BUILT GREEN

Built Green homes are even more efficient than you—and we—thought

As proven by hundreds of Seattle homes in first ever study of its kind

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ABRIDGED REPORT

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Executive Summary

In cooperation with the City of Seattle and Seattle City Light, Built Green, a residential green building certification program of the Master Builders Association of King and Snohomish Counties, conducted research to determine how much electricity is saved by single-family homes and townhomes that are certified Built Green compared to non-certified homes.

In order for a home to achieve Built Green certification, it must meet minimum requirements and achieve a total point score that measures the four key areas in which homes impact the environment: site and water, energy efficiency, indoor air quality, and materials efficiency. In addressing energy use, a home must demonstrate that it exceeds the Washington State Energy Code through an energy model. However, energy models, though extensively researched and widely accepted, are simply an estimate of how much energy a home will use—much depends on occupant behavior and other factors.

This study determined the actual electricity savings of Built Green homes by examining how much electricity the homes used after being occupied for a at least one year. Built Green obtained electricity data for all single-family homes and townhomes that had been built in Seattle in the year 2014. 746 homes were examined in the final evaluation, making the study, to our knowledge, one of the largest of its kind.

By comparing the usage of homes that were not certified as Built Green to those certified at various star-levels according to Built Green's tiered rating system, we determined the actual savings that result from building to Built Green's certification standards. We found that, on average, Built Green homes perform far better than non-certified homes, as well as exceed the modeled savings required for certification at all star-levels. At the time these homes were certified in 2014, the 3-Star certification level had no energy modeling requirements, 4-Star homes had to demonstrate modeled savings at 15% above energy code, and 5-Star homes had to model at 30% more efficient than code. Comparing the average annual electricity consumption of all-electric non-Built Green homes to all-electric Built Green homes of different star-levels, we observed the following:

- **A 25% improvement in 3-Star homes**
  (or 2,900 kWh saved per home annually)
- **A 33% improvement for 4-Star homes**
  (or 3,806 kWh saved per home annually)
- **A 40% improvement for 5-Star homes**
  (or 4,708 kWh saved per home annually)

Based on these findings, it is clear that Built Green homes are far more efficient than non-certified homes. Further, these results demonstrate the efficacy of Built Green certification; the certification indicates significant electricity efficiency as compared to non-certified homes.

The electricity savings provided by Built Green homes benefit homeowners financially and give them more flexibility in their spending while simultaneously producing a positive environmental impact.

The gains in electricity efficiency resulting from Built Green certification standards present significant financial and environmental savings:

- Built Green 4-Star homes save about $450 each year on electricity costs when compared to non-certified homes; Built Green 5-Star homes save about $558 annually.
- The annual Built Green 4-Star electricity savings are equivalent to installing more than ten solar PV panels (a cost above $8,000) on a home.
- These yearly Built Green 4-Star savings are also equivalent to the amount of electricity it takes to provide electricity for 1.3 years' worth of typical Nissan Leaf driving habits; pairing a green home with an electric vehicle would not use more electricity than a non-certified home would on average, but the occupant's carbon footprint would be drastically reduced through use of an electric, rather than conventional gas-fueled, vehicle.

These proven electricity savings, determined from an unusually large number of homes, and their corresponding environmental, social, and financial impacts, provide local governments, utilities, and builders with the tools to better promote green construction and the Built Green program, which in turn contributes to sustainability and community health. This paper explains how analysis was conducted, details the results of the study, speculates as to why the results are what they are, provides environmental and monetary equivalencies, and elaborates on implications and next steps for the program, local governments and utilities, residents, and builders.

Introduction

Buildings have a large environmental footprint: they require materials for construction and land where they can be built, their construction and operation generates waste and greenhouse gas emissions, and their occupants, through the building's appliances, consume water and electricity. All these environmental impacts deserve attention. With the urgency of climate change becoming ever more pressing[i], it is understood that carbon emissions need to be reduced across all sectors, including within the building industry. Apart from the carbon emitted through building materials manufacturing and the construction process, buildings contribute to climate change via their energy consumption. In fact, in 2016, about 40% of U.S. energy consumption was from the residential and commercial sectors, which account for almost all U.S. building energy consumption.[ii]

In the City of Seattle, which is the geographic focus of this study, buildings account for 33% of greenhouse gas emissions, with 14% coming from the residential building sector. As such, improving building energy efficiency has a significant impact on greenhouse gas emission reductions. As cities, states, and countries work to reduce their greenhouse gas emissions, the building sector's impact cannot be ignored. It is less clear what specific building strategies will have the most positive impact, and how these strategies can become more widespread. This study presents some answers by quantifying electricity savings stemming from Built Green certified homes and elaborating on their impact and how certified green home construction can be encouraged.

Background

Built Green is a holistic green home certification program of the Master Builders Association of King and Snohomish Counties, established in partnership with King and Snohomish counties in 1999. In addition to certifying green homes, remodels, multifamily buildings, and communities, Built Green hosts a membership network of companies and individuals involved in the green building industry, conducts research, and markets the social and environmental benefits of green building. The program's mission is to serve as the driving force for environmentally sound design, construction, and development practices in the state of Washington's cities and communities. Since its inception (as of March 2017), Built Green has certified more than 31,000 housing units and 17,000 buildings. The program has partnered with local governments and utilities to create green building incentive programs, which have helped spur uptake in the region.

Working in conjunction with City of Seattle and Seattle City Light (the local electric utility), Built Green examined the electricity consumption of new construction single-family homes (including townhomes) built in the City of Seattle in 2014. After cleaning data, 746 homes were included in the analysis, which compared the electricity consumption of Built Green homes to non-certified homes during the year 2015 (give or take a couple of months depending on when bills were issued).[1] This analysis was checked by an independent consultant for accuracy.

[1] See Determining time frame in appendices.

Findings

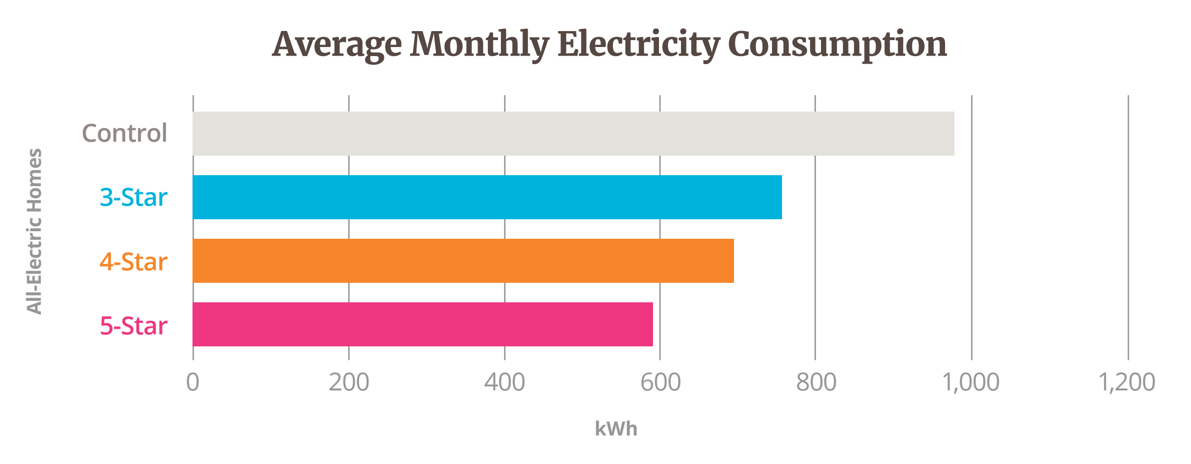
The results of the analysis not only demonstrate that Built Green certified homes on average are more energy efficient than non-certified homes, but that they exceeded our expectations and home energy models significantly.

Homes that were certified Built Green in 2014 were certified under the 2011 version of Built Green's single-family/townhome checklist (in other words, the checklist iteration that had been finalized in 2011). Under this checklist, homes were required to demonstrate 15% improvement above 2012 Washington State Energy Code for 4-Star projects, and 30% improvement above 2012 Washington State Energy Code for 5-Star projects. There was not yet any energy modeling requirement for 3-Star certification.

When comparing the total electricity consumption of all-electric homes to each other[2], 3-Star, 4-Star, and 5-Star homes outperformed control group homes by 25%, 33%, and 40% respectively.[3] This represents a significant increase in overall energy performance than was required by Built Green's modeling standards.

All-Electric Homes kWh Usage

Group	Average yearly kWh usage	Average monthly kWh usage	Percent improvement over control group
Control *(Non-certified homes)*	11,632.40	962.38	N/A
3-Star	8,732.00	722.31	25%
4-Star	7,826.23	646.05	33%
5-Star *Note: Only one home in sample*	6,924.00	570.66	40%



[2] This report focuses on all-electric homes since we were unable to obtain gas consumption data and therefore all-electric homes provided an even point of comparison. For details, see Gas connections in appendices.

[3] See Determining average kWh usages in appendices.

One factor that we were able to account for, and one that can greatly impact the total electricity use of a home, is housing size.[4] We gathered square footage for the 94% of homes in our data set via their building permits.

Data Group	Average Housing Size	Average kWh Use/Square Foot
Control Gas-Connected	2,610	3.36
Control All-Electric	1,930	6.36
3-Star Gas-Connected	2,269	4.39
3-Star All-Electric	1,452	5.90
4-Star Gas-Connected	1,716	3.34
4-Star All-Electric	1,489	5.43
5-Star Gas-Connected	1,752	2.56
5-Star All-Electric	1,480	4.68

As anticipated, all-electric homes have a higher electricity intensity than gas-connected homes of the corresponding data group (Built Green star-level or control), since, for gas-connected homes, gas would be offsetting some of the electricity use.

There are a couple of noteworthy conclusions that can be drawn from this data. One is that Built Green homes are, on average, smaller than non-Built Green homes. This is unsurprising since the Built Green checklist is advantageous for smaller homes over larger homes because of its housing size matrix. Homes that, based on a combination of bedrooms and overall square footage, receive a points multiplier that increases the project's point total by a factor that increases the smaller the home is. Conversely, larger homes do not receive a multiplier that amplifies their point total—and large homes may also be subject to higher point thresholds that must be met in the energy and materials categories of the Built Green checklist.

[4] *See Housing size and electricity intensity* in appendices.

Though smaller house sizes contribute to Built Green's electric savings for all-electric homes, Built Green homes tend to have a lower electricity intensity, which compounds these savings. All-electric control group homes have the highest electricity intensity at 6.36 kWh/square foot on average. All-electric 3-Star homes come in at an electricity intensity of 5.90 kWh/square foot, 4-Star at 5.43 kWh/square foot, and 5-Star at 4.68 kWh/square foot. Interestingly, both 4- and 5-Star all-electric homes are slightly larger, on average, than 3-Star all-electric homes. It is their lower electricity intensity, therefore, that causes them to still be 8% and 16% more efficient than 3-Star homes.

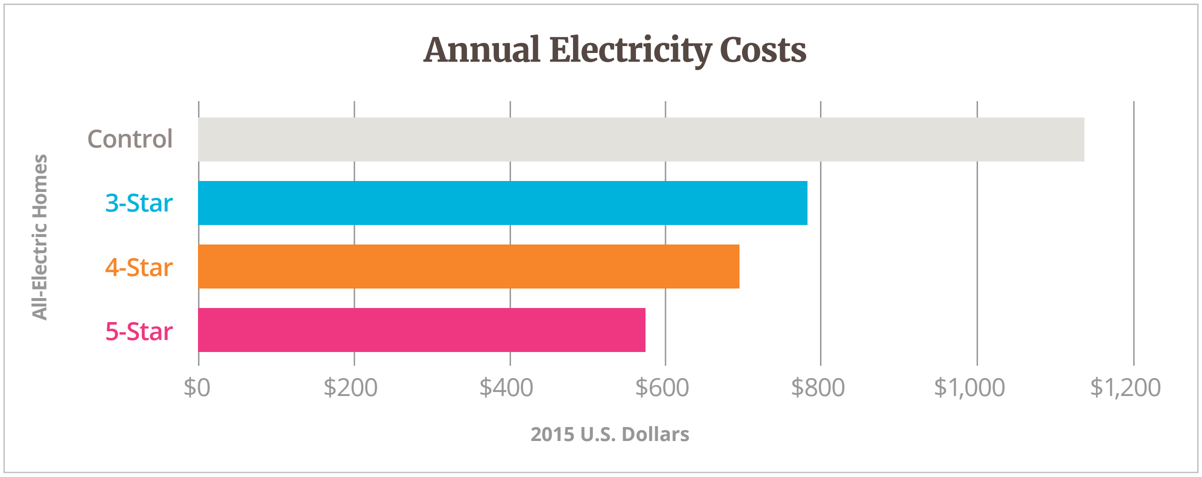
Overall, this analysis shows that although Built Green homes are generally smaller than non-Built Green homes, it is not only their size that accounts in full for their electricity reduction, but rather, most groups of Built Green homes are additionally more electrically efficient per square foot than the corresponding control group homes due to the energy efficiency measures that must be taken in order to achieve certification.

Impacts

Now that it has been established that Built Green homes use less electricity than non-Built Green homes, the ramifications of these electricity savings will be discussed. The two main categories we examined were the financial and environmental impacts generated by these savings each year.

Using the electricity use and cost data in our possession, we were able to simply calculate yearly and monthly electricity costs for the homes in our study.[5] As expected, for all-electric homes in the study, the biggest difference in electricity bills was between control group homes and 5-Star homes. For all-electric control homes, the monthly cost of electricity was an average of $93.80, whereas the all-electric 5-Star home's monthly costs were only $47.43 on average. That is a not insignificant difference of $46.37. For comparison, the monthly electricity costs for a gas-connected 5-Star home are, on average, $23.96—compared to $65.68 for gas-connected control homes (of course, these homes must also pay gas bills as a part of their energy usage).

When viewed on the timescale of a year, the all-electric 5-Star home on average was only billed $575.46 for electricity, whereas all-electric control homes incurred a total annual electricity cost of $1,133.67. These monetary savings generated by Built Green homes would occur each year, compounding their financial impact over time.



[5] *See Seattle City Light average rate and average costs* in appendices.

These savings can translate into greater home purchasing power.[6] The electricity savings gleaned from a Built Green home as opposed to a non-certified home, if redirected toward mortgage payments, enable the purchaser to consider homes that have a more expensive up-front cost. Though the price of the home itself may be higher, the monthly payments made by the homeowner would not be any different, thanks to significant electricity savings leading to lower utility bills. If the 2016 monthly electricity savings of an all-electric 4-Star home (compared to a non-Built Green home) were applied to a monthly mortgage payment, the buyer would be able to afford a loan of $9,077.64 more. If they still paid 20% down, they could afford a home with the sales price of $599,347.04, which is $11,347.04 more than the median housing price, while still spending the same amount per month on home ownership as someone purchasing a non-certified home at the median price would. When the even bigger electricity savings of 5-Star homes, when compared to non-certified homes, are applied to the monthly mortgage payment, the sales price of a home could increase from the median price of $588,000 to $602,048.44—a difference of $14,048.44. The only difference is the purchaser would be spending more money on the mortgage payment, and that much less on electricity.

At its root, Built Green's objective is to lessen the environmental impact of housing. Ultimately, Built Green's energy efficiency requirements for certification are in place to lessen the environmental impacts associated with energy, of which there are many, and which depend on the energy source. To better demonstrate the environmental impact of Built Green certification, we calculated various equivalencies that provide a more tangible representation of the electricity savings.

An important calculation is that of how many greenhouse gas emissions are averted by a Built Green home.[7] This calculation, however, is entirely dependent on where the homes are theoretically located, and what electricity source they are using. Since Built Green is a program that operates around Washington state and certifies a significant number of homes outside of Seattle in King County, it is appropriate to look at the carbon dioxide savings of Built Green homes in this area, most of whose electricity would be served by Puget Sound Energy.[iii]

Annual Carbon Dioxide-Equivalent Savings Per Home Using Puget Sound Energy Emissions Rate

Comparison	**Resulting Savings**
Built Green 4-Star v. Study Control	3,920.35 lbs CO_2e
Built Green 5-Star v. Study Control	4,849.65 lbs CO_2e
Built Green 4-Star v. Average WA Home	3,854.02 lbs CO_2e
Built Green 5-Star v. Average WA Home	4,783.32 lbs CO_2e

[6] *See Home purchasing power* in appendices.

[7] *See Carbon emissions* in appendices.

The preceding chart demonstrates that an all-electric 4-Star Built Green home built outside of Seattle but in King County would avert either 3,920.35 or 3,854.02 pounds of carbon dioxide equivalent emissions annually, depending on whether or not the home is being compared to an average non-certified Seattle home built in 2014's usage as determined by this study, or to an average Washington home.

Another comparison that can be made is that of electricity efficiency to solar photovoltaic electricity production.[8] We calculated it would take it would take 11 individual panels to make up the difference in electricity consumption between an all-electric 4-Star and an all-electric control group home. To make up the gap between an all-electric 5-Star and a control group home would require 14 panels. A solar photovoltaic system that closes the electricity use gap between an all-electric control group home and a 4-Star home would cost about $8,147[iv], while making up the difference between an all-electric control home and a 5-Star home through solar would cost $10,078.

Given that Seattle's electricity is relatively very clean, the transportation sector accounts for a large portion of the city's greenhouse gas emissions. Passenger road transport alone counts for 45% of the city's emissions.[v] This means that in order to seriously tackle climate change from the local level, Seattle needs to take big steps to decarbonize its transportation sector. Increased public transit plays a significant role, but so does the decarbonization of individual vehicles. The electricity savings from an all-electric Built Green 4-Star home as compared to a non-Built Green home are enough to power 1.3 typical Nissan Leafs under typical usage. 5-Star savings provide the same amount of electricity it would take to account for the electricity use of 1.6 average Leaf drivers in a year. These results are roughly the same if we look at a different electric vehicle, the Tesla Model S. Taking an average passenger vehicle off the road for a year would avert 10,362 pounds of carbon emissions.[9] Also, replacing a conventional vehicle with an electric vehicle would lead to monetary savings in Seattle, since charging an electric vehicle is cheaper than purchasing gasoline.

Annual Built Green Savings Equals

Driving an electric vehicle **for over 15,000 miles**

A 12W LED running continuously for **over 44 years**

[8] *See Residential solar PV equivalency* in appendices.

[9] *See Electric vehicle equivalency* in appendices.

We calculated a few other environmental equivalencies for both demonstrative and comical purposes. One of these was how many times, using a year's savings from a Built Green home, an iPhone 6 could be fully charged up.[10] We calculated that the annual savings of one all-electric Built Green 4-Star home compared to a non-certified home are enough to charge an iPhone 6 362,492 times. The yearly difference in electricity use between an all-electric Built Green 5-Star home and a control group home provides enough electricity to charge an iPhone 6 448,419 times; if you assume this phone is charged once a day, and that the battery is fully drained daily, this amount of electricity would be enough to charge the phone for more than 1,000 years—far longer than the phone, or the user, would last!

Another easily relatable equivalency is how long a LED light bulb can be kept on using Built Green electricity savings.[11] LEDs are recognized for their energy efficiency and long lives and have become increasingly common. The electricity savings in one year between one all-electric Built Green 4-Star home and a control group home would be enough to continuously run a 12W LED for 36 years and 77 days. The difference in electricity use between an all-electric 5-Star home and a non-Built Green home could run such an LED for 44 years and 288 days. Of course, people utilize more than one light bulb in their homes, but these savings, when spread across many efficient light bulbs (which usually are not running continuously), could still provide a household's lightning needs for a significant amount of time.

Conclusion

Built Green offers proven benefits for the environment and for those who live in certified homes. This unprecedented research quantifies electricity savings and the corresponding environmental and monetary savings resulting from homes that are Built Green certified at different levels, and provides further insight into the traits, such as size and fuel sources, of both Built Green and non-certified homes. The fact that Built Green homes save significantly more electricity than was required for certification and was estimated through energy models solidly justifies its use as a basis for incentive programs offered by governments and utilities. Indeed, quantifying the environmental benefits that stem from Built Green help justify green building as a whole. As new buildings are inevitably built as populations grow, it is highly important to make this new infrastructure greener. The impact of more environmentally friendly building is magnified over time, as the environmental benefits accumulate during the life of a building. During this era of pressing climate change, energy efficient buildings are all the more necessary.

The findings of this study, proof of Built Green's electricity and environmental savings, present positive ramifications for Built Green as a program, local governments and utilities, those who live in Built Green buildings, and for the population as a whole, since everyone ultimately benefits from environmental savings. Built Green is committed to strengthening its program, increasing its utilization, and supporting the growth of green building in other locations to the same effect. In turn, the results of this study highlight the importance of supporting Built Green, and perhaps other, similar, green building certification programs due to their impact. Built Green certification represents proven environmental and monetary savings, and is a mechanism to ensure more sustainable development as our infrastructure develops and changes.

[10] *See iPhone 6 equivalency* in appendices.

[11] *See LED equivalency* in appendices.

ACKNOWLEDGEMENTS

From start to finish, this research project took well over a year, and many people shepherded it to completion along the way. Sandra Mallory, with the City of Seattle, helped me gather large amounts of data, both by connecting me with the appropriate people and by adding some requests to her employees' work load. She also helped guide the research aims and reviewed early calculations as well as the final draft. Heather Eklund and Scott Cooper with Seattle City Light were my primary points of contact regarding the utility data early on. Heather, in particular, worked on ensuring the data request could be granted, and at what level of detail. Jess Harris, with the City of Seattle, helped by providing permit data as well as by cross-checking questions that came up during the research process against his records. Alexandra Ramsden and Stefanie Young from Rushing provided their services in reviewing this study's methodology and calculations used as well as the final draft of the paper and the feedback they provided was incredibly helpful. Finally, I would like to thank Talia Haller, Built Green's summer intern in 2016. She shouldered even more of the data analysis and organization than I first envisioned, and played a tremendous role in shaping the research and final product. Without her hours and hours of time immersed in Excel spreadsheets, I might still be plugging away at the data analysis.

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Appendices

Determining time frame

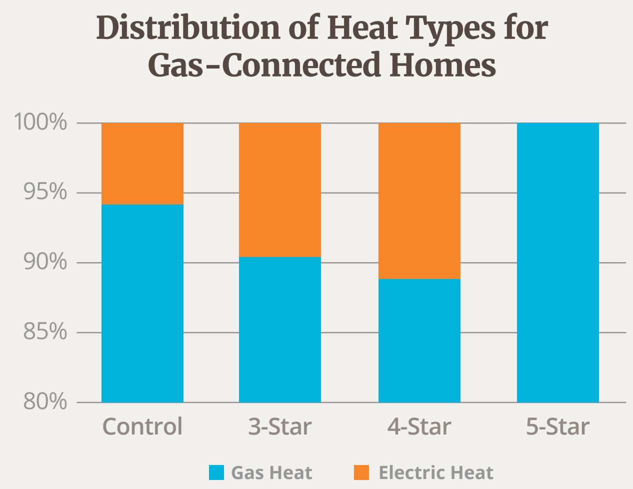
Many addresses included in this study had more than a year's worth of electricity consumption data. First, we determined which time frame would allow us to examine a period of a year, plus or minus a week (358 to 372 days). If an address had more than one time frame that would meet this requirement, we selected the range closest to a start date in December 2014 or January 2015 (Seattle City Light bills bimonthly).

Gas connections

Seattle City Light is an electricity utility and thus, does not sell gas. Some homes in Seattle do have gas connections, and their gas supply is provided by the utility Puget Sound Energy. Unfortunately, we were unable to obtain gas consumption information by address from Puget Sound Energy, and our analysis therefore only examines electricity, rather than overall energy, consumption.

To accommodate the reality that some addresses in the study use gas for a percentage of their home energy needs and some don't, addresses were split by those with gas connections and those without. This information was found from public King County records as well as from City of Seattle permit information. First, we split addresses by whether or not they were listed as having a gas piping permit according to King County records. Then, after City of Seattle staff examined individual permit records, we did a double check for homes that showed they used gas heating but did not have their address listed as having a King County gas piping permit. Usually, we were able to ascertain the reason for the discrepancy, most often a changed address or one address in a development being used for the permit of multiple townhomes rather than each individual address. We also double-checked against Built Green submittal records for certified projects to see if they contained gas appliances or equipment and, as a result, many homes were moved into the gas-connected group.

However, despite our diligence and best efforts, this separation mechanism is imperfect for a post-occupancy analysis consisting only of electricity data. An address may have a permit for gas connection, but it may not use any gas appliances. Alternatively, a home that has a gas connection could heavily rely on gas for heating and more. There is a range of appliances that utilize gas and a range of the amount of gas used by those appliances. A home that only uses a gas connection for a gas cooking stove may be in the same data set—homes with gas connections—as a home with a gas connection that uses a gas furnace for home heating. The latter, relying more heavily on gas, would likely use less electricity—but not necessarily less total energy—than the former home. Based on the homes we have permit data for, however, we were able to get an idea of this distribution.



Both gas-connected 3- and 4-Star homes are more likely to have electric heating than control group homes. This indicates that 3- and 4-Star homes would have a higher electricity load, making electricity savings over gas-connected control group homes on average all the more impressive. No gas-connected 5-Star homes had electric heating, however. In fact, only one 5-Star home out of 33 total was classified as all-electric based on our information. Based on Built Green certification data, we found that these gas-connected 5-Star homes were using high efficiency tankless water heaters and hydronic radiant heating, which is very efficient and at the time of certification one of the most cost-effective ways to meet the high-efficiency requirements for Built Green 5-Star certification. For consistency between data sets, we still focused on the comparison of all-electric homes to one another, even for 5-Star homes. It is worth noting that had we compared all 5-Star homes to all control group homes, Built Green savings would have been even greater.

Determining average kWh usages

Using the SUM function in Excel, we found the total kWh used for each address in the selected time frame. We calculated each address's usage per day by dividing this total by the number of days in the address's individual time frame. To calculate an address's monthly mean usage, we multiplied the daily usage by 30. We did this because SCL's billing periods are roughly—not exactly—bimonthly, and this maintained consistency across addresses.

The above calculations (total kWh usage, monthly mean usage, daily usage) were then grouped by certification level (or lack thereof) and then subdivided by whether or not a home had a gas connection. For these groups, we used the AVERAGE function across all addresses in a group to find the group's average total kWh usage, monthly mean usage, and daily usage.

Housing size and electricity intensity

For most addresses, we were able to obtain housing size (square footage of living space) from individual permit records. Using this data, we were then able to look at average house size across data groups, as well as electricity intensity. To calculate, we simply divided the total kWh usage for an address (for our approximate year time frame) by the number of square feet.

Seattle city light average rate and average costs

2015 rates were calculated based on 2016 rates and their percent increase from the prior year (information downloaded from SCL's website)[vi]. SCL charges a daily base rate, a first block rate (upper limit varies by season), and a second block rate. Since we were looking at yearly averages for groups, we used 13 kWh as the first block's upper limit, which is the average upper limit between the winter and summer seasons. We then used the following formula to calculate bills for each group: daily base charge + (13 kWh or lesser amount, if applicable) * first block rate + (daily usage – 13 kWh) * second block rate = daily electricity cost. This daily cost was then multiplied by the number of days in a month, billing period, or year to get the corresponding electricity costs. Average cost per kWh for each group was found by dividing the yearly cost by the total kWh used. The weighted average cost per kWh across all groups was found using a simple weighted average that looked at each group's kWh cost weighted by the number of data points in that group.

Home purchasing power

To determine this, we first calculated electricity savings based on 2016 Seattle City Light prices and on 2015 usage (assuming usage was similar in 2016). We did this since our housing price information was in 2016 U.S. dollars and we wanted to eliminate the impact of inflation. Monthly electricity costs were slightly higher in 2016 than in 2015. Then, we used an interest rate of 3.31% and a housing price of $588,000—the Washington state interest rate and the Seattle mean housing price at the end of August 2016, according to Zillow.[vii] Using these numbers as a base, we calculated loan amounts, assuming a down payment of 20% and monthly payments through a 30-year mortgage. We then added the difference in monthly electricity costs between both 4- and 5-Star and non-certified homes to this standard monthly payment, and back-calculated to see how the home price would change based on these larger monthly mortgage payments.

Carbon emissions

CO_2-equivalent emissions savings resulting from Built Green homes were calculated using Puget Sound Energy's CO_2-equivalent emissions per kWh.[viii] Comparisons were made based on yearly differences in electricity consumption between different groups of homes: 4-Star all-electric Built Green, 5-Star all-electric Built Green, all-electric control homes and an average Washington State home (sourced from Energy Information Administration data)[ix]. The difference in kWh consumption between a group was simply multiplied by the resulting emissions per kWh. This resulted in the emissions reduction of one home between two comparison groups, which could be further multiplied out to see the emissions savings from a larger number of homes.

Residential solar PV equivalency

The electricity savings from Built Green homes compared to either control, average Washington state, or average U.S. homes was compared to the number of standard sized (65" by 39", 250 W) residential solar photovoltaic panels by first determining how much electricity one panel would produce in a year. A Seattle capacity factor of 0.16 was used in the equation based on information from Sunmetrix.[x] To determine annual kWh production of a typical panel we used the equation: 250 W * 1/1000 * 8760 hours/year * 0.16 = 350.4 kWh. Savings between different groups of homes were simply divided by this annual production number to determine how many solar PV panels would make up the difference.

To determine cost estimates of purchasing that number of panels, we used a cost estimate of $3.00/W (obtained from Greentech Media)[xi], multiplying that by 250 W (per panel) and the number of panels.

Electric vehicle equivalency

To calculate the average number of Nissan Leafs the electricity savings of a Built Green home could power, we assumed typical usage (the Idaho National Laboratory published a paper[xii] which listed the average number of miles driven by a typical Leaf driver in a year) and used the Environmental Protection Agency estimate of how many miles per kWh a Leaf can travel.[xiii] We multiplied annual kWh savings by the number of miles per kWh a Leaf can drive and then divided this by the number of miles a typical Leaf driver drives in a year to estimate the average number of Leafs, with typical usage, Built Green savings could power. We did similar calculations for a Tesla Model S, also using EPA mileage estimates[xiv]; however, we used typical Leaf usage for average number of miles driven since we could not find this information for Tesla drivers.

We affirmed that the cost of using electricity for transportation (with a Nissan Leaf) is cheaper than using a conventional gas-fueled vehicle, on a cost per mile basis. According to the EPA, the average fuel economy of model year 2015 vehicles was 24.8 miles per gallon[xv]. The EPA also estimates the fuel economy of a Nissan Leaf as being equivalent to 114 miles per gallon, and a gallon as being equivalent to 33.7 kWh[xvi]. Using a price of $2.93 per gallon for gas, we see that an average vehicle would cost 12 cents per mile to drive. Using Seattle City Light's current average (as of June 2017) residential electricity cost and multiplying that by 33.7 kWh/gallon and by one gallon/114 miles, we see that a Nissan Leaf costs just 3 cents per mile to drive.

iPhone 6 equivalency

We obtained an estimate from Opower[xvii] of how much electricity (kWh) it takes to charge an iPhone 6 and then divided savings between data groups by this number to determine how many iPhone 6 charges to which these savings are equivalent.

LED equivalency

We used a 12W LED as the basis of our calculations. Running continuously, such a lightbulb would use 12W * (1/1000 kW) * 8760 hours = 105.12 kWh in a year. Electricity savings between data groups were then divided by this number to determine how many years the savings could run a 12W LED continuously.

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