Python-based online tool to perform spatial analysis of rooftop solar potential in the continental USA

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Abstract:

With the rise of renewable energy, investors are looking to adopt rooftop solar potential onto their grid. Multiple novel algorithms and softwares have been built to help users, however, there is a lack of software to spatially analyze DC array output for investors. Past software, such as PVWatts, averages data from NSRDB(National Solar Radiation Database) and outputs an estimated DC Array Output. Our software uses this estimated DC Array Output, and analyzes the hourly averages per month, the cumulative daily per month, and provides a heatmap for users. This new software offers a user-friendly platform for users to compare DC array output spatially. Furthermore, it encourages users to adopt rooftop solar output into their homes.

Introduction:

With international cooperation, national leaders are targeting the overconsumption of fossil fuels, and switching over to renewable energies to power the country. Solar, wind, and hydro-electric power are the biggest powerhouses for evolving the country's reliance on fossil fuels. However, each energy system has geographical limits, in contribution to the lack of reliable energy storage. Consequently, there are ongoing issues towards adopting renewable energy due to the lack of reliability in certain scenarios. To remedy this challenge, this study explores the development of a software to spatially analyze the rooftop solar potential nationally. This study uses data sets from various locations throughout the USA, thereafter comparing the geographical effects on solar output. This software will help aid in the adoption of renewable energies into homes nationwide.

Methodology:

In building this software, we had to first get familiar with the advantages, problems, and current research surrounding renewable energy. Furthermore, we had to familiarize ourselves with the problems in the US National Grid. We learned throughout our research the outdated design of the national grid. The US grid has 3 separate parts, Eastern Interconnection, the Western Interconnection, and the Texas Interconnected system. The grid runs through generation, fossil fuels, transmission, and distribution to local homes and businesses. However, the biggest issue is the fragility of the system in extreme weather, and or power shortages. For instance, when the Texas system failed, hundreds of people were left without power in winter. Consequently, there've been push from investors to upgrade the grid's infrastructure. However, the cost to upgrade the entire national system is immense, and requires significant time to design.

Moreover, 'greening' the grid becomes another layer to the problem. Currently, the national grid relies entirely on burning fossil fuels to meet the ever-changing demand in electricity. For instance, if a neighboring town is demanding high-energy usage, the generator plant can quickly produce electricity. However, ‘greening’ the grid loses this reliability. Once again, each renewable energy generation relies on ‘perfect conditions’ to function. For instance, solar power relies on constant sunlight and ideal temperatures. Therefore, generator plants become useless during cloudy days, causing no energy production for homes and businesses. On the other side, you can’t just place solar panels in hot climates because they become inefficient with extreme temperatures. Similarly, wind and hydro-electric power need sufficient wind-speed and bodies of water, respectively. Therefore, renewable energy overall doesn't have the same reliability compared to fossil fuels.

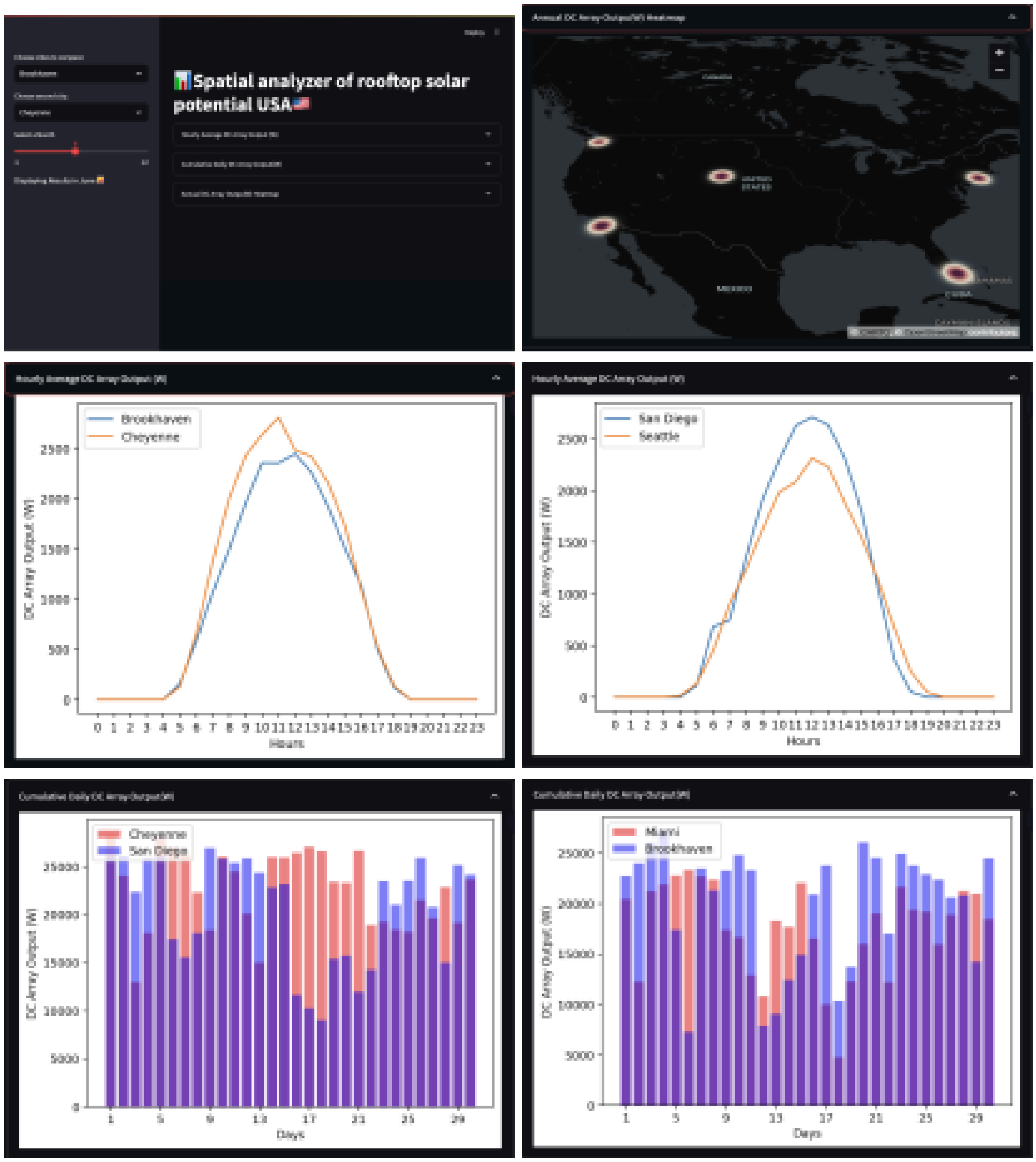
Another perspective in this debate is the geographical limits to distribute renewable energy. Since each respective renewable energy system relies on the ‘ideal climate’, the US National Grid will have to be formatted to be a hub of various renewable energy systems supplying demand nationwide. Yet, this idealistic design is infeasible due to our current technology.

Overall, with our background research into the geographical limits of renewable energy, we then have to analyze the data sets of our location. We used PVWatts, an online calculator tool created by the NREL(National Renewable Energy Laboratory), to collect our data. PVWatts produces an annual estimation from a 12 year meteorological collection from NSRDB. Our datasets will include a variety of outputs narrowed down by the hour per day. This format provides us concise data to manipulate in our data analysis.

The first step we deliberated was to build a simple GUI application that takes a date and outputs DC array output, wind speed, and cell temperature. After that we then used matplotlib to display our data in 24 hour line graphs. However, this was simply from a specific month and day. Later on we focused on displaying averages from every hour in that month. This provides a general analysis of the weather per month. Further on we then integrated our matplot graphs onto the GUI. Now we have the essential graphs onto the GUI, my project shifted into designing a spatial analyzer to compare different case studies in America. I repeated my initial data analysis, but with different datasets. I reformatted my initial application to offer a multi-select tool for users to compare locations based on the month. Continually, I updated and changed to provide a user-friendly web-application. I offered a side-bar, expanders, and sub-headers for a neat application. Furthermore, until last week I added more and more graphs for the user. I pinpointed specifically on analyzing DC array output, and created a cumulative daily graph per month, as well as a heatmap of annual DC array output on pydeck. This full system offers an approachable software for the user to analyze the benefits of rooftop solar potential in their locations.

Results:

Here are some screenshots of the GUI application of my project. I created a user-friendly



web-application for anyone to generate 480+ unique graphs based on location and time of month.

Discussion:
These results provide a user-friendly visualization for anyone to take rooftop solar potential in various case-studies. This software can provide a gateway for anyone to adopt rooftop solar power. In this project I specifically took data from the DC array output and created visualizations for any user.

Conclusion:
Now with the creation of this coding project, I hope to provide an easy way for anyone to adopt rooftop solar power, no matter the location. Further research will be needed to create an even better software that would generate from data in any location, another approach would be to offer unique machine learning approach to various research areas.