**Cost/Benefit Analysis of Installing Solar Panels in Albany, NY**

**Introduction**

Over the last few decades, the efficiency of solar panel systems available for residential use has steadily been increasing, with the costs associated with these systems trending inversely, decreasing significantly over the years. When solar panels were first introduced as an alternative power source to residential customers, prices were prohibitive, and the early adopters were often those concerned more about the environmental impacts of coal and gas-powered energy generation rather than their financial bottom line. However, as technology improved and manufacturing has scaled up, the math has started to shift towards a residential solar power market that is not only the “green” option, but a financially profitable one.

In 2006, the federal government enacted the solar Investment Tax Credit (ITC) to support the growth of solar energy infrastructure in the United States (<https://www.seia.org/initiatives/solar-investment-tax-credit-itc>). Since then, a multitude of Federal and State financial incentives have been introduced to help customers interested in switching to solar power commit to their transition ([https://www.dsireus HYPERLINK "https://www.dsireusa.org/"a HYPERLINK "https://www.dsireusa.org/".org/](https://www.dsireusa.org/)). Additionally, the costs associated with both installation and upkeep have dropped significantly since the early 2000s and many states have become much more creative in the way the solar market operates in order to benefit both companies and customers. For instance, in 2008 the state of California allowed photovoltaic installers to start offering third-party ownership (TPO) arrangements, where end-use customers “host” a third-party owned photovoltaic system instead of getting a direct installation. This practice not only requires little to no upfront cost, but also expanded the market drastically. As of 2018, twenty-six states have since adopted this option. Additionally, many states have passed net metering laws ([https://www.seia.org/initiat HYPERLINK "https://www.seia.org/initiatives/net-metering"ives/net-metering](https://www.seia.org/initiatives/net-metering)) which allow customers with solar power to essentially "sell back" any power they generate in excess of what they use - a huge boon since solar panels cannot generate power at night and "saving up" excess power with batteries can be extremely costly. With innovations and offerings like these that have flooded the market in recent years, the United States has seen a 52% average increase in solar growth since the ITC was enacted 15 years ago (<https://www.seia.org/initiatives/solar-investment-tax-credit-itc>).

There are, however, limitations and considerations that need to be taken into account in order to evaluate the financial viability of transitioning one's home to solar power. One of these is the amount of sunlight one's roof is exposed to throughout the year. The National Solar Radiation Database (NSRDB) has been tracking the Global Horizontal Irradiance (GHI) for the United States for over 25 years (<https://nsrdb.nrel.gov/>). This database provides geographic coordinate data and information pertaining to the amount of sunlight an area was exposed to on any day of a given year (hourly data is available). The azimuth angle of one’s roof, defined as the direction the roof is pointed with respect to the degree and direction of a compass (North, South, East, and West), is also an important factor in determining the solar panel-viability. For instance, whether solar panels are installed on a north-facing or south-facing roof can drastically influence solar panel productivity given how much sunlight the home is exposed to and the amount of energy converted by the panels. Another factor is the length of time before one’s house is sold, since the major costs associated with solar panels are paid up-front, a house that may be sold within a five to ten-year span may not reap the full rewards of a solar energy transition. Although, it’s debated that this aspect is counter-balanced by the value added to a home by the presence of solar panels (Soak up the sun Article). The surface area and space available on one's roof obviously limits the size of the system a house can handle. And, finally, the power consumption habits of the household and local electricity costs impact the demands on the system and baseline cost-profile. All of these factors must be considered when deciding whether or not to switch to solar panels.

**Problem Formulation**

The costs associated with transitioning one’s residential energy system to solar power have dropped dramatically over the years. Additionally, given the increasingly dire outlook of climate change on the health of our planet, the collective benefit of transitioning away from destructive energy practices for the sake of the environment is both as real as it ever was and more important than ever. This project will seek to help potential solar panel customers in the Albany, New York area weigh the costs and benefits of making the transition. We plan to create a calculator that will account for the factors discussed above in order to provide a consumer with a detailed prediction on how installing a solar panel system would impact them financially.

**Objectives**

This project will provide an interactive calculator of the long-term financial outlook of installing a solar panel on a home in Albany, NY. In order to perform this calculation, the calculator will:

* Ask for one’s home address and use the Google Maps API to determine the roof surface area and azimuth angle of the roof. These values will be either collected based on a user-interaction (outlining their roof via the tool to gather surface area and azimuth), or, if this fails, these values will be inputted by the user manually.
* Based on the geographic coordinates and inputs received from the user via the Google Maps API, it will then run multiple simulations based on data from the NSRDB to estimate likely sunlight exposure over the next several years.
* The simulation will also take into account different panel efficiencies present in the market ([https:// HYPERLINK "https://news.energysage.com/what-are-the-most-efficient-solar-panels-on-the-market/"n HYPERLINK "https://news.energysage.com/what-are-the-most-efficient-solar-panels-on-the-market/"ews.energysage.com/what-are-the-most-efficient-solar-panels-on-the-market/](https://news.energysage.com/what-are-the-most-efficient-solar-panels-on-the-market/))
* Energy consumption will also be estimated based on household size ([https://www.sciencedirect.com/science/article/ HYPERLINK "https://www.sciencedirect.com/science/article/pii/S2352484716300932"p HYPERLINK "https://www.sciencedirect.com/science/article/pii/S2352484716300932"ii/S2352 HYPERLINK "https://www.sciencedirect.com/science/article/pii/S2352484716300932"484716300932](https://www.sciencedirect.com/science/article/pii/S2352484716300932)) and Albany-specific energy-use data ([https://compare HYPERLINK "https://compareelectricity.com/energy-usage/NY/Albany/12244"e HYPERLINK "https://compareelectricity.com/energy-usage/NY/Albany/12244"lectricity.com/energy-usage/NY/Albany/12244](https://compareelectricity.com/energy-usage/NY/Albany/12244))
* Finally, given these inputs, the simulation will generate a long-term financial forecast graph and data visualization/interactive that will help users make a decision

**Paper Summaries**

* Household installation of solar panels – Motives and barriers in a 10-year perspective - J. Palm (2017)
* This paper analyzes changes over time in homeowner’s motives and barriers for installing photovoltaic panels in Sweden. Members of households that had installed solar panel systems (households that were “on-grid”) were interviewed in either 2008-2009 or 2014-2016, and perceptions in changes in the solar market, financial incentives, and installation process were documented.
* Trends in the market structure of US residential solar PV installation, 2000 to 2016: An evolving industry
* This paper analyzes the rapid expansion of the solar energy market in the United States since the turn of the century. Although much of the content is focused primarily on the impact of third-party ownership (TPO) systems, it does provide important information and context about photovoltaic installation companies and the major players in the field.
* Qiu, Y., Wang, Y., &amp; Wang, J. (2017, August). Soak up the sun: Impact of solar energy systems on residential home values in Arizona. Elsevier, 66, 328-336. doi:https://doi.org/10.1016/j.eneco.2017.07.001
* This paper looks into (among many other factors) the ways in which home price was affected by the presence of solar panels in Arizona

**Methodology**

The project will begin by identifying and gathering all of the data needed, with the exception of user-input, in order to construct our initial system and simulation. The initial data gathered will include:

* Energy consumption data based on household size and for residents of Albany, New York
* Different efficiencies present in the market for solar panel array output
* Global Horizontal Irradiance (GHI) data from The National Solar Radiation Database (NSRDB)

We’ll then create an initial simulation and system, testing based on dummy user inputs to determine mock financial forecasts. The simulation and system will be built in python and be expressed via Flask in order to connect to our front-end user interface.

With the back-end modeling set up, we’ll finally create a front-end user-interface via JavaScript (or Python, if time is limited), to then connect user-inputs from the Google Maps API and our front-end system to feed into our simulation and model.

**Evaluation**