SOLAR ENERGY DEVELOPMENT IN APPALACHIA AND THE BARRIERS THAT STAND IN ITS WAY

A Research Paper submitted to the Department of Engineering and Society

Presented to the Faculty of the School of engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Partial Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

Frederick Van Winkle

Spring 2024

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

Advisor

Joshua Earle, Department of Engineering and Society

Introduction

The Appalachian Region of the state of Virginia is a piece of a larger socio-economic region consisting of 206,000 square miles covering the central and southern sections of the Appalachian Mountains on the East Coast of the United States. This region has historically experienced economic prosperity due to the booming coal industry, but that growth has been curbed in recent years. From 2005 to 2020, employment in the coal industry fell by 54% and it is estimated that the industry will continue to see steady layoffs of 5% every year (Pollin, 2021). While this decline has impacted every aspect of life in the region, there are two primary reasons this is happening. First, there are changes in the coal industry that have rendered some of the previously necessary jobs useless. For example, automation of the coal mining process has allowed for more efficient coal mining and has increased layoffs. Additionally, the cost of coal has become comparably higher than other alternatives mined in the Western United States (Plumer). Due to these factors, and the sheer fact that the coal resources in the Appalachian mountains are simply running out, the coal industry has experienced a large hit.

The second reason that the coal industry has seen such a steep decline in the past decade is due to the overwhelming push to implement renewable energy sources into the country's energy grid. According to the International Energy Authority, the primary goal to mitigate the effects of climate change is to reach Net Zero Emissions by 2050. For this to happen the world must triple the current investment in renewable energy by 2030 to 4 trillion dollars. While this is what Net Zero Emissions would look like on a global scale, this goal would require most of the Western world to implement this strategy in all areas, including the Appalachian region of Virginia. The Biden Administration has set the target of 80% renewable energy generation by 2030, and 100% carbon-free energy by 2035 (Mai, 2023). This goal, set in 2023, was announced

following an Act that allocated $370 billion in funding subsidies for renewable energy technologies. With goals and monetary incentives like these, the developers in the region are sure to push for more renewable energy development, and because of this, the communities are beginning to divest from coal.

The declining coal industry in the Appalachian region of Virginia has brought socioeconomic hardship upon the communities that depended on coal, but the transition away from coal is not all bad. Renewable energy development can create many positives for surrounding communities from job growth to more dependable energy infrastructure. A report done by the Political Economy Research Institute claims that in West Virginia alone, more than 25,000 jobs could be created annually due to investment in renewable energy (Pollin, 2021). With projected job growth like this, communities that have suffered at the hands of the declining coal industry could prosper from the implementation of renewable energy technologies. Solar Energy specifically offers many plausible solutions to these communities due to its ease of implementation and its low cost of energy generation. Solar Power offers one of the lower costs per Kilowatt Hour (kWh) of energy produced at ~ $0.10 while fossil fuels tend to cost ~ $0.15 - $0.20 / kWh (Inspire Clean Energy, 2024). This low cost of energy is just one way that Solar Energy can help stimulate surrounding communities. With lower energy costs, local governments can use the excess funds to invest in the people, rather than having to worry about supporting the energy demands.

The implementation of renewable energy, and solar energy specifically, should appeal to almost everyone, but some people still have issues with it. Whether those issues are rooted in political beliefs or genuine safety concerns, there is a legitimate movement in the region opposing the development of renewable energy. Said movements have created barriers that limit

the possibilities of Solar Energy and the benefits that could be seen by the communities that continue to reject the technology.

Methods

When attempting to understand the landscape of the Appalachian Solar Energy sphere, it was deemed best to investigate this issue under the lens of the Actor-Network Theory Framework. The Actor-Network Theory (ANT) was created to establish how a group of actors, human or nonhuman, "form alliances or associations to produce and stabilize a particular state of affairs" (Crawford, 2020). As I look into the relationship between the many actors I have deemed to be in this network, this framework will allow me to answer the question: *What are the main challenges facing the implementation of Solar Energy in Appalachia, and what steps, if any, can be taken to help overcome these challenges?*

Solar Energy System

The technology of the solar energy system comprises everything from the panel itself to the battery, to the method at which the energy goes from point A to point B. The technology itself is essential to analyze because many of the issues surrounding the development of solar energy systems is the lack of effectiveness. Currently, solar panels range from 2% - 20% effective in capturing the energy from the sun (Hudedmani, 2017). This alone has the general public skeptical and believing that the investment required for these systems is not enough for the return seen. This issue is just one of the many riddled within the landscape of solar energy systems, and if things aren't done by actors in this network to fix these issues, then the future of solar energy development is in trouble.

The General Public

One Actor that will be considered will be "The General Public". This group will represent the people within the Appalachian communities who will deal with all consequences, good or bad, of Solar Energy projects in their neighborhood. The General Public plays an essential role in the network because their approval drastically influences the future of Solar Energy development. Historically, most of the policy, an element of another actor in this network, has used strategies to increase public acceptance as a means to incorporate new technologies (Lucas, 2021). If this strategy were to continue to be implemented, this means that The General Public could be an ultimate decider in the future of Solar Energy technologies and how they would be implemented at a mass scale.

Government / Policy Makers

Another Actor that will be a large player in this issue will be the Local, State, and Federal Governments that govern the land on which these projects would be built. Currently, the Federal Government's goal is to accelerate the development of solar energy systems to decarbonize the electricity grid by 2035 (Department of Energy, 2024). With goals like these, the government will push to develop solar energy in every corner of the country, and it will incentivize local and state governments to do so through federal grants and tax incentives. While the government will do everything monetarily to encourage growth in the solar sector, it still must provide the appropriate information to the public. The lack of information about renewable technologies such as solar is a driving force in the hesitancy surrounding solar energy (Carbajo, 2017). If the government can diversify its engagement effort by supplementing fiscal incentives with accurate

and reassuring information, policymakers could be a driving force for solar technologies in this network.

Developers

Developers play an interesting role in this network because they primarily interact with only the government and the technology itself. The Developer typically does not care how the public feels about the project because they are there to complete a job they were hired to do. Developers are the primary point of contact with the technology itself as they are the ones responsible for building the systems and helping the system become more efficient when it is used.

Through all of these actors in the network, there will be a discussion that examines the relationships between each actor and how those relationships can be molded to encourage the growth of solar energy in Appalachia.

Literature Review

Existing Issues

Through extensive research, two classifications of issues were identified surrounding Solar Energy: Social issues and Technological Issues. Social issues can be defined as issues within the public such as Education or Politics that have defined the public sediment surrounding Solar Energy. Technological issues are issues that must be addressed to increase the efficiency of

integrating Solar Energy into the power grid. Both of these issues play an equal part in creating barriers to the development of Solar Energy, but their root causes are drastically different.

Education Issues

A primary issue delaying the development of Solar Energy in the Appalachian Region is the lack of widespread knowledge concerning renewable energy sources. In a survey conducted for a worldwide Solar Energy Conference in Abu Dhabi, citizens cited environmental health and safety concerns as the top two reasons they opposed the development of Solar Energy (Lucas, 2021). While, yes, these issues are cause for some concern, any negative consequences that arise from the development of Solar Energy, like increased runoff and erosion, can easily be mitigated through engineering methods designed specifically for these issues. It is small instances like this that add up to create public opposition to renewable energy sources like Solar Energy, but as the world continues to evolve, this issue only gets worse with the lack of good information regarding Solar.

Within the scope of the Appalachian region of Virginia, the lack of public knowledge is the driving factor that has continued to push away Solar Energy. As the writing previously mentioned, this region in particular has suffered from the declining coal industry, and this suffering has impacted the education in this region. According to an article written about education levels in Virginia, the southwestern counties (Appalachian Region) have the “lowest educational attainment rates in the state” (Yancey, 2023). The article continues to state that these drops can be attributed to the declining population, which can be tied to the increased layoffs in the region. The continuously declining levels of education in southwestern Virginia are a reason to be concerned, but when it comes to education and the link to Solar energy, the news about the

lack of education becomes worse. An Article from The Journal of Business & Economic Policy states, “It is predicted that income per capita, which is largely dependent on education level, has implications on demand of renewable energy” (Ozcicek, 2017). The Appalachian Region of Virginia acts as a clear representation of what is being described in this quote, and therefore, conclusions can be drawn between the lack of public support for Solar Energy and the lack of quality education in the region.

Policy / Political Issues

Additional influencing factors for the citizens of southwestern Virginia are the political affiliations of people in the region and the policies passed by local governments concerning Solar Energy. Specifically, one conservative group called “Citizens for Responsible Solar” is doing its best to influence the role of Solar Energy in the Appalachian Region of Virginia. A recent NPR article highlighted a story of a struggling landowner trying to lease out some of his land to Solar Energy Developers to make extra money in a struggling economy. The story continued to explain that Citizens for Responsible Solar immediately became involved in the situation and blocked the landowner from leasing his land to the Solar Developer (Copley, 2023). The traditionally conservative base uses a grassroots approach to appeal to local communities that have proposed Solar Energy projects in their area. The group claims to oppose these projects in the name of protecting timberland, but in many cases, they block projects that would not destroy any timberland. While it is unfair to claim that all conservatives in the country oppose the expansion of renewable energy, a study conducted by the Pew Research Center found that Republicans are far more likely than moderates or their counterparts across the aisle to support the expansion of

fossil fuels (Kennedy, 2023). This research suggests that while Citizens for Responsible Solar may be trying to "protect timberlands", they also could have ulterior political motives.

Separate from individual, citizen-led groups, some local governments in southwest Virginia have implemented policies that have made it harder for developers to build Solar Energy Systems in certain counties. For example, in 2023, Henry County voted to put a cap on the amount of land that can be used for Solar Energy Development in the county. The cap allocated 1% of the county's land for Solar Development, and when the motion was passed, existing projects already accounted for 1,807 acres of available 2,445 acres. The meeting notes claimed that this was done to minimize the impact on the county's view shed and rural character (Henry County Planning Commission, 2023). This ordinance by Henry County's government is a blatant deterrent for any future Solar Energy Development and also signals to the citizens that it does not support the expansion of Solar Energy in the region.

Technological Issues

Many of the issues surrounding the adaptation of widespread renewable energy sources have to do with the parties involved in interacting with them, but other issues are purely technological. Like all technologies, Solar Panels and Solar Panel Systems do have their limitations and these constraints have slowed the growth of the technology. One of these issues is the fact that even the best solar panels are not that efficient. According to a study conducted by the KLE Institute of Technology, the best solar panels can only capture 20% of the sun's energy while the lower-tiered solar panels can only capture 2% (Hudedmani, 2017). These efficiency issues make it difficult for developers or landowners to justify the installation of solar panels due to their high price point, but if the efficiency of solar panels could continue to increase, then

there would be a massive potential for the market of solar energy to expand. Another technological issue that limits the growth of solar is an energy storage issue. Energy storage has always been an issue for solar energy systems because even with their lack of efficiency, during peak hours, solar panels can produce more than enough energy. But producing more than enough energy is the problem. Solar panels produce most energy between the hours of 11 a.m. and 4 p.m., but because there is not much energy demand from the grid, this energy must be stored. When this energy is stored, there is either not enough storage to supply all the demand that will happen in the evenings, or energy is lost because the grid is not efficient enough. Problems like these result in a positive feedback loop where the overgeneration of solar energy leads to damaging the infrastructure, and then the process continues to get less efficient. This issue must be addressed if solar panels are to supply energy on a mass scale, but clearly, the process must be fixed so that energy can be stored and transferred efficiently.

Lastly, another thing that limits the growth of solar energy in the region is the lack of sunlight in the region relative to other parts of the United States. While the region has acceptable amounts of sunlight to support the growth of solar energy, its maximum power output can only reach 73% of the highest energy output in the country (Global Solar Atlas, 2024). This data could push developers to stay away from the region because the return on investment would be lower for projects in this region. This drawback for developers could justify public backlash to the technology and slow the growth of solar in the region altogether. The region's lack of sunlight primarily comes in the winter months when it is cloudy and stormy, so there is not much that the community or the government can do to fix this issue. To mitigate this downfall, governments could look to encourage developers to build diverse renewable energy generation sites that would allow other forms of energy to make up for the lack of solar energy during these

months. With government encouragement, community members would not be able to attack only solar, and they could see how beneficial all types of renewables could be for the region.

Potential Solutions

Finding concrete solutions to all of these problems is a challenging task, but finding solutions that allow for progress in western Virginia surrounding solar energy is a more manageable task. Addressing social issues first, the key to making a change would be to improve the education systems in the Appalachian region, yet this is an obvious answer. To start doing this, communities would need to be more engaged with their energy sources and that begins with more accessible information regarding renewable energy. The paper previously discussed that many of the issues that residents had surrounding renewable energy sources were issues that could easily be confronted with the correct information. While this information could have been rolled out with the technology, it is now in the hands of local and state governments to educate communities that push back on integrating solar energy into the surrounding energy grid. Access to correct and informative information is so vital to begin solving this issue because many believe that integrating people into energy policy must be done through a social acceptance approach (Lucas, 2021). If the community could understand the environmental and fiscal benefits of adopting solar energy, then the transition would be seamless, but the disconnect is the crux of the issue.

In addition to focusing on educating communities, an effort should be made to urge local governments to create policies that encourage the development of renewable energy sources. Cases like Henry County are not uncommon when it comes to passing legislation limiting the growth of solar power; in fact, Henry County was following the footsteps of six other counties in

Virginia that decided to limit the available land for solar power. Because local governments are making rules like these, the State of Virginia is attempting to make a change. The state government has explored its options regarding overriding local ordinances to help bring more solar power to the state of Virginia. These efforts would allow for the State of Virginia and developers to coordinate where future solar projects would be built regardless of local ordinances (Paullin, 2024). Moves like these by elected officials are promising because they show that cleaner and more efficient energy is being prioritized, and this will help mitigate the impact that less educated individuals and politicians will have when developing solar energy systems.

Regarding the technology issues that are holding back the expansion of the solar energy market in the Appalachian region of Virginia, many things are being done in the science community to find possible solutions. The efficiency of solar panels, which was previously discussed as an issue, fluctuates based on the material used within the panel itself. Recently, the Massachusetts Institute of Technology has been researching to find ways to increase the efficiency of solar panels. Their research has led them to discover that solar panels made out of a material called perovskite could increase the efficiency to 25.2% (Chandler, 2021). Perovskite is not only an exciting alternative because of its increased efficiency, but its lower cost is another factor that will excite developers. Developments like these will be necessary for the growth of solar energy in the future, and if solar panels can continue to advance technologically, then the barriers to a growing solar market will dwindle.

Discussion

When analyzing the issues and potential solutions surrounding solar energy in the Appalachian region of Virginia, the Actor-Network theory provides an excellent framework for

understanding how the actors interact with each other. From the research provided above, it is clear that the driving factor of this entire issue is the general public. The people who reside in this region have done nothing to help the growth of solar energy as they have actively opposed its development. Even though the research suggests that if the general public encouraged solar development then there would be fewer issues, the institutional powers that are pushing solar have not done a good job of deploying information about the technology. Yes, there is an argument to be made regarding the abundance of tax incentives and green initiatives passed, but many Americans do not pay attention to or are aware of these policies. If solar energy is to succeed in rural, traditional areas like western Virginia, then the government must encourage citizens through monetary policy and education.

Another layer of the solution could come from the developer community. Western Virginia, a traditionally blue-collar region, would respect the input of developers who were responsible for building these types of projects. It would most likely be a change of pace from hearing about this technology from the Washington elites, and if they heard that members of their community thought it was a good idea, then solar energy may become more appealing. Additionally, the role of the developer in this scenario does not have to be purely influential. The development of Solar energy systems means that industries like construction would be in high demand in this region. When this demand trickles down to the supply chain and surrounding communities, the entire region could stand to be revitalized. This revitalization would not only occur fiscally, but it would also aid the culture of education in these communities. New frameworks of construction techniques would be required to build these systems, and community members who traditionally helped supply the energy generated by coal would need to learn a new skill set to understand how to distribute renewable energy. There are many ways in which

the local developer can help stimulate the conversation around solar or renewable energy in rural communities like western Virginia, but they have to be given the right tools to do so.

Conclusion

There are so many promising aspects of solar energy systems that could help the struggling Appalachian communities in Virginia, but social and technological barriers continue to stand in the way of progress. The lack of accurate and available information to these communities can be seen as the crux of the issue, and a driving factor that is making renewable energy sources seem so unappealing to this region. The government's mistake of focusing solely on the policy issues and not the human appeal aspect of renewable energy in rural communities has created a disconnect between working-class Americans and the Washington elites that control this country. Moving forward, this issue will be perpetuated if social acceptance is not prioritized by the people pioneering this industry. While many issues still need to be addressed regarding the technology itself, none of these solutions will matter if Solar energy is not widely accepted by all. Renewable energy sources, like solar energy, have the potential to reinvigorate struggling communities that have relied on coal in the past. This technology not only has the opportunity to restore economic prosperity to these citizens, but it also has the potential to improve the quality of life, surrounding environments, and education in this region. While the direct benefits of solar energy seem to only be a lower cost of energy and a smaller carbon footprint, the indirect benefits will expand beyond just the infrastructure of these small towns and will help rebuild the working class of America.

References

Bowden, E. (n.d.). An Overview of Coal and the Economy in Appalachia - Fourth Quarter 2020 Update (PDF: 2 MB). *Appalachian Regional Commission*.

Carbajo, R. (2017, December 18). Renewable energy research and technologies through responsible research and innovation looking glass: Reflexions, theoretical approaches and contemporary discourses. *Applied Energy*, *211*(1), 792 - 808. Science Direct.

Chandler, D. L. (2021, February 24). Researchers improve efficiency of next-generation solar cell material. *MIT News*.

Crawford, H. (2020, September 28). *Actor-Network Theory*. Oxford Research Encyclopedias.

Copley, M., Kellman, R., & Green, M. (2023, February 18). How misinformation about solar power hinders the fight against climate change. *NPR*.

Denholm, P., Clark, K., & O'Connell, M. (2016). Emerging Issues and Challenges in Integrating High Levels of Solar into the Electrical Generation and Transmission System. *Golden, CO: National Renewable Energy Laboratory*.

Department of Energy. (n.d.). *Grid Solutions Program*. Department of Energy.

Global Solar Atlas. (2024). *Virginia Solar Atlas*. Global Solar Atlas.

Henry County Planning Commission. (2023, June 14). *Minutes of Meeting* [Minutes of a planning council meeting in Henry County that approved a motion to cap the amount of land available for solar development to 1% of the county]. Henry County, Virginia, United States.

Hudedmani, M. G., Soppimath, V., & Jambotkar, C. (2017). A study of materials for solar PV technology and challenges. *European Journal of Applied Engineering and Scientific Research*, *5*(1), 1-13.

Inspire Clean Energy. (n.d.). Is Renewable Energy Cheaper Than Fossil Fuels? | Inspire Clean Energy. *Inspire Clean Energy*.

Kameli, Reza and Shen, Sun, "Developing Solar Energy in Rural Virginia: An Analysis of Legal, Environmental, and Policy Issues" (2022). *Virginia Coastal Policy Center*. 80.

Kennedy, B. (2023, June 28). How Americans view transitioning from fossil fuels to renewable energy. *Pew Research Center*.

Kobayashi-Solomon, E. (2022, Aug 18). *We Have An Energy Storage Problem*. Forbes

LandGate Resources. (2023, August 25). Solar Energy – An Economic Opportunity for Landowners. *LandGate.com*.

Lucas H, Carbajo R, Machiba T, Zhukov E, Cabeza LF. Improving Public Attitude towards Renewable Energy. *Energies*. 2021; 14(15):4521.

Mai, H.J. (2023, February 2). Energy experts share how the U.S. can reach Biden's renewable energy goals. *NPR*. https://www.npr.org/2023/02/02/1148370220/biden-renewable-energy-goals

ÖZÇİÇEK, Ö. (2017, December). The Role of Education on Renewable Energy Use: Evidence From Poisson Pseudo Maximum Likelihood Estimations. *Journal of Business and Economic Policy*, *4*(4), 12.

Paullin, C. (2024, February 12). In Virginia, new debates over who gets the final say on solar projects. *Virginia Mercury*.

Plumer, B. (2013, November 4). Here's why Central Appalachia's coal industry is dying. *The Washington Post*.

Pollin, R., Wicks, J., Chakraborty, S., & Kosnik, L. (2021, February). IMPACTS OF THE REIMAGINE APPALACHIA & CLEAN ENERGY TRANSITION PROGRAMS FOR WEST VIRGINIA. *Political Economy Research Institute*.

Saguaro Solar. (2022, March 29). The Solar Industry is Growing. Saguaro Solar is Tucson's Premier Solar Installer. *Saguaro Solar Electric*.

Sinsel, S. R., Riemke, R. L., & Hoffmann, V. H. (2020). Challenges and solution technologies for the integration of variable renewable energy sources—a review. *renewable energy*, *145*, 2271-2285.

Solar Atlas. (n.d.). *Energy Data*. Global Solar Atlas. Retrieved March 11, 2024

Taft, M. (2023, February 21). Republican Operatives Are Astroturfing Opposition to Solar Power. *Gizmodo*.

Tosado, G., Siegner, K., Stone, L., & Dyson, M. (2021, September 21). Reality Check: Appalachia Poised to Become Clean Energy Country. *RMI*.

Yancey, D. (2023, March 7). Virginians aren't as educated as new report makes them sound. *Cardinal News*.