

Continuous Rooftop Solar Panels on Groups of Row Homes in Philadelphia

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Introduction

In early 2017, the National Oceanic and Atmospheric Administration (NOAA) released shocking data about the Earth's global temperature in the year prior. Since the beginning of temperature recordkeeping in 1880, 2016 was marked to be the warmest year in history. This year is not an outlier. Even more recently, global temperatures in 2020 tied with 2016 as being the hottest year on modern record. The reason for these rising temperatures can be explained by climate change, a phenomenon that is induced by the increase in greenhouse gases in the Earth's atmosphere due to the advance of technology. This phenomenon concerns many scientists due to its harmful effects on the planets and one way to tackle this problem is using renewable energy and increasing energy efficiency.

In light of the Green New Deal, energy efficiency and the need to integrate more renewable energy systems have become an ever more important issue in our country. When planning the implementation of these systems, whether it be a series of solar panels or wind turbines, the main aspect is to choose a sufficient location as to increase the efficiency of these systems in order to offset the large investment that comes from purchasing and installing them. The city of Philadelphia is a prime example of such a case due to its number of row homes and it being the 6th most densely populated American city¹. This research paper explores the plausibility of installing solar panel systems on Philadelphia row homes in terms of energy efficiency and cost.

History of Row Homes and Reasoning

A rowhome is one unit of a group of residential buildings that shares one or both side walls and a roofline with the structures next door. The construction of Philadelphia row homes

¹ Emily Badger, C. (2019, April 26). The most popular type of home in every major American CITY, CHARTED. Retrieved May 06, 2021, from <https://www.washingtonpost.com/news/wonk/wp/2015/09/21/the-most-popular-type-of-home-in-every-major-american-city-charted/>

date back to the 17th century when the large population called for a more spatially efficient form of housing. They were also easy to build on narrow lots and affordable to buy, and today, Philadelphia has the highest rate of families living in row homes, with almost 60% of its population being a row home resident². In the grand scheme of increasing renewable energy, by replacing fossil fuel dependency with systems such as solar panels, row homes have a lot of potential due to the sole fact that their roofs are interconnected with those of their neighbors. A single, contiguous rooftop would allow for a less costly installation and more efficient usage of solar panels as compared to standard, separated houses. It is also important to note that Philadelphia's row homes exist in large sectors containing several blocks of row homes, meaning that there are virtually no taller buildings and barely enough trees that could hinder energy production of these panels due to shade. This prevalence of row homes also suggests that large-scale solar panel installation could significantly increase the energy efficiency and green energy across any given area, which could lead to increased property values. Given this, Philadelphia is the ideal location for this plan of solar panel installation on row homes.

Solar Tilting Systems

In trying to optimize savings and energy usage, it is also worth considering the feasibility of solar tilting systems along with these panels. A tilting system would give the solar panels the ability to vary their angle in order to constantly face the position of the sun throughout the course of the day, thereby maximizing the intensity of sunlight exposure for these solar panels. The entire tilting system includes a tilt sensor, a servo system, and a controller that jointly tilt the solar panel based on the sun's orientation throughout the day. Although solar tilting would add

² McQuade, D. (2015, September 22). This chart Proves Philadelphia is the King of the rowhome. Retrieved May 05, 2021, from

on extra costs to installation, it may be worth it in the long run, given the large number of panels that would be installed within just one block of row homes.

Project Expenses

For this research project, calculations for energy savings were made for one block of row homes in Philadelphia, PA 19135. The reason for this choice of Philadelphia area is because the blocks are almost aligned from north to south, which allows this tilting solar system to work as the whole system needs to tilt towards the East in the morning and tilt towards the West in the evening to follow the sun.

To calculate how much energy a system of continuous rooftop solar panels would produce, a number of measurements are needed, such as how many solar panels can be installed with this system. According to the Philadelphia Rowhouse Manual, a document from the Office of Housing and Community Development, it is stated that a medium sized rowhouse is about 1000-1800 square feet, spread between two floors and the basement³. Therefore, we took a conservative estimate that the average size of a rooftop is about 400 square feet. However, noting how the roofs of row homes are occupied by various obstacles, such as vents, chimney, uneven surface, we estimated that only about half of the roof to $\frac{3}{4}$ of the roof (200-300 square feet) may be used for solar panel installations. For a block of 15 row homes (typical amount of row homes in a block), this means that there is about 3000-4500 square feet of space for solar panel installations.

³ Office of Housing and Community Development. (2008). Philadelphia Rowhouse Manual. City of Philadelphia. https://www.phila.gov/media/20190521124726/Philadelphia_Rowhouse_Manual.pdf

The average size of a solar panel is 5.4 feet by 3.25 feet⁴, which takes about 17.5 square feet. Since each roof has about 200-300 square feet of installation space, we can fit about 11-17 solar panels per roof. Therefore, for a block of 15 roofs, we can fit about 165-255 solar panels.

According to Solar Reviews, it is stated that a system of 15 single-axis rotating solar panels costs about \$22,125 to install⁵. Scaling this up to the 165-255 solar panels, it will cost about \$243,375 - \$376,125 for one system on the roofs of a block of row homes.

Carbon Reduction

Implementation of the contiguous rooftop solar panel could make waves in terms of reducing carbon emissions in Philadelphia. The average U.S household emits around 48 metric tons of Carbon dioxide per year⁶. This data adjusted for 15 rowhomes would lead to 720 metric tons of CO₂ emitted per year. This data combined with the fact that over 60 percent of Philadelphian families live in rowhomes, these homes contribute extensively to the carbon emission of the city. With conventional fossil fuels, these 15 homes would produce around 18 thousand tons of CO₂ over 25 years. Studies have found that Solar PV is more carbon efficient than coal and switching energy sources will severely decrease the city's carbon footprint. The main benefit of solar is that it emits carbon only in its production, generating 50g of CO₂ per kWh. While coal on the other hand generates 975 g of CO₂ per kWh. This means that solar is 20 times cleaner than other fossil fuels⁷. Solar PV production and installation for 15 rowhomes would emit 8.2 metric tons of CO₂. However, over the course of the next three years, the panels

⁴ How Many Solar Panels Do You Need: Panel Size and Output Factors. (n.d.). Sun Power. Retrieved May 5, 2021, from <https://us.sunpower.com/how-many-solar-panels-do-you-need-panel-size-and-output-factors#:~:text=Typical%20residential%20solar%20panel%20dimensions,with%20some%20variation%20among%20manufacturers>.

⁵ Lane, C. L. (2021, January 2). What is a solar tracker and is it worth the investment? Solar Reviews. <https://www.solarreviews.com/blog/are-solar-axis-trackers-worth-the-additional-investment>

⁶ Carbon footprint factsheet. (n.d.). Retrieved May 05, 2021, from <http://css.umich.edu/factsheets/carbon-footprint-factsheet#:~:text=A%20typical%20U.S.%20household%20has,tons%20CO2e%2Fyr>

⁷ How Clean Is The Solar Panel Manufacturing Process? How Much Carbon Dioxide Is Produced? (2019, June 19). Retrieved May 05, 2021, from <https://gvecsolarservice.com/how-clean-is-the-solar-panel-manufacturing-process-how-much-carbon-dioxide-is-produced/#:~:text=A%20counting%20for%20the%20amount%20of,of%20coal%2Dpowered%20electricity%20sources>

would create the same amount of energy it consumed in its production and thus would live carbon negative for the rest of its 25-year lifespan. By installing the contiguous rooftop solar panel CO₂ emissions would decrease 77 metric tons per year.

With Philadelphia's Office of Sustainability setting a goal leading up to 2050. This project could help the city make strides in reducing its carbon footprint. One of the city's lofty goals is to achieve a 100 percent carbon-free electricity grid by 2050 and the contiguous solar rooftop could fit seamlessly into this plan⁸. By fitting this concept on the thousands of row home rooftops spread across the city, Philadelphia would be making significant progress towards their carbon-free grid.

Government Incentives and their Applications

The scale of the project brought questions about how to minimize the cost while maximizing the production of solar energy for blocks of rowhomes. There are several government incentives for the State of Pennsylvania that could be applied to the project and make the project financially viable for homeowners. Philadelphia has a solar rebate program that pays back commercial projects .1 cents per watt and residential projects .2 cents per watt. The solar rebate caps off at \$100,000 which prompted worries about scalability⁹. With the cost of solar installation for one row home ranging from \$12,112 to \$16,388, it is improbable that the solar rebate would apply to the entirety of our contiguous solar panel¹⁰. Future researchers will have to decide whether installing onto fewer homes and using the rebate is more beneficial than installing on a block and forgoing the rebate.

⁸ Ackley, J., Jada is a senior Environmental Studies major at Temple University with a minor in City and Regional Planning. Currently Jada is an Editorial Intern at Green Philly. Her Interests includes enjoying nature and advocating for sustainability!, Says:, S., & Says:, R. (2020, July 20). Where do philly's carbon emissions come from? Retrieved May 05, 2021, from <https://www.thegreencities.com/philly/where-do-phillys-carbon-emissions-come-from/>

⁹ Philadelphia solar Rebate: Office of sustainability. (n.d.). Retrieved May 05, 2021, from <https://www.phila.gov/programs/solar-rebate-program/>

¹⁰ How much do solar panels cost in Philadelphia, PA in 2021? (n.d.). Retrieved May 06, 2021, from <https://www.energysage.com/local-data/solar-panel-cost/pa/montgomery-county/philadelphia/>

Another program that could be beneficial to the project is the Pennsylvania metering program. This program allows residents with solar panels to sell back excess electricity to the grid. For every kWh that a homeowner does not use per month, residents earn one credit. These credits could be later used to decrease their energy bills for the subsequent months. With a contiguous solar panel, this program will decrease the energy bill of 15+ homeowners per block. Nine utility companies in Philadelphia offer this program limiting maximum system capacity at 50 kilowatts¹¹. With our system for 15 rowhome generating around 82,500 to 140,250 kWh per year it is unsure whether the system capacity would be considered for each row home or for the entire block. In addition, this cutting edge innovation may not fit under the categories of solar panels detailed by current legislation.

The investment tax credit and the solar savings grant program are also two programs that could benefit homeowners. The investment tax credit reduces the cost of PV solar installation by 26% on that year's taxes¹². If applied to each home, the installation of the contiguous solar panel will become more financially viable for homeowners across Philadelphia. The solar savings grant targets low and moderate income households. In order to qualify for the program, homeowners must be at or below the 80 percent median income level of the area, own and live at the address, and have paid their PECO bill on time for the past year¹³. This program is ideal for Philadelphia as the city has an abundance of low-income families making the project more accessible to the general public.

¹¹ How net metering in Pennsylvania works. (2020, December 15). Retrieved May 05, 2021, from <https://freedomforever.com/net-metering-in-pennsylvania/>

¹² Solar investment tax Credit (ITC). (n.d.). Retrieved May 05, 2021, from <https://www.seia.org/initiatives/solar-investment-tax-credit-itc>

¹³ P. (n.d.). Solarize Philly. Retrieved May 05, 2021, from <https://philaenergy.org/programs-initiatives/solarize-philly/#:~:text=PEA's%20Solar%20Savings%20Grant%20Program,start%20savi ng%20from%20Year%201.>

Unexplored Problems

Although the installation of continuous rooftop solar panels on rowhomes is an appealing concept in theory, its possible implementation on rowhomes in the city of Philadelphia does raise a few challenges and questions about whether or not such a project can actually be financially and practically feasible. Because the installation of solar panels on any home requires the physical state of the home to meet certain industry standards, there is a question of whether rowhomes in particular do meet the standards needed for solar panel installation.

Before most solar panel installations are approved on any home, there is a process of home evaluations that take place in order to determine whether a given home appropriately meets the given standards for solar installation. These standards and requirements about the home mainly focus on the condition of the roof and its ability to safely support a system of solar panels¹⁴. A transition to a focus on the physical state of a majority of row homes in Philadelphia however possibly brings up the concern of whether the installation of continuous rooftop solar panels on row homes will be a challenge.

Currently, studies show that of the many houses in Philadelphia that are in need of health-related repairs, nearly 70 percent are rowhomes¹⁵. With rowhomes being prone to roof damage due to water leakage as a result of demolition to a neighboring row home or the natural aging of the roof, the frequent occurrence of roof damage to row homes in the city of Philadelphia could potentially cause a financial burden as row homes with roof damage would have to undergo a roof repair or re-roofing process that could cost roughly \$6,000 to \$7,000¹⁶.

¹⁴ Solar Power Installation Requirements: What You Need to Know. (2020, February 25). Retrieved from <https://stellarsolar.net/2018/11/14/solar-power-installation-requirements-what-you-need-to-know/>

¹⁵ (n.d.). Retrieved from <https://www.healthyrowhouse.org/understanding-the-need/>

¹⁶ Guy, A. M. (2021, April 28). Roof Repair Cost: Minor and Major Repairs in 2021. Retrieved from <https://www.roofingcalc.com/roof-repair-cost/>

Although acknowledging that this financial burden could be a major discouraging factor in the installation of continuous rooftop solar panels on row homes in the city of Philadelphia, it is however apparent that the successful implementation of such a project could potentially open the door for the implementation of other innovative projects just like this.