well	●●●●●●	●●●			

Appliances and fixtures appear to be performing well for zHome occupants, with a positive response rate of 87%. The toilets, though most residents found them to be working well, had the least strong positive responses, whereas the showerheads and dishwashers were the most positively viewed.

	#	Statement	STRONGLY AGREE	AGREE	NEUTRAL	DISAGREE	STRONGLY DISAGREE
	6	The cistern that supplies the toilet and clothes washer works well	●●●	●●●●	●●		
	7	The rainwater from the cistern is relatively clean and odorless	●●●●●●			●●	●
	8	The cistern's water supply lasts through the summer	●●●	●●	●	●●	

The rainwater harvesting systems also had a positive response rate overall, at 69%. However, there were a few negative responses regarding the cleanliness of the harvested rainwater. It was later found that some residents had not been aware that they had to clean the cisterns' filters. Additionally, birds had been nesting under solar panels on the roof — located above the cisterns — and defecating. Netting was put up to prevent the birds from nesting under the panels, and residents were given more information on the maintenance on their systems. This demonstrates the importance of education, as well as the need to monitor and resolve any unforeseen issues.

	#	Statement	STRONGLY AGREE	AGREE	NEUTRAL	DISAGREE	STRONGLY DISAGREE
	9	I don't miss having a traditional grass lawn	●●●●●●●	●	●		
	10	I enjoy the native landscaping	●●●●●●	●●	●		
	11	The rain gardens effectively absorn and manage storm water runoff	●●●●●●	●●			

zHome's native, drought-resistant landscaping was viewed as overwhelmingly positive. All of these responses demonstrate that a water-saving living situation need not entail discomfort or sacrifice. zHome residents believe their systems are working well, and all surveyed agreed that they enjoyed living in their zHome.

The Homeowner Experience: Comfort, Cost and Education

zHome may be performing well and leading to lower bills, but what is its actual comfort level? What factors, including cost, contribute to the purchasing decision? What is the experience of living in a net zero, water-efficient development? Karin Weekly and Bryan Bell, who bought and moved into their two-bedroom zHome unit in July 2014, spoke about their experience as being overwhelmingly positive.

Purchasing zHome

Bryan and Karin's zHome purchase was in fact the first home they bought. They had been looking for a residence in the Issaquah Highlands, but buying a green home was not at all on their radar. However, during one of their walks through the Highlands in March 2014, they noticed zHome and the interpretive signs outside. They thought the development was interesting and looked into it. At that time, no units were available, but to their surprise, that May a unit came on the market.

Their primary reason for purchasing their zHome unit was the open layout with the loft and windows; the nearby amenities, such as the shopping center, were also attractive. However, they were concerned about having adequate storage space. As they researched zHome and learned more about its environmental attributes, they began to become more invested in the idea of living in a green home — the solar panels and rainwater cisterns became more and more of a draw and they couldn't get the idea of living in zHome out of their minds. After some back and forth, Karin and Bryan ended up deciding to significantly downsize, ridding themselves of unnecessary possessions and lessening their footprint in order to move into their zHome.

A year later, the couple can say their quality of life has increased. "Living in our zHome feels like being on vacation," they explain. "It has a nice vibe, layout, and feels extremely comfortable everywhere in the unit, no matter the weather." Even on very hot summer days, their zHome unit remains a comfortable temperature when the blinds are closed.

Cost considerations

Bryan and Karin paid special attention to their monthly payments when calculating what would be within their home purchasing budget. They concluded that zHome, with its lower energy bills, would provide them with additional money to put toward other factors, such as a monthly mortgage or Homeowners' Association dues.

It is instructive to look at the price of a home beyond its sticker price, since a large portion of homeowner expenses come from the operation of the home itself, and not solely from the monthly mortgage. Knowing zHome's utility energy and water usage, it is possible to calculate average monthly bills based on unit size and extrapolate savings from there.

Even though zHome is around 70% more water efficient than the average Issaquah home, this unfortunately does not lead to significant monthly cost savings. Water bills are issued bimonthly, and the estimated average savings per bill is only $2.24. This is because base connection charges make up the majority of the bill, whereas the price by volume is low and accounts for a far smaller portion of the bill. The case of zHome makes it clear that if water providers want to increase water efficiency – which, particularly in the case of drought, would be a wise course of action – adapting their bill structure to reward those who consume less water by increasing the price per unit of water and decreasing the base price would be an incentive for bill payers to use less water.

However, zHome's energy profile has a significant impact on electricity bills. Depending on the unit size, the estimated average monthly electricity bill ranges from a $4.67 per month credit to a $10.78 bill. This is a far cry from the average monthly bill based on average Issaquah household electricity usage of $92.24. On top of this, the average household uses 65.75 therms of gas, which produces a monthly bill of $82.40. The difference between total zHome energy-related bills and those of the standard home in Issaquah is astounding: living in zHome saves owners an estimated $172 per month! Even when only accounting for the difference in electricity prices and excluding gas bills, the difference remains significant at around $90 in savings.

One way to view the impact of these utility savings is by evaluating increased purchasing power. The fact that zHome residents will have lower monthly bills adds to their purchasing power, since lower bills are an embedded value of zHome. If the average utility savings for zHome as compared to the average Issaquah home are subtracted from the monthly mortgage payment, the upfront price is reduced by $44,570 (for a three-bedroom unit) to $51,547 (for a two-bedroom unit). This difference represents the additional purchasing power that zHome buyers have, thanks to their greatly lowered utility bills.

Another way to examine the expanded value of living in a zHome, solely based on utility savings, is by calculating the simple net present value of 30 years of utility savings. Based on unit size, the net present value of these savings ranges from $40,392 (for a two-bedroom unit) to $44,196 (for a one-bedroom unit). Again, these numbers showcase the additional monetary value inherent in a zHome. Interestingly, the net present value of utility savings is not very different from the additional purchasing power described above.

Finally, the additional value of zHome can be viewed through the per square foot price premiums zHome buyers paid versus the median price per square foot of similarly sized, new construction homes that were listed and sold during the same time interval as the zHome units. The premiums ranged from an average of $30,942 (for a one-bedroom) to $54,040 (for a three-bedroom) to $54,519 (for a two-bedroom). These per square foot price premiums indicate that the market recognized that zHomes were more valuable than comparably sized homes in the area at the time of sale.

These three methodologies offer alternative views of the extra value that zHome exhibits through different perspectives. There is the obvious financial value that stems from lower monthly payments, since zHome residents have significantly lower utility bills, and sometimes even receive credits for their electricity bills.

However, the two financial examinations of value based on utility savings do not account for the social and environmental values exhibited in the zHome community. What the first two calculations cannot show is the additional value that zHome holds on top of financial savings stemming from energy and water efficiency, such as higher indoor air quality, greater comfort, an increased sense of community and other benefits that are intangible but not unimportant. For example, according to this analysis, the premium for a two-bedroom zHome unit was $54,519, but the net present value of utility savings is $40,392. This suggests that the premium represents an additional $14,127 of embedded value in a zHome two-bedroom unit beyond reduced utility savings.

zHome, as a deep green community, holds value in many forms that other, non-green homes do not have. The data show that this extra value was at least somewhat accounted for in the premium price, and that residents were justified in paying a premium solely by way of the additional purchasing power that comes through utility savings. And, zHome has even more benefits that lead to greater homeowner health and comfort.

Energy experience

Bryan and Karin feel like their zHome unit is performing up to their expectations energy-wise. Their most common monthly bill is $8.39, which is simply a charge for holding the electricity account. Over the year they've lived in zHome, it was only December through March (when heating was needed), that their bill exceeded this base charge. Living in zHome has made them much more conscious about their energy consumption and how they can lessen it. They use the Energy Detective system to see how much energy they are using at any given time and to figure out what they are able to switch off. In fact, it has become part of their routine to check the system every night before bed to ensure all non-essential items are shut off. Other energy-saving habits Bryan and Karin have adopted include using cold water for most laundry loads (rather than always using hot water) and using LEDs for any incidental lighting. Before living in zHome, energy consumption was not a topic Bryan and Karin thought about, whereas now they would not consider living in a non-green home, and have blended conservation measures into their daily routine.

Water consumption

Karin and Bryan also began monitoring their water consumption. By using Badger Meter's Orion CE In-Home Display, they are able to check how much water they've used each day. They can also track the water level in their cistern using Conservation Technology's Digital Water Level Indicator and are able to monitor the water use of their toilets, clothes washer and outside hose. Living in zHome, Bryan even began turning off the water in the shower between rinses while soaping up! They also strive to use the less water-intensive flush (0.8 gallons) on the toilets as much as possible.

Questions they had about their cistern did highlight an area for improvement — new homeowner education. Karin and Bryan had to elicit an explanation from a neighbor regarding the hook-ups for the washing machine since one used public water and one used rainwater from the cistern. It also took them some time to discover the filters on the cistern, which do periodically need to be cleaned. Not knowing what to expect from a cistern, they were also worried when they initially heard the pumps cycling, though that is normal when the cisterns are low due to little rainfall. They would suggest more robust education for new residents on how to maintain the systems in zHome.

Community

The community as a location is also a big benefit for zHome residents. Bryan and Karin expressed that they love being next to transit, which Karin has begun to take to work. They also bus to downtown Seattle. The amount of amenities nearby — restaurants, grocery stores and a movie theater — is also a significant benefit of living in zHome. It is important to consider that the surrounding location has an impact on homeowner satisfaction. Happily, in the case of zHome, the transit-oriented community with plenty of amenities is a positive factor.

Additionally, there is much positive to say about the community of zHome residents themselves. Neighbors provided Bryan and Karin with explanations as they learned more about the systems utilized in their home. There is an email list of homeowners and the builder that is utilized as a method of giving and seeking advice related to living in zHome. Bryan and Karin said they were able to learn a lot thanks to this list.

Bryan and Karin's story is an interesting and important one. They went from not paying much attention to their energy and water consumption to being avid proponents of net zero and green housing thanks to their positive experience living in zHome thus far.

Conclusion

Though zHome was a demanding project that was situated in an extremely challenging time for the housing market and building industry, it ended up being a measurable success — meeting both energy and water benchmarks based on post-occupancy data analysis. A project that managed to weather the recession, achieve net zero energy and a 70% reduction in water use, as well as sell all nine listed units, should be considered a significant achievement. Lessons have been learned about the importance of a shared vision, the need for monitoring and the ability to adapt to unforeseen circumstances (which in zHome's case ranged from the housing market crash to birds nesting under the solar arrays) and the importance of training new homeowners on their home's equipment and appliances. zHome has also helped chart progress for green building in the region. It was the first project in Issaquah that was permitted to use rainwater for indoor use, and, as a result, helped change code and add flexibility for other green building innovations, which also set an example for other small municipalities in the region.

Now, in the Pacific Northwest, green building is far ahead of where it had been during zHome's inception. In 2014, 58% of new homes in the city of Seattle were Built Green certified. There are now two other Emerald Star certified projects in addition to zHome. zHome is an incredible demonstration of environmentally friendly, carbon neutral housing for the everyday person — a housing type that, as the zHome partners intended, is becoming more widespread.

Endnotes

[1]Puget Sound Energy, email message to author, October 7, 2015.

[2]Tesla Motors, "Tesla Powerwall," http://www.teslamotors.com/powerwall.

[3]Eric Roston, "By the Time You Read This, They've Slapped a Solar Panel on Your Roof," Bloomberg Business, February 25, 2015, accessed October 20, 2015. http://www.bloomberg.com/news/articles/2015-02-25/in-the-time-it-takes-to-read-this-story-another-solar-project-will-go-up.

[4]Steven Nadel, "The Rebound Effect: Large or Small?," ACEEE, August 2012. http://aceee.org/files/pdf/white-paper/rebound-large-and-small.pdf.

[5]Ibid.

[6]City of Issaquah, email message to author, September 28, 2015.

[7]Estimate based on numbers from Alliance for Water Efficiency, "Residential End uses of Water Study (1999)," http://www.allianceforwaterefficiency.org/1Column.aspx?id=4324&LangType=1033&terms=residential+end+use+study and ENERGY STAR, "Clothes Washers for Consumers," http://www.energystar.gov/products/appliances/clothes_washers.

Appendices

Methodology

All data used for the following was provided by Puget Sound Energy (energy) and Cascade Water Alliance (water).

Figure 1 — Net Energy from Grid from April 2013 to 2015: Each unit's net consumption (energy from grid – solar panel production) from April 2013 to May 2015.

Figure 2 — Net Energy Usage by Unit from April 2013-May 2014: Each unit's net yearly consumption (energy from grid – solar panel production) from the start date over the next year. One unit is excluded because of periods of homeowner transition.

Figure 3 — Total Average Solar Production vs. Total Average Energy Consumption: The monthly average kWh production of all units' solar PV systems compared to the monthly average kWh consumption of all units from April 2013 to April 2015 for the units that had available data.

zHome Utility Water Consumption: The average daily consumption for all units from November 2012 to May 2015. The unit's average daily consumption was found by taking the number of CCFs consumed bimonthly and multiplying by 748 (gallons per CCF) then dividing by 60 (to find daily consumption). To find per capita consumption, the average daily consumption was divided again by the number of residents in the unit.

Average Water Use: The above utility water consumption per unit numbers were averaged across all months for which we have data. Then, 11.46 gallons were added to account for rainwater usage. The rainwater usage per unit was estimated based on appliance and amount of use information from the Alliance for Water Efficiency and ENERGY STAR. To calculate per capita, the total (utility + rainwater) usage was divided by the number of residents in each unit.

Monthly Utility Bills: Water pricing information came from Cascade Water Alliance, and electricity and gas billing information from Puget Sound Energy. Monthly bills were calculated for both average Issaquah and average zHome water and energy use. The difference in monthly payments was then added to an estimated mortgage payment based on zHome unit size.

Cost Considerations: Estimated monthly mortgage payments were found by taking real sales data (the price each unit sold for and the standard interest rate in the month each unit sold) and doing a fixed rate 30 year mortgage amortization calculation:

*Monthly payment = (monthly interest rate / (1 – (1 + monthly interest rate) – number of payments)) * loan principal*

When the zHome monthly bill savings were subtracted from the monthly interest rate, the loan amount was then back-calculated from the above equation by solving for loan principal rather than monthly payment. Once the loan principal was calculated, it was divided by 0.8 to determine the home sales price (assuming 20% was a down payment).

The net present value of zHome utility savings was generated by taking the difference in zHome bills (varied by unit size) and the average Issaquah home and projecting them for thirty years, factoring in an energy price increase of 1% a year. A discount rate of 3.6% was used.

The difference in zHome sales prices versus the average comparable home price in Issaquah was taken by searching Northwest MLS data for average and median prices of homes sold from September 2011 through December 2013. From there, a median price per square foot for comparably sized homes in Issaquah was found. This was compared to the median price per square foot of zHome, which shows zHome had a median price per foot premium of $37.53. This premium was then multiplied by the assessor's square foot measurement of each zHome unit to generate the total premium per zHome unit.

Acknowledgments

Many parties contributed to the success of zHome, as well as to this white paper. With specific regard to the white paper, I would like to thank Devin Melville, Built Green's intern for the summer of 2015, who spent a lot of time digging through the data with me. I would also like to thank Megan Curtis-Murphy and David Fujimoto from the City of Issaquah for helping gather data, evaluate methodologies and edit sections of the paper. Brad Liljequist, formerly with the City of Issaquah and now with the International Living Future Institute, was happy to discuss data over several phone calls and to provide some of the rolling yearly energy calculations, and share his own findings. Bryan Bell and Karin Weekly not only provided an interview for the purposes of this white paper, but then went on to contribute a great deal more of their time by presenting on zHome at the Built Green Conference, critiquing sections of the paper and even opening their own home for zHome tours. Aaron Fairchild, with local builder Green Canopy, heard about the white paper's progress and excitedly offered his feedback, which was very valuable and spurred additional points of evaluation. Sam Lai, also with Green Canopy, provided a double check of cost calculations and offered great suggestions for their presentation. Mike Brent and Elizabeth Bley at Cascade Water Alliance tracked down usage numbers, calculated estimated rainwater usage, and Mike reviewed the water-related portion of the paper. Nick Nied with Ichijo dealt with all of the detail questions I shot at him. Aaron Adelstein with the Master Builders Association (and my boss) spurred the idea along early on and encouraged ambition in reach and scope. Ellen Cole, Built Green Coordinator, frequently helped with maintaining the zHome Stewardship Center and other zHome-related efforts. The zHome partners and collaborators — City of Issaquah, King County GreenTools, Ichijo USA, Puget Sound Energy, and Cascade Water Alliance — as well as the homeowners who shared their data played an integral role of course, since this paper would not exist without them. Thank you!

Leah Missik
Built Green Program Manager

425.460.8238 | builtgreen.net

MASTER BUILDERS ASSOCIATION of King and Snohomish Counties