Application of Machine Learning for Optimizing Solar Output

Evaluation of New Strategies When Introducing Wind Turbines to New Areas

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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General Research Problem:

What current technologies and strategies can be employed to improve the effort to increase sustainability in the United States?

Currently, there exists a significant societal challenge in the United States regarding the effort to become more sustainable. This challenge is particularly noticeable in regard to energy production. Renewable energy production accounts for 16.9% of all U.S generated energy (US EIA, 2019a). There are numerous factors that complicate the expansion of renewable production. One of these factors is a lack of predictability as to how much energy will be produced. Projecting energy production is essential for the expansion of solar energy production. In addition to predicting how much energy will be produced, utility companies also need to predict how much energy will be demanded. Another factor limiting the expansion of renewable production is societal. Obtaining the necessary approval for the installation of renewable generation, such as wind power, can be a long and arduous process. A better understanding of the factors that inhibit the expansion of renewable power allow for better strategies and solutions to be employed to overcome these challenges.

Application of Machine Learning for Optimizing Solar Output

How can machine leaning pattern recognition technologies be harnessed to predict the immediate future supply and demand of energy?

Solar energy is referred to as a “intermittent” energy supply by utility companies. The reason for this is the inherent variability associated with it. Usually the sun is shining,

but sometimes it is not. This variability is one of the most significant challenges facing utilities, according to Adam Maguire, a Dominion Energy manager (A. Maguire, personal communication, Oct 5th, 2019). There is an opportunity that exists for technology to aid in combating this uncertainty. The pattern recognition abilities of Machine Learning has the potential to be harnessed by utilities. Existing Machine Learning models, such as Support Vector Machines (SVMs) and neural nets, can be trained on data to recognize complex patterns. This could be quite useful for utilities in two regards. It could be trained to predict the amount of solar power that the utility would produce in the near future. Also, it could be used to predict what the demand for power would be in the near future.

The data to analyze for predicting energy generation would primarily be weather data and time of year data. Both the amount of available sunlight per day and meteorological conditions would likely be the two most significant factors for predicting how much power could be produced. For predicting how much power will be consumed, the day of the week and weather will probably be the most important factors. Weekends will have different power demands than work days, and very cold days will likely have a higher demand than a more temperate day due to the need of a heating unit. Historic data on the projected meteorological conditions and how much solar power was produced will be necessary. The machine learning taking place will be supervised machine learning with labeled data. The meteorological conditions and other factors will be the data, and the label will be the result. The factors will be used to predict the label. The data will be split into testing and training sets. The models will be trained on the training set, and then presented the test data which it has never seen before to make its predictions. We

will be able to evaluate the accuracy, precision, and recall of the models from how the model performs on the test. The final result of this research will be a trained, evaluated, and functional machine learning model. This model could then be leveraged by utilities for predicting future solar production, and future energy demand. This enhanced insight into the future could allow for greater expansion of renewable generation. The model will aim to mitigate the “uncertainty” factor associated with solar production.

Evaluation of Strategies When Introducing Wind Turbines to a New Area

What are the similarities among the successes of utilities introducing wind turbines to a new area, and what are the similarities among the failures?

The percent of wind-generated power has been increasing quickly in the United States (US EIA, 2019b). Over the last thirty years, the wind power’s proportional share of production has increased sevenfold (US EIA, 2019a). There is still a great opportunity for further expansion of wind generation. However, one of the largest challenges facing increasing wind production is societal. Frequently, when utility companies try to introduce wind turbines to a new area, there is a strong pushback from the community. A phenomenon known as “Not In My BackYard” or NIMBYism is a prevalent issue. NIMBYism means that the community supports an increase in wind generation, however they do not want wind turbines built in their communities. A study of an attempt to introduce a wind farm to a new area in Ohio found that the number one factor determining whether a community member supported the incoming wind farm was the proximity of that community member’s land to the location of the new wind farm

(Campbell). Community members are generally concerned about wind turbines being unsightly. Also, the introduction of a wind farm in near proximity to a home can have a negative impact on the value of that home. Understanding how a community impacts and shapes the expansion of wind farms, and moreover how wind farms impact and shape the community it enters allows for better strategies to be developed by utilities when trying to introduce new wind generation.

Background

Understanding the different stakeholders and their motivations is essential to understanding the sociotechnical system at play. The utility company is one of the primary actors in this scenario. Utilities frequently have many motivations for wanting to introduce more wind power. Meeting power demand, economic incentives, and public relations are all large motivators that can contribute to utilities trying to build new wind farms. Another major stakeholder in this dynamic is community members who oppose the construction of the wind farm. The reasons for opposing can be both self interest or environmental concern. The unsightliness, negative home value impact, and damage to local environment from construction can all be factors for opposition. Finally, the last major stakeholder is community members who support the measure. Community members may support the measure due to a desire to see increased sustainability in energy production, or a hope that maintaining the wind farm will promote economic growth in the region. There has been some research conducted regarding the dynamics between these three groups, including the aforementioned case study that took place in

Ohio. Better understanding these actors, and their motivations, will help to uncover the deeper sociotechnical system.

Evidence

I will build on previously conducted research to understand this system better. Using the Ohio case study and others, I will look for emergent patterns in the successful and unsuccessful attempts to introduce wind power to a new area. In addition to what was documented in the case studies, I will look for newspaper editorials and public hearings which occurred at the time. I suspect that there will not be a “one size fits all” solution that comes from this, but there will be general motifs I find in both the successes and failures. In locations like Texas, oil rigs are a very common thing to see. Due to the community being used to seeing these, I suspect Texans are less likely to consider wind turbines unsightly. On the contrary, in a place like the great plains where communities are used to be everything being grassy and uniform, the introduction of something like wind turbines would be more jarring, and more likely to be considered unsightly. For these reasons, it seems unlikely to find the panacea strategy. However, there will likely be aspects of strategies that would be successful when introducing wind power to either Texas or the great plains.

In addition to learning from existing case studies, I plan to conduct my own interviews. I will interview both utility stakeholders, community members who supported the wind farm construction, and community members who opposed construction of wind farms. I am going to choose two locations that I want to interview people from. One where the implementation of wind farms was successful, and another where the community was

able to successfully resist the incoming wind generators. I will seek to learn what strategies the utilities and people used, so I can evaluate which strategies are effective. I am particularly interested to interview community members who had a leadership role in supporting/opposing the introduction of wind turbines. Understanding how these people were selected by their respective groups, and what their motivations were, will be particularly insightful into understanding the mindsets of the different groups.

Methods

One of the primary tools I plan on using to analyze my findings will be a content analysis. I plan on doing both conceptual and relational content analysis. I will use the conceptual analysis to see what themes emerge from the conversations. After that, I will dive deeper by doing the relational analysis from these emergent themes. Understanding how the concepts relate to each other will allow for a better understanding of the sociotechnical system. These analyses will provide a comprehensive picture of what successful and unsuccessful strategies entail. Another method I will employ to better understand the data is statistical analysis. The statistical analysis of covariance was what was used to show zip code as the most important factor in determining if a community member would support incoming wind turbines (Campbell). For polls and other number heavy documents, doing a statistical analysis will allow for the numbers to be understood and for patterns to emerge.

Conclusion

Both projects that I am undertaking have the goal of increasing sustainable energy production in the United States. The technical aspect of my project is primarily focused on addressing the significant challenge that faces utilities: the uncertainty factor. By making solar power less of an intermittent resource, and more of a dependable resource, utilities will be able to more confidently invest in solar production. Solar is one of the cheapest options when it comes to constructing and maintaining a new plant, however the uncertainty factor is significantly delaying the more widespread use of solar. My STS research question hopes to better understand the sociotechnical system surrounding the expansion of wind generation. By better understanding how this technology shapes society, and how society continues to shape this technology, more informed decisions can be made by utilities when attempting to construct wind turbines in a new area. This better strategy could allow for utilities to better understand the mentality and motivations of the opposition, and preemptively mitigate those concerns. It could also allow for utilities to select better locations when deciding areas they want to add wind turbines to. The efforts of both my projects will primarily be useful to utility companies. The trained machine learning model will allow for better information and less uncertainty, while the STS research will enable them to make more educated decisions regarding the construction of new wind turbines.

Citations:

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