Habitat for Humanity Solar Share Benefit Analysis

A Kentucky Study

by Nicole Kitko, Rosemary Alden, Lisa Keels, Aron Patrick, and Dan M. Ionel

Executive Summary

Providing 4.5 kW DC of solar photovoltaic (PV) capacity to low-income residences in Kentucky reduced their electricity bills by an average of $27.94 per month and lowered their equivalent emissions by 88.7%. The monetary value of the community solar electricity was determined by comparing 15-minute residential load data with the solar PV generation in that time. The summer months provided the most monetary benefit on average, but also the widest range in value to participants. Winter had the lowest solar PV generation and lowest average monetary benefit for the participants. The program allowed low-income homes to reduce their bills and emissions while supporting community solar.

Background

Ten Habitat for Humanity[1] households were selected to receive eighteen shares of solar PV panels through LG&E and KU's Solar Share community solar program. Those 18 shares are equal to a capacity of 4.5 kW DC, 3.78 kW AC, per household and were provided with no cost to the participants. The collaborative initiative was designed jointly by LG&E and KU and Habitat for Humanity as a sustainability effort to reduce participant electricity bills while also decreasing the environmental impact. After the first year of operation, the data collected through the program, including customer energy use and solar PV generation, was provided to the University of Kentucky (UK) Power and Energy Institute of Kentucky (PEIK) for further evaluation of the effectiveness of the program and quantification of its benefit to participants.

Solar Share allows customers to sponsor local renewable energy by leasing a utility scale solar PV facility in rated 250-watt DC, 210 watt-AC, increments. Each 250-watt rated share of solar capacity is currently estimated to generate between 18 and 38 kilowatt-hours (kWh) of energy per month, depending on factors such as weather conditions and time of year. A typical residential household uses approximately 1,100 kWh of electricity each month[2] and Habitat for Humanity subscribers could expect to receive a monthly credit for 324 to 684 kWh from the estimated generation of eighteen solar shares.

The solar PV generation plant, which is physically located in Simpsonville, Kentucky, is owned and maintained by LG&E and KU, and new sections are built based on subscriptions. Shares of the solar panels can be leased by customers and the credit for the energy the panels generate is provided to the customer electronically in real-time reducing charges for energy they consume. A section must be 100% subscribed before construction can begin. The first section went live in June of 2019 and the second in May of 2020. Sections three and four both came online in June of 2021 and a fifth section is fully subscribed but has not yet started construction. When completed, the site will consist of eight sections that are rated 500 kW each, resulting in subscribers sponsoring 4 MW of solar PV capacity in total.

Electricity use data for these residences was also collected and analyzed from July, 2020 to July, 2021. Through this collaborative charitable initiative, the residents were not required to pay any monthly subscription fee or upfront costs for the panels, so all credit from solar PV generation directly decreased their bill. Energy produced by the panels in excess of the customer's load is called overgeneration[4]. The buy-back value of this overgeneration also decreases the residence's bill, while continuing to reduce the environmental impact of the

[1] Habitat for Humanity – https://kyhabitat.org/
[2] Solar Share Program – https://lge-ku.com/solar-share
[4] National Renewable Energy Laboratory – https://www.nrel.gov/docs/fy16osti/65023.pdf

power system. The monetary benefit of the allotted solar PV panels with a 4.5 kW DC capacity rating is mostly influenced by the participant's electricity use in the middle of the day, during peak solar PV generation.

Calculation

The customer's load and solar PV generation data are compared over fifteen-minute intervals to determine the amount of energy offsetting the customer's use and the amount of overgeneration. The offset rate is applicable when solar PV generation is equal to or less than the house's load in the fifteen-minute interval. Offset generation received the full price, at the time, of 8.96 cents per kWh in KU's territory or of 9.28 cents per kWh in LG&E's territory. Solar PV generation in excess of household energy use is credited at a buy-back rate of 2.17 cents per kWh.

Five of the Habitat for Humanity households are served by LG&E and five by KU. Although all the residences have been allotted the same amount of free solar PV based energy monthly, their electricity use affects the monetary value of that energy. For those who have a high load in the afternoon during peak solar PV generation, more of the participant no-cost solar PV energy will be used to offset the full electricity rate. The households that use less energy in the middle of the day will likely have a greater amount of excess solar PV generation that is credited at a lower buy-back rate.

Calculations are performed on fifteen-minute intervals and the difference between load and solar PV generation results in the net load (1).

$$Customer\ Load\ [kWh] - Solar\ Generation\ [kWh] = Net\ Load\ [kWh] \tag{1}$$

If the net load is positive within the fifteen-minute interval, the customer has used more energy than their shares have generated during that period, and the entire value of the solar PV generation is credited at the full electricity rate (2).

$$Solar\ Generation\ [kWh] * Full\ Electricity\ Rate\ [\frac{\$}{kWh}] = Energy\ Bill\ Savings\ [\$] \tag{2}$$

If the net load is negative within the fifteen-minute interval, the solar PV generation was greater than the customer's load. This results in part of the solar PV based energy to be valued at the offset rate (3) and the overgeneration valued at the buy-back rate (4).

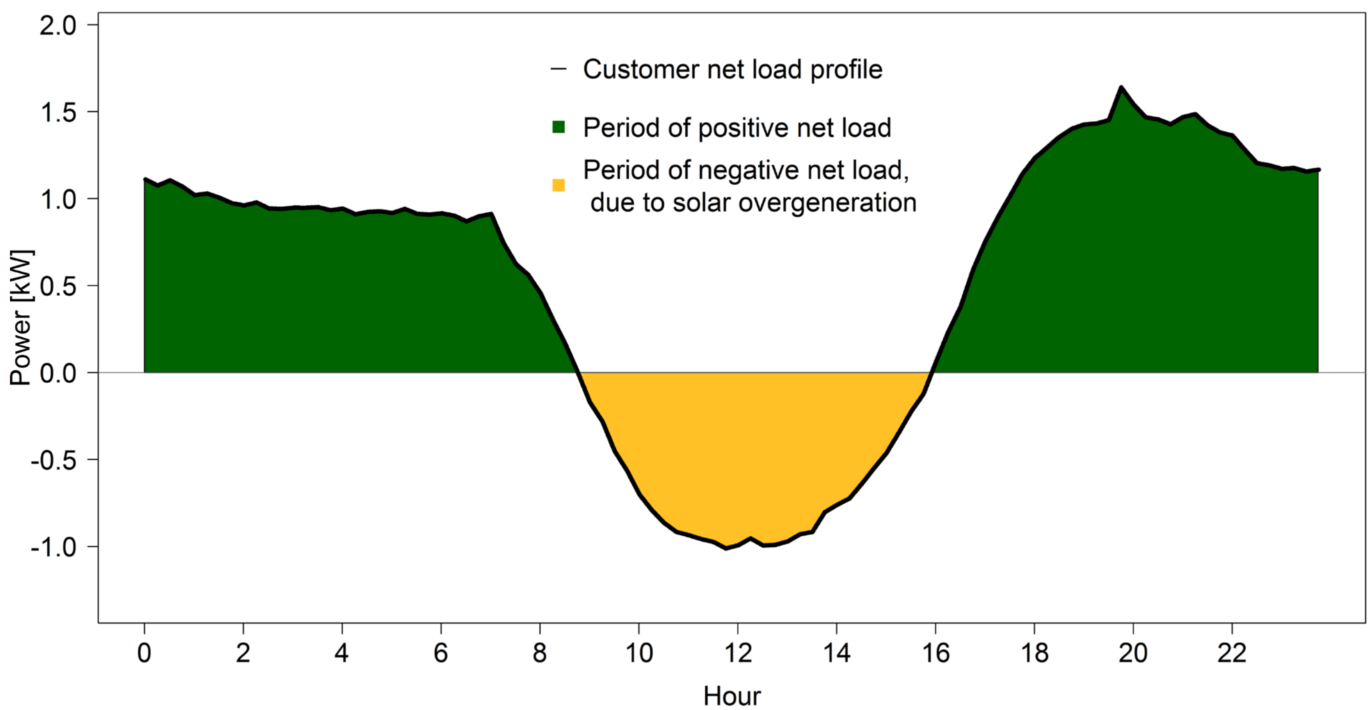
$$Customer\ Load\ [kWh] * Full\ Electricity\ Rate\ \left[\frac{\$}{kWh}\right] = Offset\ Energy\ Credit\ [\$] \tag{3}$$

$$|Net\ Load|[kWh] * \ Buy\ Back\ Rate\left[\frac{\$}{kWh}\right] = Buy\ Back\ Energy\ Credit\ [\$] \tag{4}$$

At the end of the monthly billing cycle, the contributions in terms of Energy Bill Savings, Offset Energy Credit, and Buy Back Energy Credit from all the fifteen-minute intervals are added together to yield the Monthly Savings.

Net Load Effects

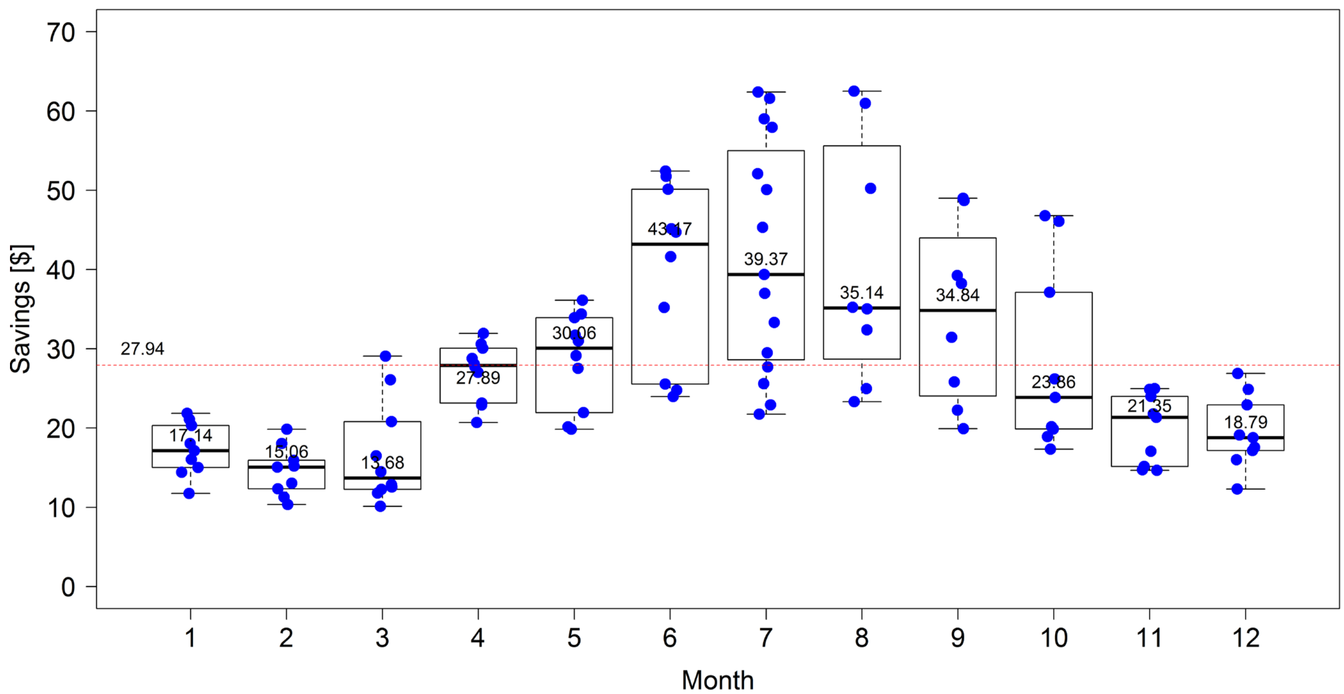
The average net load for the households is shown in Figure 1, where the black line depicts the net load. In green are the time durations of positive net load, and yellow visualizes the portion of the day when there is negative net load due to solar overgeneration. The plot illustrates that on average there is more solar PV power generated during the middle of the day than there is load from the studied households. Over a one-year period of the 4.5 kW DC capacity solar PV generation subscription, 58% of the generation for these accounts was overgeneration and was monetarily valued at a buy-back rate.



Seasonal weather affects both the amount of solar PV generated and the household load. In winter when load is high from heating and solar PV generation is low, the electricity from the solar PV panels is typically less than the household load, and there is no overgeneration. The solar PV generation for that period is generally credited at the full electricity rate. The shoulder seasons of spring and fall have lower customer load, but relatively high solar PV generation compared to winter. Lower total load results in most of the solar PV generation credited at the lower buy-back rate, and therefore results in less monetary value per share for participants when compared to summer months. On average, households gain the most monetary benefit from the generation subscription in the summer months. The solar PV generation can typically entirely offset the increased load due to air conditioner use.

Monthly Analysis

Habitat for Humanity customers have benefitted an average of $27.94 per month from their no-cost 4.5 kW DC capacity solar PV generation subscription. The average monthly savings ranged from $13.68 to $43.17, where March had the lowest average and June had the highest. Individual savings show a much greater range with the overall distribution of savings spread between $10.13 to $62.50 depending on season and customer load. Monthly savings ranges are shown as a boxplot in Figure 2 with the boxes representing the middle 50% of users, the black center line is the median, and the edges are the minimum and maximum savings. The red line across the plot represents the monthly average savings, and the blue data points show individual household savings.



Conclusion

The analysis of household load and solar PV generation data gathered over the course of a year from ten Habitat for Humanity residencies in Kentucky showed an average savings of $27.94 each month from a 4.5 kW DC capacity solar PV generation subscription. Monthly savings ranged from $10.13 to $62.50, depending on weather, solar PV generation, and customer load. Participation in this program offset from the emission footprint of participating homes on average the equivalent amount of 88.7%. Participation in the Habitat for Humanity and Solar Share collaborative initiative reduced electric bills for low-income households, lowered net emissions, and supported local community solar.

Authors

Nicole Kitko, Lisa Keels, and Aron Patrick are with Louisville Gas and Electric Company and Kentucky Utilities Company (LG&E and KU), part of the PPL Corporation. Kitko is a Research Engineer, and Keels is a Manager in Emerging Business Delivery. Patrick is a Manager in Technology Research and Analysis.

Rosemary E. Alden and Dan M. Ionel are with University of Kentucky, SPARK Lab and PEIK Institute. Alden is a PhD student and NSF Graduate Research Fellow. Ionel is EE Professor, Director of the SPARK Lab and PEIK Institute, and the L. Stanley Pigman Chair in Power.