Assessing the Potential for Renewable Energy Development in Appalachia

Applying the Social Construction of Technology to Public Support of Renewable Energy

A Thesis Prospectus
In STS 4500
Presented to
The Faculty of the
School of Engineering and Applied Science
University of Virginia
In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science in Systems Engineering

By
Charlotte Browder

December 15, 2023

Technical Team Members: Abby Dawley, Luke Mathe, Conor Murphy, Fritz Van Winkle

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.

ADVISORS

Rider Foley, Department of Engineering and Society

Julianne Quinn, Department of Systems and Information Engineering

Introduction: The Need And Opportunity For Renewable Energy In Appalachia

Energy consumption in the U.S. is increasing every year, and it has yet to peak. We currently rely on fossil fuels, with about 79% of the U.S.' energy coming from coal, petroleum, and natural gas (Center for Sustainable Systems, 2022), and some models estimate that the U.S. will run out of them within the next one hundred years (Kuo, 2019). However, there is a larger threat than just the depletion of resources–fossil fuel usage is harming the environment and people's health. In the U.S., 29% of global warming emissions come from the energy sector, mainly from coal and natural gas. Air and water pollution from coal and natural gas plants are connected to a variety of health issues such as breathing issues, neurological damage, and cancer (Union of Concerned Scientists, 2017).

Appalachia is being strongly impacted by the shift towards more renewable energy methods. Appalachia is a region made up of 423 counties across 13 states, spanning from southern New York to northern Mississippi, see Figure 1. 26.2 million people live within this area (Appalachian Regional Commission, n.d.-a). In Virginia, 25 counties and 8 independent cities in the southwestern part of the state are a part of Appalachia (Appalachian Regional Commission, n.d.-c). From the 1880s to 1970s, Appalachia was the country's "primary coal-producing region" (Zipper & Skousen, 2021), but mining has declined since. Between 2001 and 2021, coal production dropped 64% in Appalachia and coal employment decreased by 62% (Bowen et al., 2022).

Figure 1. Blue shaded area on map shows Appalachian region (Appalachian Regional Commission, n.d.-b)

Appalachia has historically been and is currently a key region for energy in Virginia, and this creates an opportunity for it to lead the way in renewable energy development. Large scale wind and solar projects are most successful in rural areas that have access to land and resource potential, and Appalachia fits these criteria (Tosado et al., 2021). Socially, a transition has been occurring over the past 10-15 years in Appalachia to move the region away from self-reliant communities and economies that are dependent on exporting cheap commodities. This will hopefully lead to a more sustainable economy. The vision is that this new economic model will be community based, prioritize local business, and span various sectors (Flaccavento, 2010). Clean energy is the foundation of this more sustainable economy, making it a critical part of this social transformation. My technical project will assess the potential for renewable energy in Appalachia by evaluating different types of renewables and potential sites, and later I will focus on how to successfully implement these chosen technologies with public support.

Analyzing Renewable Energy in Appalachia

Even though coal is on the decline in the U.S., Appalachia has remained crucial to coal production in the country. 27% of coal produced in the U.S. comes from Appalachia, and underground mines in the region make up 57% of total underground coal mine production (U.S. EIA, 2022). In 2020, the Virginia Clean Economy Act was passed which requires the state's two largest utilities, Dominion Energy and American Electric Power, to no longer use carbon-emitting electricity generation technologies by 2045 and 2050, respectively. This legislation will force Virginia to retire coal and natural gas and replace it with clean energy sources in the near future. In 2021, renewables provided 9% of Virginia's total electricity net generation. The state has 25 conventional hydroelectric power plants and 2 pumped-storage hydroelectric facilities. One of these pumped-storage hydroelectric facilities is the Bath County Pumped Storage Station in Appalachia (U.S. EIA, 2022). At the end of 2021 there were 51 utility-scale solar facilities (greater than 5 MW in capacity) in Virginia, and only 1 was in Appalachia, see Figure 2 (Virginia Department of Energy & Virginia Solar Initiative, University of Virginia, 2022). There are currently no utility-scale wind farms in Virginia (U.S. EIA, 2022).

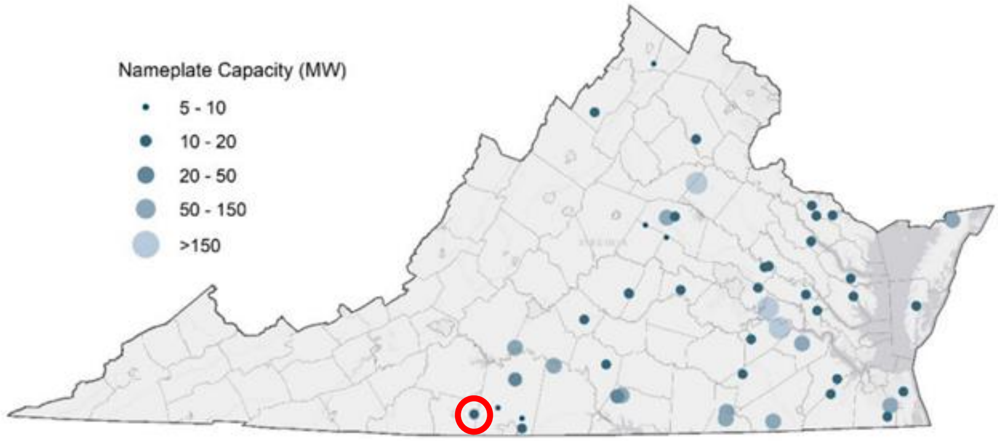

Figure 2. Utility-scale solar facilities in Virginia. The red circle highlights the one site in Appalachia in Henry County. (Virginia Department of Energy & Virginia Solar Initiative, University of Virginia, 2022)

To address this problem of a lack of renewable energy in Appalachia, my technical project will evaluate the capacity for hydropower, solar energy, and wind energy in the region, then identify favorable spots for renewable energy development. To identify sites for solar we will use data on elevation, current land use, conservation areas, and solar direct normal irradiation (measure of solar radiation received on the Earth's surface), and then examine if these areas have enough space for a solar facility (Arnette & Zobel, 2011). We will then design and propose wind, solar, and/or hydropower operations at the chosen sites. All three options will be considered, as renewable energy systems should incorporate multiple different technologies to maximize energy production (Smith & Tran, 2017). Successful implementation of renewable energy will require resource availability, appropriate technologies, and systems that can properly integrate clean energy sources to meet demand (Østergaard, 2020). Our work will assess resource availability in order to suggest which technologies would work best in Appalachia. Systems of integration are beyond the scope of this technical project.

Increasing renewable energy in Appalachia will alleviate the negative environmental and human health impacts that the region has faced. Although more will still need to be done, it will bring Virginia closer to its goal of having 100% renewable energy by 2050. This project will also aid in Appalachia's transition to a more sustainable economy. Local tax revenues, land lease payments, and employee wages from both construction and operation jobs will bring economic benefits to the region. For all of Appalachia, these economic benefits could total billions of dollars, depending on how many projects are deployed (Tosado et al., 2021).

Social Acceptance of Renewable Energy

Most people in the U.S. interact with energy almost every day whether they are conscious of it. For this reason, the social acceptance of renewable energy involves collective practice and participation with the technology, as this is not an individual issue. To achieve successful implementation and public support, areas around proposed technologies should be considered "communities of relevance" (Marres 2016), as the people involved in projects have an interest in the issue at hand and should be involved in decision making (Batel, 2018). People interact with renewable energy as stakeholders in the system, not as a group solely being impacted the system. People obviously enjoy the environmental benefits that renewable energy brings, but this is not directly felt by most citizens. Other impacts from renewable energy are more felt by the community, such as how construction may disrupt land use and/or wildlife. Understanding how people living nearby will be affected by the renewable energy facilities is a crucial step of implementation to ensure that the communities will be in favor of the technology.

An analysis of interviews with various stakeholders in renewable energy projects such as developers, regulators, and engineers found that a main source of opposition to renewable energy comes from a fear of the unknown (Cass & Walker, 2009). Often people are unsure of how projects will be implemented and what effect this will have on them, making them resistant. In order for the technology to be successfully implemented, it must be accepted from the social side. A key component of this is the need for local ownership. Renewable energy implemented by outside groups who do not understand the culture of the area will likely face more opposition than local initiatives (Flaccavento, 2010). When considering Appalachia's shift to a sustainable economy, clean energy is the foundation for this.

To examine the basis of public support and opposition, I will apply the Social Construction of Technology (SCOT) framework to analyze how characteristics of different social groups form their perception of nuclear energy. A social constructivist view on technology is based upon a multidirectional model that describes the developmental process of a technological artifact as alternating between variation and selection. The concept of interpretive flexibility also plays a role in this developmental process, which is the idea that the differing perspectives of a technological artifact held by social groups create different problems according to each group's priorities (Bijker & Pinch, 1987). In this way, technology will conform to social pressures in order to appease social groups' needs. These concepts are relevant when considering renewable energy, as proposed developments go through many phases of edits, largely dependent on feedback they receive from various stakeholders. My thesis will examine public support, or lack of it, of previous renewable energy projects to understand how various social groups in Appalachia feel about renewable energy, and how that impacts the development of these projects.

Research Questions and Methods

My research will answer the question of how public support affects the development of renewable energy. We have proper technology for renewable energy to be successful, but if communities reject it then this technology will never be implemented, and therefore never contribute to easing the environmental problems we are currently facing. To analyze this question, I will assess prior solar and wind projects that were both approved and denied. To choose these projects, I researched renewable energy projects in Appalachia and consulted a 2021 report on Opposition To Renewable Energy Facilities In The United States from Columbia Law School. I selected Leatherwood Solar in Henry County, VA (approved solar), Beech Ridge Wind Farm in Greenbrier County, WV (approved wind), Pulaski County solar farm in Virginia (denied solar), and NextEra Energy Resources and Duke Energy Renewables wind farm in Mason County, KY (denied wind) to analyze. Leatherwood Solar was chosen because it is the only utility-scale solar facility in the Appalachian region of Virginia (Virginia Department of Energy & Virginia Solar Initiative, University of Virginia, 2022). Beech Ridge Wind Farm was chosen because there are no utility-scale wind farms in Virginia, but Greenbrier County in West Virginia has similar demographics to the Appalachian region of Virginia such as median income, percentage of population that is white, and percentage of population with a bachelor's degree or higher (Pollard et al., 2023 and U.S. Census Bureau, 2022-a). The proposed solar farm in Pulaski County was chosen because it was recently denied in 2022 and is in the Appalachian region of Virginia. The proposed wind farm in Mason County, KY was chosen because there were no viable options in Virginia, but Mason County has similar demographics to the Appalachian region of Virginia, as discussed with Greenbrier County, WV (Pollard et al., 2023 and U.S. Census Bureau, 2022-b). I will research how the decision to execute or reject these projects was made to determine what factors lead to the support of renewable energy development in Appalachia. To do this I will read local news coverage, statements from support and opposition groups, and comments from local governments. I will identify key reasons for approval or denial from stakeholders such as citizens, developers, and members of the government and find any common themes in order to understand what factors are most crucial to the success of renewable energy implementation from a social perspective.

Conclusion: Implementing Renewable Energy with Public Support

As a country, our fossil fuel usage is contributing significantly to environmental degradation through greenhouse gas emission and air and water pollution. On top of these climate issues, Appalachia is suffering economically from a decline in the coal industry. This region has the land and resource potential for renewable energy projects, and development of utility-scale wind and/or solar projects will bring revenue to the area through local taxes, land lease payments, and employee wages. My technical project will assess which sites and technologies would be best implemented in Appalachia based on resource and environmental conditions. My STS research will examine what factors affect public support of renewable energy projects. Together, these two aspects will provide insight into how clean energy can best be developed in Appalachia, addressing environmental concerns with acceptance from the people in the region.

References

About the Appalachian Region. (n.d.-a). Appalachian Regional Commission. Retrieved October 17, 2023, from https://www.arc.gov/about-the-appalachian-region/

Arnette, A. N., & Zobel, C. W. (2011). Spatial analysis of renewable energy potential in the greater southern Appalachian mountains. *Renewable Energy*, *36*(11), 2785–2798. https://doi.org/10.1016/j.renene.2011.04.024

Batel, S. (2018). A critical discussion of research on the social acceptance of renewable energy generation and associated infrastructures and an agenda for the future. *Journal of Environmental Policy & Planning*, *20*(3), 356–369. https://doi.org/10.1080/1523908X.2017.1417120

Benefits of Renewable Energy Use. Union of Concerned Scientists. (2017, December 20). https://www.ucsusa.org/resources/benefits-renewable-energy-use

Bijker, W. E., & Pinch, T. J. (1987). The Social Construction of Fact and Artifacts. *The Social Construction of Technological Systems* pp. 17–50. Cambridge, MA: MIT Press.

Bowen, E., Christiadi, Deskins, J., & Lego, B. (2022). *Coal Production and Employment in Appalachia*. Bureau of Business and Economic Research, West Virginia University.

Cass, N., & Walker, G. (2009). Emotion and rationality: The characterisation and evaluation of opposition to renewable energy projects. *Emotion, Space and Society*, *2*(1), 62–69. https://doi.org/10.1016/j.emospa.2009.05.006

Flaccavento, A. (2010). The Transition of Appalachia. *Solutions for a Sustainable & Desirable Future*, *1*(4), 34–44.

Goyal, R., Marsh, K., McKee, N., & Welch, M. (2021). *Opposition To Renewable*

Energy Facilities In The United States (p. 57). Sabin Center for Climate Change Law, Columbia Law School. https://climate.law.columbia.edu/sites/default/files/content/RELDI%20report%20updated%209.10.21.pdf

Investing in Appalachia's Economic Future. (n.d.-b). Appalachian Regional Commission. Retrieved October 17, 2023, from https://www.arc.gov/

Kuo, G. (2019, May 23). *When Fossil Fuels Run Out, What Then?* MAHB. https://mahb.stanford.edu/library-item/fossil-fuels-run/

Marres, N. (2016). *Material Participation: Technology, the Environment and Everyday Publics.* Springer.

Østergaard, P. A., Duic, N., Noorollahi, Y., Mikulcic, H., & Kalogirou, S. (2020). Sustainable development using renewable energy technology. *Renewable Energy*, *146*, 2430–2437. https://doi.org/10.1016/j.renene.2019.08.094

Pollard, K., Srygley, S., & Jacobsen, L. A. (2023). *The Appalachian Region: A Data Overview From The 2017-2021 American Community Survey Chartbook* (pp. 22, 53, 115). Appalachian Regional Commission. https://www.arc.gov/wp-content/uploads/2023/05/PRB_ARC_Chartbook_ACS_2017-2021_FINAL_2023-06.pdf

Smith, A. D., & Tran, T. T. D. (2017). Evaluation of renewable energy technologies and their potential for technical integration and cost-effective use within the U.S. energy sector. *Renewable and Sustainable Energy Reviews*, *80*, 1372–1388. https://doi.org/10.1016/j.rser.2017.05.228

Tosado, G., Siegner, K., Stone, L., & Dyson, M. (2021, September 21). *Reality Check:*

Appalachia Poised to Become Clean Energy Country. RMI. https://rmi.org/rmi-reality-check-appalachia-poised-to-become-clean-energy-country/

U.S. Census Bureau QuickFacts: Greenbrier County, West Virginia. (2022-a). U.S. Census Bureau.
Retrieved October 27, 2023, from
https://www.census.gov/quickfacts/fact/table/greenbriercountywestvirginia/PST045222

U.S. Census Bureau QuickFacts: Mason County, Kentucky. (2022-b). U.S. Census Bureau.
Retrieved October 27, 2023, from
https://www.census.gov/quickfacts/fact/table/masoncountykentucky/PST045222

U.S. Renewable Energy Factsheet (CSS03-12). (2021). Center for Sustainable Systems, University of Michigan. https://css.umich.edu/publications/factsheets/energy/us-renewable-energy-factsheet

Virginia. (n.d.-c). Appalachian Regional Commission. Retrieved October 17, 2023, from https://www.arc.gov/appalachian-states/virginia/

Virginia Solar Survey (pp. 13–16). (2022). Virginia Department of Energy & Virginia Solar Initiative, University of Virginia. https://energytransition.coopercenter.org/virginia-solar-survey

Virginia State Energy Profile. (2022). U.S. Energy Information Administration. Retrieved October 16, 2023, from https://www.eia.gov/state/print.php?sid=VA

Where our coal comes from. (2022). U.S. Energy Information Administration. Retrieved October 17, 2023, from https://www.eia.gov/energyexplained/coal/where-our-coal-comes-from.php

Zipper, C. E., & Skousen, J. (2020). *Appalachia's Coal-Mined Landscapes: Resources and Communities in a New Energy Era* (p. 1-26). Springer Nature.