



Seattle's First Emerald Star Home: Two Years Later

FULL REPORT

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Executive Summary

Emerald Star is Built Green's highest certification level. To date, only four projects have achieved this status. Dwell Development's Ballard Emerald Star Home, certified in 2015, was the third project to receive Emerald Star certification and the first to do so in the city of Seattle. Emerald Star certification requires that a project demonstrate it will achieve net zero energy use and a 70% reduction in average water consumption through modeled projections. Given that modeled projections may differ from reality, however, it is important to compare models to actual performance once a home has been lived in. In 2017, Built Green undertook this comparison for the Ballard Emerald Star and analyzed the home's energy and water consumption to determine whether the modeled projections accurately predicted real-world outcomes. The results showed that this project well exceeded net zero energy use, producing 3,941 kWh more renewable energy than energy consumed over a 25-month period. The residents also used just 19.95 gallons of utility-supplied water per person per day, slightly less than the required 20.1 gallons per person per day (a 70% reduction from the average 67 gallons per person per day Emerald Star baseline).

In addition to the environmental impact, meeting these energy and water reduction goals contributes to significant financial savings. As a result of selling electricity to the local utility and receiving a renewable energy credit, the Ballard Emerald Star owners have earned \$3,533 thus far! They also save an estimated \$493 in water and sewer bills annually. These financial savings contribute greatly to the homeowners' expressed happiness with their home, though they also cite the home's comfort and design as factors.

It is clear the Ballard Emerald Star is realizing its environmental goals through both quantitative and qualitative measures. After two years of being occupied, the home is exceeding net zero energy performance and has cut utility water consumption by more than 70% compared to the average household. The home demonstrates that the Emerald Star certification parameters are achieving the desired results and that deep green buildings such as this can be successful in a speculative housing market, leading to happy homeowners.



Background

Built Green Emerald Star Certification

Built Green introduced Emerald Star, its highest certification level, in 2012. This checklist was guided by the process of building zHome, the nation's first net zero energy townhomes (for more information on zHome, see the white paper on the project at builtgreen.net/library/zhomewhitepaper.pdf). Like other Built Green checklists, the Emerald Star checklist is holistic, requiring rigorous measures in the environmental categories of energy, water use, stormwater runoff, materials, and health and indoor air quality.

Once the checklist was finalized, zHome was certified at the Emerald Star level—though retroactively, since the project had already been completed. The Eastside Harvest House in Kirkland, designed by George Ostrow of Velocipede Architects and built by Model Remodel, also received Emerald Star certification based on documentation from its recent 5-Star certification. However, until the Ballard Emerald Star home was completed in 2015, these projects were the only two that had obtained Emerald Star certification. As such, the Ballard home was the first project to receive Emerald Star certification after the checklist was officially launched. It was also the first Emerald Star project in Seattle and the first independent speculative project to aim for this certification level. The builder, Dwell Development, was no stranger to certifying projects with Built Green, though Emerald Star was their most challenging undertaking yet. Prior to the completion of this project, Dwell had already certified 82 homes through Built Green, 78 of which achieved certification at the 5-Star level.

Each section of the Emerald Star checklist is rigorous. Builder feedback indicates the most difficult action items to achieve are the reduction in water use and the requirement to use at least 90% FSC certified, reclaimed, recycled, and/or rapidly renewable wood. However, this study will focus on energy and water consumption, since these factors represent the data we could obtain on the home's performance. The Emerald Star checklist requires a model demonstrating net zero energy use and a model showing 70% reduction in occupant water use, given a baseline of 67 gallons per person per day. These requirements necessitate the installation of renewable energy systems and rainwater capture for indoor use.

Building to Emerald Star certification is rare. While we hope this changes as development becomes more sustainable, it is clear the Ballard Emerald Star project is exceptional and represents some of the greenest building practices and technologies in the country.

The Importance of Emerald Star Building

Emerald Star certification indicates that a building is highly water efficient, energy efficient, healthy, and minimizes its environmental impact by utilizing more sustainable materials. These attributes are important for human and environmental health—which, of course, are intertwined.

From an environmental perspective, energy efficiency and net zero energy homes are of vital importance. In the Drawdown plan to reverse global warming, edited by Paul Hawken, net zero energy building is listed as a solution. According to the research, if 9.7% of new buildings are net zero by 2050, the integrated carbon dioxide savings would be 7.1 gigatons.¹ Slowing and reversing global warming is becoming increasingly more urgent, and the more net zero energy buildings created, the quicker we will be able to do so.

From an occupant's perspective, environmental concerns aside, living in a net zero energy home presents a significant benefit: no or even negative bills. Depending on the electric utility and policies in place, residents will be compensated for excess solar energy generated that flows onto the grid.

If a home creates more energy than it consumes from the utility over the course of a year, electric bills will be canceled out by the income from electricity generated (roughly speaking, since some utilities charge different amounts during different times). Additionally, utilities typically compensate solar at a subsidized rate, meaning they are paying more for solar energy than a resident is paying for energy off the grid. The additional income from selling solar energy often offsets any connection fees, meaning residents of a net zero energy home may well find that the utility is paying them, rather than vice versa! At the very least, any energy bills would be minimal.

Conserving water is also very important from an environmental perspective. Due to climate change, both the amount of total snowfall and the proportion of precipitation falling as snow are on the decline in the Pacific Northwest.ⁱⁱ According to the EPA, "Increasing temperatures and populations could deepen demand and further stress urban water supplies that are already at risk of diminishing because of climate change."ⁱⁱⁱ Therefore, building for water efficiency is becoming of even greater importance.

Saving water also saves money via lower utility bills. The per unit charge for water in Seattle is low relative to the base charges levied, irrespective of use.^{iv} Due to this pricing structure, there is less monetary incentive for homeowners to conserve water since the overall impact on their bill will be less noticeable. Nonetheless, the 70% or more reduction in average water usage required for Emerald Star certification is significant and is reflected in water bills.

The benefits of deep green building and Emerald Star certification are clear, but the benefits also hinge on the home's actual performance and the behavior of the occupant(s). Homes can be designed and built well, but if the occupants are not conscientious, or if the systems fail or are not operated correctly, the benefits of the home as projected by energy and water modeling may be diminished. Therefore, it is important to examine how the home is performing after it has been occupied. To do so, one must obtain utility bills to see the home's energy and water consumption. It was especially important to check on the performance of the Ballard Emerald Star project, as it was the first of its kind, to ensure the certification was meeting its objectives. Happily, it is.

The Results

Energy Performance

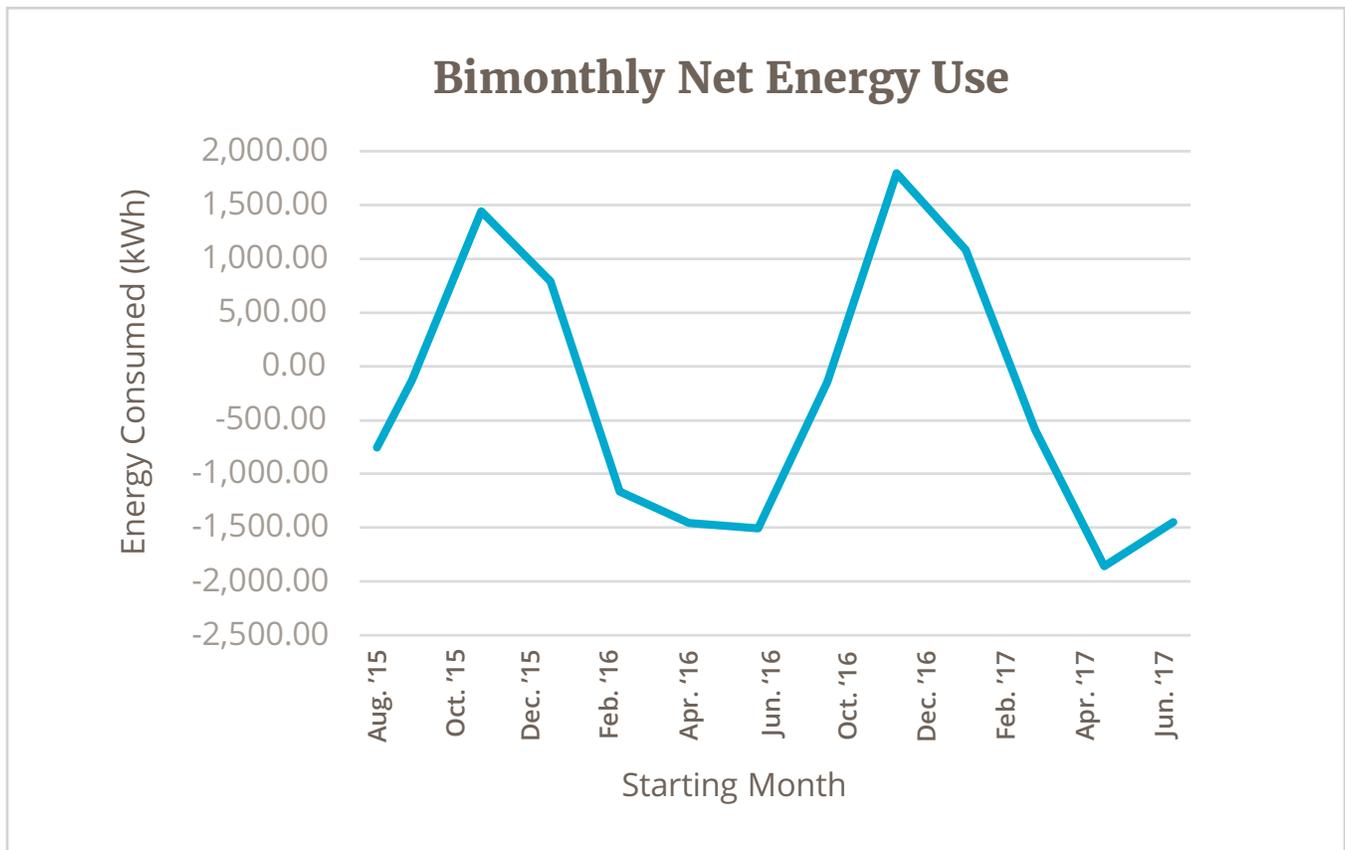
To achieve Built Green Emerald Star certification, a project must be modeled to achieve net zero energy. But what does net zero energy really mean? Definitions depend on who you ask, but at its most basic interpretation, and the one employed by Built Green, net zero energy is achieved when the project produces as much renewable energy on site (or within a quarter mile) as it consumes over the course of a year. In other words, the renewable energy produced by the home is equal to or exceeds the amount of energy the home consumes in a year. Specifying the time frame is important because solar energy (the form of renewable energy most commonly employed by Built Green projects) is more plentiful in the sunny, summer months, while less is generated in the winter when homes tend to consume more energy due to higher heating needs. In the summer, homes with solar panels are generally producing more energy than is needed at any given moment, but if the home is connected to the utility grid, the excess energy will be consumed by someone else.

At the same time, the home can use energy from the grid even when the solar panels aren't producing; at night, for example, or when production is low on a rainy day.

The Ballard Emerald Star was modeled to achieve net zero energy, thanks to its efficient envelope and the 8 kW solar PV array installed on the roof. We wanted to see how its actual performance compared to the energy model two years after it was completed and occupied. Several factors contribute to energy consumption that cannot be easily accounted for in an energy model, including resident behavior. We were pleased, however, to find that the Ballard Emerald Star is meeting and exceeding net zero energy.

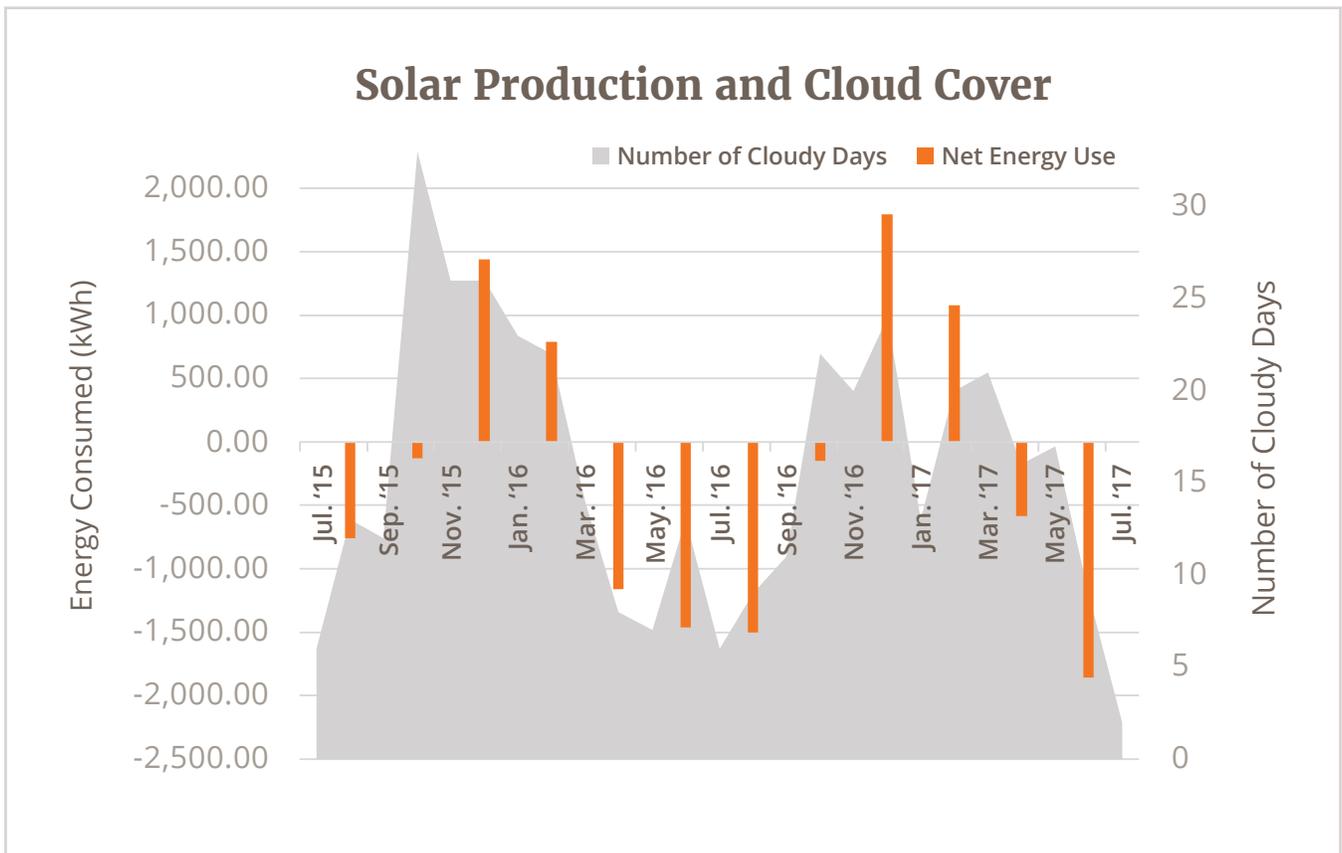
In fact, over the course of two years and one month, the home had produced 3,941 kWh more energy than consumed!

The net energy use of the Ballard Emerald Star does fluctuate seasonally. In the summer, there is a significant excess of solar energy production compared to energy consumption. At its best bimonthly period so far (Seattle City Light, or SCL, the utility this home uses, bills bimonthly), mid-May to mid-July 2017, the home produced 1,858 kWh more than it consumed. In the winter, we see the opposite effect: from mid-November 2016 to mid-January 2017, the home consumed 1,796 kWh more than the solar panels produced.



To ensure the logical conclusion—that these fluctuations were a function of weather—was correct, we compared the average number of cloudy days to the home’s net energy use. As the below graph demonstrates, during months when the number of cloudy days was low, the home’s net consumption was negative; this is because the solar panels were producing more energy than the home consumed.

Conversely, in those months when cloudy days were more frequent, the home consumed more energy than it produced. We can also assume that the homeowners used more energy due to heating demand in the winter. Solar photovoltaics perform especially well when it is cold, but the cloud cover commonly present during Seattle winters obviously hampered production.



Though the home exhibits seasonal fluctuations, its overall performance is incredibly strong. In fact, for every measured rolling annual period, the home produced more energy than it consumed.

Rolling Annual Net Energy Use	
Starting month	Net energy use (kWh)
September 2015	-2,022.00
November 2015	-2,044.00
January 2016	-1,688.00
March 2016	-1,399.00
May 2016	-822.00
July 2016	-1,220.00
September 2016	-1,161.00
Average	-1,479.43

These results are great for the environment since the home is, in fact, producing clean, renewable energy that does not contribute to climate change nor require additional resource use. But what else does net zero energy mean for the residents? Thanks to the home's performance, the Ballard Emerald Star homeowners are in fact earning money from the utility rather than paying electricity bills!

The excess energy produced by the home's solar panels is sold back to SCL. Since the home is producing more than it consumes, that means SCL is purchasing more energy from the homeowners than the homeowners are purchasing from them! Though there are charges in addition to the per unit cost of energy, such as a base service charge, the homeowners still come out ahead. In fact, from mid-August, when they moved in, until mid-September, they only had to pay SCL twice during the 2016 winter months when their consumption was greater than the credit they had banked. Cumulatively, they have earned \$3,533 in credit so far! Much of this is thanks to a renewable energy incentive credit they were granted in December 2016.

The credit comes from the State of Washington, is administered by SCL, and is intended to speed up the cost recovery of solar panel installation. Thanks to this credit, the homeowners of the Ballard Emerald Star have come out far ahead financially, though even without the credit, simple net metering would assure that their electricity bills would be minimal, if anything.

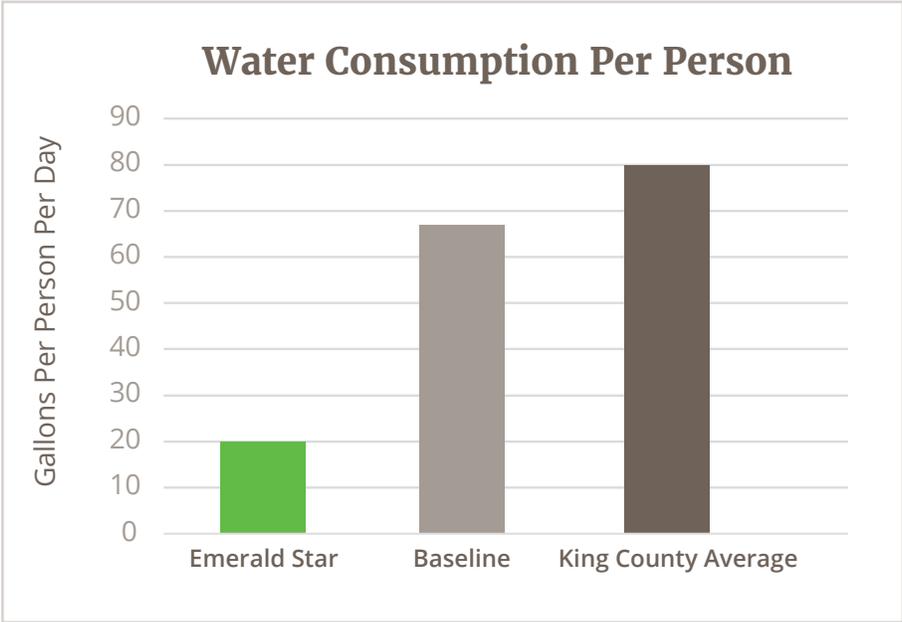
This is significant, especially when one considers that SCL customers who live in relatively new (2014) all-electric homes not certified as Built Green pay, on average, \$1,134 annually for their electricity.^v Not only do the Ballard Emerald Star owners avoid this charge, they actually earn money! It is clear that having a highly efficient, net zero energy home presents significant cost savings.

Water Performance

To achieve Emerald Star certification, a project must reduce its utility water consumption by 70%, using 67 gallons per person per day as the baseline. This baseline was determined during the development of the Emerald Star checklist and was based on regional consumption information. The average water consumption in Issaquah is 68 gallons per person per day.^{vi} Seattleites use about 50 gallons per person per day.^{vii} However, average King County consumption is estimated at 80 gallons per person per day.^{viii}

A 70% reduction from a baseline of 67 gallons means the Emerald Star checklist requires per capita daily utility water consumption to be 20.1 gallons or less—a significant decrease from any of the regional averages listed previously. To achieve this reduction, Dwell Development installed a cistern with a capacity of 420 gallons to capture rainwater not only for outdoor use but also for flushing toilets and cold water laundry. Water efficient fixtures are necessary to achieve the necessitated reduction, as well.

Over a two-year span, the Ballard Emerald Star home used on average 70.74 gallons of water per day from the utility. Given that there are three residents, the per capita daily consumption is 19.95 gallons—just under the requisite 20.1 gallons and far less than the King County average of 80 gallons. Additionally, the actual usage of 19.95 gallons is almost the same as the projected per capita usage calculated during the home’s construction of 19.8 gallons. This demonstrates that our modeling assumptions were incredibly accurate. The Ballard Emerald Star residents have a reduced water consumption, on average, of 70.3% from the baseline.

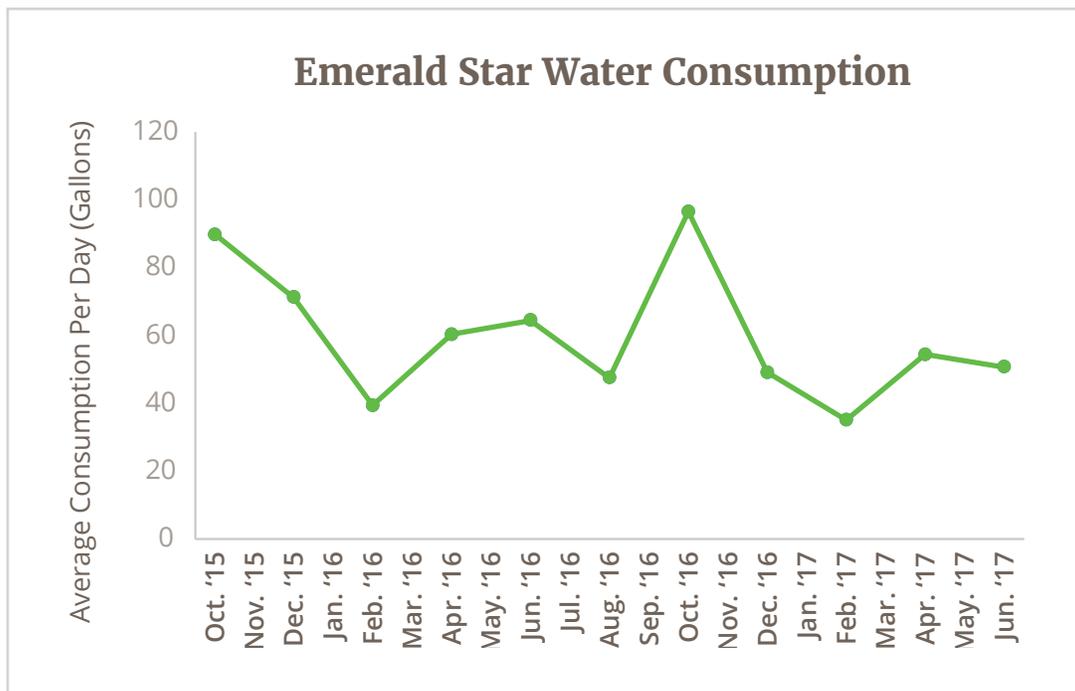


Though it is not possible to tell from the water bills, based on the modeled projection, it was estimated that rainwater would account for about 20% of indoor water usage. The rest of the indoor water used is supplied by the utility.

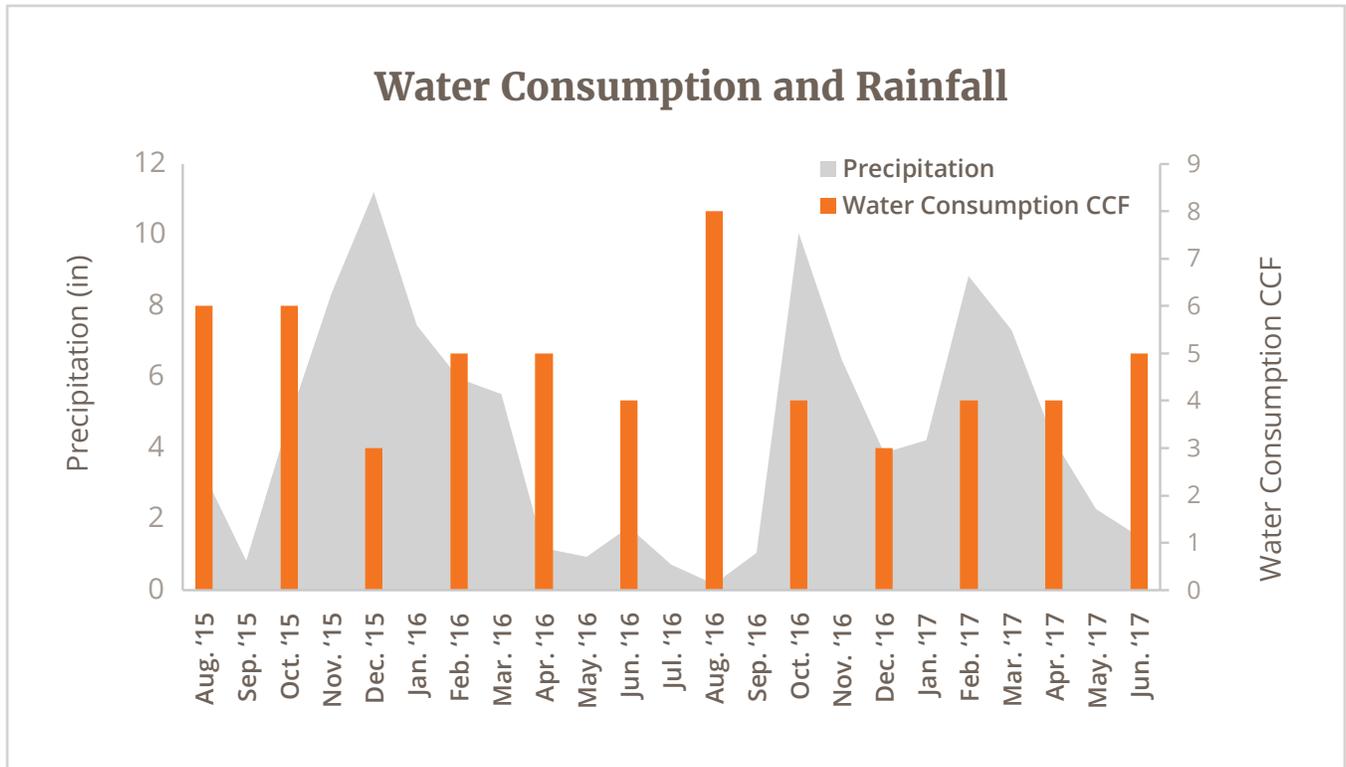




The utility water consumption of the Ballard Emerald Star's residents has fluctuated over time, with a maximum usage of 8 CCF (5,984 gallons) in August and September of 2016 and a minimum usage of 3 CCF (2,244 gallons) both in December 2015/January 2016 and December 2016/January 2017. Based on the time of year, these low usages may correspond with the family traveling for the holidays. Otherwise, there is no clear seasonal pattern.

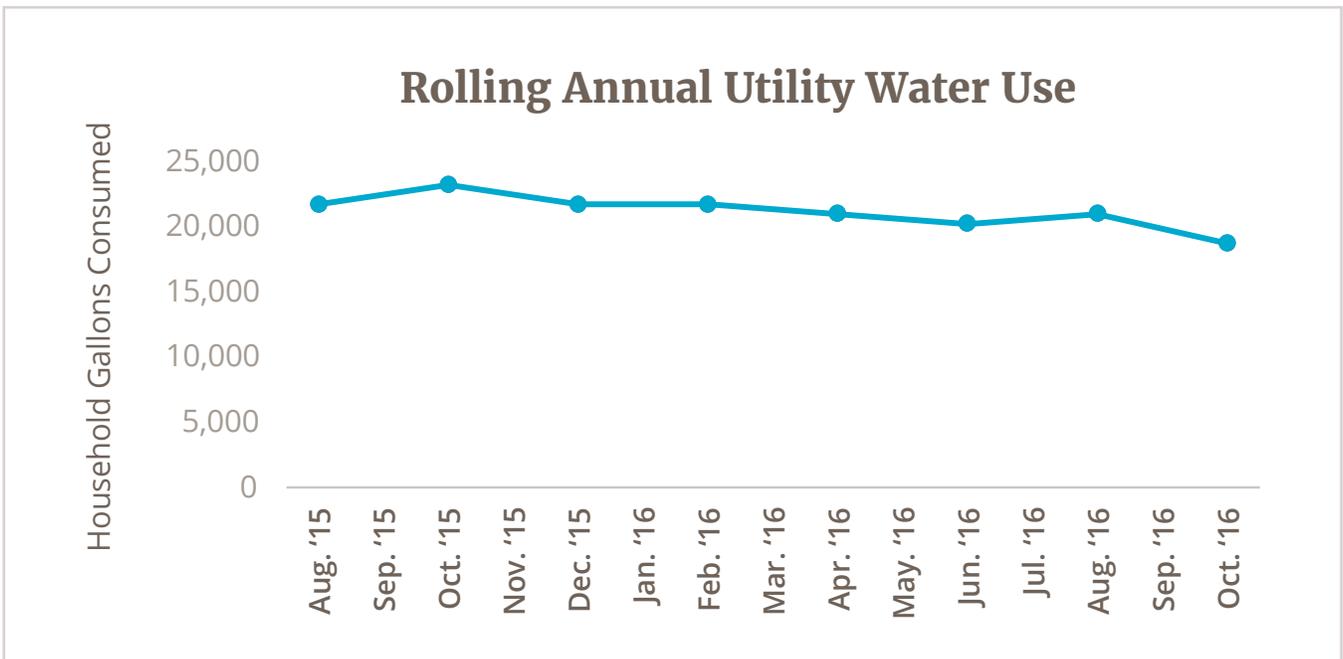


We also plotted water usage against rainfall. Since we are measuring utility water usage, we hypothesized that in dryer months, utility water usage may go up since the cisterns may be depleted of rainwater and toilet flushing and laundry may have had to be switched over to utility water. During summer months, however, we were unable to see a consistent marked increase, apart from the usage in August/September 2016, which was the highest consumption time frame. This period followed dry summer months, and it is possible the cistern did run dry, causing a greater need for utility-supplied water.





The utility water consumption in the Ballard Emerald Star has slightly decreased over time. Rolling yearly averages show a net use of 21,692 gallons over the year-long period beginning in August 2015, and of 18,700 gallons used in the year starting October 2016. With few exceptions, each year-long period's consumption has been lower than the previous year.



Seattle has some of the highest water bills in the nation; thus, water conserved means money saved. However, water bills are not simple to decipher, and it can be difficult to understand charges and potential savings: there are summer and winter rates as well as sewer service charges based on usage and base charges. In addition, the base charge is significant compared to the per unit charges. However, based on averages for typical households, it is possible to estimate how much money the Ballard Emerald Star residents comparatively save.

Based on an average of peak and off-peak pricing for Seattle Public Utilities (SPU) published rates^x, we calculated charges for both an average home and the Ballard Emerald Star. If we use the Emerald Star checklist baseline of 67 gallons per person per day and compare what a residential water bill would be at this level using the average of peak and off-peak charges, the annual bill for a family of three would be \$512 (the average yearly water bill in Seattle is \$476.16^x, which is fairly close to our hypothetical calculation). If this number looks low to Seattle residents, it is because SPU bills also include compost, recycling, and trash pickup as well as a sewer charge (estimated below), all of which are not included in this calculation. The family in the Ballard Emerald Star, using just 19.95 gallons per person per day, would have an annual bill of \$152—a savings of \$360 compared to our baseline, or \$324 compared to the actual Seattle average!

Sewer charges are on average even higher; the average Seattle household pays \$633.12 annually.^{xiv} While we do not have data on the wastewater generated each month by the Ballard Emerald Star, we can estimate it based on our prior modeling. The sewer/wastewater savings would not be as high as the utility water consumption savings since rainwater used indoors would still be wastewater.

Based on the modeled projections for all internal water use—rainwater and utility water—the homeowners would use 26.3 gallons per person per day. If all 26.3 gallons were subject to a wastewater charge, their annual sewer charges would amount to \$497.81.^{xi} A typical household’s annual bill, based on 2017 monthly charges, would be \$667.20.^{xii} That means the Emerald Star saves approximately \$169.39 per year in sewer charges. If this is added to the estimated water savings above based on the actual average Seattle charge, that is a total annual savings of \$493!

Though calculating financial savings stemming from water savings is not straightforward, because the Ballard Emerald Star is extremely water efficient, we know its residents’ water and sewer bills are significantly lower than the average Seattleite’s.



Homeowner Experience

The resident experience is an important aspect of building green that should not be ignored, though it is subjective and more difficult to measure. After all, if net zero energy homes are uncomfortable and undesirable, they won't do well in the long run! Therefore, we took the time to chat with the Ballard Emerald Star owners and get their perspective on life in their home.

We conducted a Likert scale survey to determine how they felt about various aspects of their home, and posed open-ended questions to learn more about why they chose to buy the Emerald Star home and how they adjusted to living there.

1. I am proud to live in an Emerald Star home.

STRONGLY DISAGREE DISAGREE NEUTRAL AGREE **STRONGLY AGREE**

2. My lifestyle is not significantly impacted by living in an Emerald Star home.

STRONGLY DISAGREE DISAGREE NEUTRAL **AGREE** STRONGLY AGREE

3. I appreciate the aesthetic value of my Emerald Star home (reclaimed wood, landscaping, etc.).

STRONGLY DISAGREE DISAGREE NEUTRAL AGREE **STRONGLY AGREE**

4. I find that my experiences with water features (toilets, faucets, showerhead, dishwasher, etc.) are comparable to my experiences with water features in homes prior to this one.

STRONGLY DISAGREE DISAGREE NEUTRAL **AGREE** STRONGLY AGREE

5. I find that my experiences with energy features (cooling, heating, light, etc.) are comparable to my experiences with energy features in homes prior to this one.

STRONGLY DISAGREE DISAGREE NEUTRAL **AGREE** STRONGLY AGREE

6. Living in an Emerald Star home has heightened my awareness to sustainability in other parts of my life.

STRONGLY DISAGREE DISAGREE NEUTRAL **AGREE** STRONGLY AGREE

7. Living in an Emerald Star home has increased my ability to talk about environmental sustainability issues with my family and friends.

STRONGLY DISAGREE DISAGREE NEUTRAL **AGREE** STRONGLY AGREE

8. Purchasing an Emerald Star home was a smart financial decision.

STRONGLY DISAGREE DISAGREE NEUTRAL AGREE **STRONGLY AGREE**

The Likert survey results demonstrate that the owners have had a very positive experience with their home overall. They are proud of it and believe it was a smart financial decision to purchase it. Indeed, given the water and electricity bill savings calculated above, this makes sense. After all, over the two years they have lived in the home, they have earned \$3,533 in credit from their electricity and saved roughly \$1,000 on their water and sewer bills.

The homeowners' experience with the home's systems and appliances has been positive, too. When asked about adjusting to the home's devices, they replied, "No hard adjustments. The systems kind of run by themselves." They also added, "We didn't have to change our habits that much, the house helps us to be efficient!" Repeatedly throughout the interview, they expressed delight at the electricity credit they have received and stated they "absolutely" would recommend purchasing an Emerald Star home.

Interestingly, the homeowners were not initially searching for a sustainable home. Instead, they "became interested in the sustainability and energy efficiency aspect as [they] progressed in [their] search."

They ultimately decided to purchase the Ballard Emerald Star even before its completion because they "were inspired by the project idea that combined design, unique reclaimed materials, and leading-edge technology in the sustainability area." And they "were very impressed by the level of research and details that went into building every part of the house."

Given that their purchasing priorities shifted as they explored their options shows the importance of education during the marketing and selling process. If homes are being built to high standards but their benefits are not being broadcasted, an opportunity is missed to educate potential buyers who would be interested in the benefits but have not been openly asking about sustainable homes.

Though the Ballard Emerald Star used new technologies and strategies not currently in most homes and therefore unfamiliar, the homeowner experience was still positive. The homeowners are proud of their home and especially excited about the financial savings it provides.



Implications

The Ballard Emerald Star is the second Emerald Star project to go through a post-occupancy study, after zHome. Given that both projects are meeting the goals set forth by the Emerald Star checklist and that their performance does not significantly differ from models, it seems the checklist and the modeling protocol are robust and providing appropriate benchmarks for high-performance, impactful building.

The excitement displayed by the Ballard Emerald Star homeowners regarding their electricity credits also demonstrates an important point with respect to home affordability. In the Seattle region, housing prices and rents have been rapidly increasing since 2012.^{xv} It is important to note that sticker prices and monthly mortgage or rent payments are not the only cost of housing, though they are the most visible upfront. Net zero energy and water efficient living are pathways to lower overall housing costs. When considering purchasing a net zero energy home, buyers may consider that they could divert their electricity savings to a higher mortgage payment, which would give them more flexibility in the housing they can feasibly buy. Low-income housing providers should also keep in mind that utility payments can be a disproportionate burden for some households, and affordable housing that is efficient is truly more affordable.

Finally, homeowner enthusiasm—even from homeowners who were not initially interested in sustainability—shows that Emerald Star homes are not just for people who are extremely passionate about green living from the get-go. On the contrary, Emerald Star homes spur interest in people who had not given sustainable homes much prior thought. These homes demonstrate that green living can be comfortable and save money rather than something that requires extreme sacrifice.

Conclusion

The Ballard Emerald Star home is a prime example of deep green building, not just because it has exceeded its net zero energy and water efficiency goals, but also because it provides a positive example of comfortable, sustainable living. Deep green housing does not necessitate giving up comfort, nor should it be inaccessible to the average person.

The electricity savings of the Ballard Emerald Star—3,941 kWh more renewable energy produced than energy consumed thus far—has both environmental and financial impacts. The home also reduced water usage compared to the average household by 70%, which is right on target with the Emerald Star checklist requirement. The homeowners are proud of their home and are delighted by the financial savings. This project is a showcase of why building to the Built Green Emerald Star standard is impactful and effective, and is a testament to the effort put in by the builder, Dwell Development, as they worked to build the first Emerald Star home in Seattle and prove that it would do well on the speculative market. We are happy that this project has been successful on all fronts and we hope it is the first of many as net zero energy building and Emerald Star-level rigor and savings become the norm.



ACKNOWLEDGEMENTS

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Leah Missik

Built Green Program Manager

Appendices

Net Energy Use

Net energy use in kWh was taken directly from the Ballard Emerald Star's electricity bills. The home has a net meter which tracks: the home's electricity consumption - its solar production = net energy use. From these bills, we were able to sum all bimonthly reports to see the home's kWh use to date, as well as chart its use over time for each bimonthly period.

Cloud Cover

These data are recorded from the Seattle Tacoma International Airport weather station. We simply counted the days in each month that were recorded as having cloud cover (we determined this by counting days with fog, heavy fog, thunder, hail, and smoke or haze) and charted this against net energy use.

Rolling Annual Net Energy Use

These are averages of every six consecutive bimonthly periods for which we had data. These averages show what the Emerald Star's net energy use was for every year-long period.

Energy Bills

These numbers were taken directly from the bills, which list the current billing charge as well as the credit balance or bill.

Utility Water Consumption

Consumption in CCF (748 gallons) for each billing period was taken directly from the bill. Using this information, we charted each amount over time as well as calculated average use in gallons per person per day: $CCF \text{ used} * 748 / \text{number of days in billing period} / \text{number of people in household} = \text{gallons used per person per day}$.

Rainfall

Monthly rainfall was calculated by totaling the daily precipitation as recorded at the Seattle Tacoma Airport weather station.

Rolling Annual Utility Water Use

These are averages of every six consecutive bimonthly periods we had data for. These averages show what the Emerald Star's utility water consumption was for every year-long period.

Water Use Bills

To calculate bills for a given usage, we used an average of on-peak and off-peak pricing taken from SPU's listed rates, which is listed at \$/CCF (the average of \$5.15 and \$5.29 = \$5.22). We then multiplied \$5.22 by household usage, and then multiplied this number by 365 to determine an annual bill. These bills for different households (baseline household, Ballard Emerald Star household) were then compared with each other.

It is of note that the average of off-peak and on-peak pricing likely underestimates savings, since the on-peak price of \$5.29 only accounts for the first 5 CCF used, after which the per unit price increases. Since the Ballard Emerald Star is less likely to exceed 5 CCF during on-peak months (it never did) than an average home, which consumes more, the calculated water savings represent a conservative estimate.

Sewer Charges

These were calculated using the rate per CCF as published by SPU. This rate (\$12.93 per CCF) was multiplied by CCF used per year for a given home. CCF of wastewater for the Emerald Star was calculated from its modeled per capita daily water usage, since that included rainwater used that was not on the utility bills. Since the model's projected utility use was almost the same as the actual utility use, we determined this was an accurate number.

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Built Green is the green home certification program of the Master Builders Association of King and Snohomish Counties.

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