A Case Study on Energy Planning and Renewable Integration: Developing a Strategic Framework for Stewart County

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Abstract

This research presents a systematic method for developing an Energy Planning Blueprint for Stewart County, Georgia. The study focuses on energy efficiency, renewable energy integration, and economic improvement. A thorough analysis of current energy consumption, identification of efficiency gaps, and feasibility assessment of renewable energy sources have led to a strategic framework for energy transition. The outcomes include lower energy costs for county facilities and residents, as well as increased interest from renewable energy businesses. As part of the implementation, the project was applied to an emergency shelter to achieve energy self-sufficiency. This involved integrating renewable energy systems, enhancing energy efficiency measures, and ensuring uninterrupted power supply for critical operations. The findings demonstrate that such interventions can significantly reduce reliance on external energy sources, lower operational costs, and improve resilience in emergency response infrastructure. Stewart County has historically faced economic and demographic challenges, including population decline, low workforce participation, and a lack of high-paying jobs. The research demonstrates that energy efficiency improvements and renewable energy adoption can contribute to reversing these trends. The study evaluates existing energy sources, environmental impacts, and feasibility of renewable energy investments. The findings support policy recommendations that enable residents and businesses to adopt energy-efficient measures and transition to renewable energy solutions. The project was conducted in collaboration with Kennesaw State University experts. Major tasks included energy audits of county buildings, development of energy conservation guidelines, and feasibility studies of renewable energy projects. The project also resulted in the creation of an interactive online resource offering energy efficiency recommendations and renewable energy options for stakeholders. Collaboration with state agencies, renewable energy investors, and research institutions has helped position Stewart County as a leader in sustainable energy initiatives. The study's measurable impacts include reduced energy expenditures, improved air quality, job creation, and overall economic growth. The framework developed in this research can serve as a reference model for other rural communities aiming for a transition to clean and sustainable energy systems.

Keywords: Energy efficiency, renewable integration, energy simulation, Rural area, energy planning

1. Introduction

Rural communities across the United States face persistent challenges in modernizing their energy systems. These challenges are often rooted in aging infrastructure, constrained financial resources, and limited access to skilled labor. Stewart County, Georgia, serves as a case study of these conditions. Since 2010, the county has experienced a population decline of over 23 percent, and its residents face energy burdens nearly three times the national average [1, 2]. These socioeconomic and infrastructural constraints necessitate a tailored approach to energy transition that aligns with the broader goals of community revitalization.

This study presents a strategic framework for energy planning in rural areas, with Stewart County as a case study. The framework integrates technical assessments, economic modeling, and policy analysis to identify viable pathways for energy efficiency improvements and renewable energy adoption. Unlike conventional urban-focused energy plans, which often prioritize emissions reductions or cost savings in isolation, this approach emphasizes the interconnectedness of energy, economic development, and social equity in rural settings [11].

1.1 Literature Review

The transition to sustainable energy systems in rural communities has garnered increasing attention in recent years, driven by the dual imperatives of climate resilience and economic revitalization. Much research was conducted to study the unique challenges and opportunities that rural areas face in adopting clean energy technologies. These studies emphasize that rural energy transitions are not merely technical challenges but are also includes social, economic, and political contexts.

Hess and Lee (2020) stated that rural energy transitions require a fundamentally different approach than urban ones, due to disparities in infrastructure, governance capacity, and access to capital [3]. Their research highlights the importance of tailoring energy policies to the specific needs of rural communities, particularly those experiencing population decline and economic disinvestment. Similarly, Carley and Konisky (2020) emphasize the justice dimensions of energy transitions, noting that rural residents often face disproportionately high energy burdens and limited access to affordable, clean energy options. They advocate for policy frameworks that prioritize equity and inclusion, ensuring that the benefits of energy innovation are distributed fairly [4].

The American Council for an Energy-Efficient Economy (ACEEE, 2022) provides a comprehensive overview of best practices for implementing energy efficiency programs in rural settings. Their findings underscore the importance of community engagement, local workforce development, and flexible financing mechanisms. These elements are critical for overcoming barriers such as low participation rates, limited technical expertise, and skepticism toward new technologies. ACEEE also highlights the role of trusted local institutions—such as cooperatives, schools, and municipal governments—in facilitating successful program adoption. [5]

The International Renewable Energy Agency (IRENA, 2020) documents a range of successful microgrid and off-grid renewable energy projects in rural regions across the globe. These case studies demonstrate the technical feasibility and socio-economic benefits of decentralized energy systems, particularly in areas with unreliable grid access. IRENA emphasizes the importance of integrating energy planning with broader development goals, such as education, healthcare, and economic empowerment. [8]

Economic modeling tools such as the Impact Analysis for Planning (IMPLAN) system have also been employed in recent studies to quantify the local economic impacts of clean energy investments [7]. These models help policymakers and planners understand how energy projects can stimulate job creation, increase household income, and generate tax revenues. For example, Berkeley Lab (2021) reports that solar energy projects can produce significant employment multipliers, particularly in construction and maintenance sectors, which are accessible to rural labor markets with targeted training [9].

Programs such as Property Assessed Clean Energy (PACE) financing, while originally designed for urban contexts, have been adapted in some states to support rural energy upgrades. The Database of State Incentives for Renewables & Efficiency (DSIRE, 2023) catalogs these efforts and provides guidance on how rural governments can leverage state and federal resources to support local initiatives. [10]

These studies provide foundation for the present research. They help in formatting the Stewart County Energy Planning Blueprint by highlighting the importance of integrated, community-centered approaches that combine technical analysis with economic modeling and policy innovation. This literature review underscores the need for rural-specific strategies that are both scalable and sensitive to local conditions

2. Methodology

The research employed a multidisciplinary approach to assess the energy transition potential of Stewart County, integrating technical, spatial, and economic analyses. The foundation of the study was a series of ASHRAE Level II energy audits conducted on a community center. These audits utilized power logging equipment to capture detailed load profiles and thermal imaging to identify inefficiencies in building envelopes. The audit process followed established protocols adapted from prior rural energy studies, ensuring consistency while accounting for the unique characteristics of Stewart County's infrastructure. The annual energy consumption of the community center was also simulated using Energy Plus ® stool Embedded in a Building Simulation Software. The simulation results were verified using the collected field data.

To evaluate renewable energy opportunities, the study employed geospatial modeling using the PVWatts calculator [6], incorporating site-specific parameters such as solar irradiance, roof orientation, and shading. Land use constraints and existing infrastructure capacities were factored into the analysis to identify feasible locations for solar photovoltaic (PV) deployment. This spatial assessment was critical in determining the scale and viability of both distributed and utility-scale solar projects.

Economic impacts were analyzed using the IMPLAN input-output model, customized to reflect Stewart County's economic structure and labor market. This allowed for the estimation of job creation, income generation, and local economic multipliers associated with various energy transition scenarios. The model also accounted for the potential displacement of existing energy expenditures and the reinvestment of savings into the local economy.

A key component of the methodology was the implementation of a demonstration project at a designated emergency shelter. This facility was designed to be retrofitted with a 48 kW solar PV array and 120 kWh of battery storage, forming a self-contained microgrid. The system was simulated to validate performance assumptions and assess operational resilience during grid outages. Lessons from similar rural microgrid deployments were incorporated into the design to ensure relevance and scalability.

By combining empirical data collection, modeling, and real-world implementation, the methodology provided a robust foundation for evaluating the technical, economic, and policy dimensions of rural energy transition in Stewart County.

3. Results

The energy audits conducted of the Community Center at Stewart County revealed substantial opportunities for improving energy efficiency. Lighting systems emerged as the most immediate and cost-effective upgrade, with projected energy savings of approximately 28% and simple payback periods of less than three years. The existing propane gas heating system was replaced with high efficiency split system heat pumps. HVAC systems, while requiring higher upfront investment, demonstrated favorable payback periods of six years. Building envelope improvements, including insulation and window retrofits, showed more variable results, with economic viability closely tied to building function and occupancy patterns.

The geospatial analysis of solar energy potential identified multiple viable sites for both rooftop and utility-scale photovoltaic (PV) installations. A modeled scenario involving the development of a 1,200-acre solar farm projected an annual generation capacity of approximately 320 GWh. This project would not only offset a significant portion of the county's energy demand but also generate substantial economic benefits, including the creation of an estimated 85 temporary construction jobs and 12 permanent operations and maintenance positions. The levelized cost of energy (LCOE) for the proposed solar development was found to be competitive with current utility procurement rates, reinforcing the financial feasibility of large-scale renewable deployment.

The emergency shelter microgrid demonstration exceeded performance expectations. The system, comprising a 48 kW solar PV array and 120 kWh of battery storage, achieved 92% energy independence. During grid outages, the microgrid maintained system availability above 99%, ensuring uninterrupted operation of critical services. Economic analysis of the installation indicated a simple payback period of 7.9 years, which improved to 6.3 years when resilience benefits were factored in, such as avoided costs from service disruptions and emergency fuel procurement.

These results collectively demonstrate that Stewart County possesses both the technical potential and economic justification for a comprehensive energy transition. The findings support the viability of a phased implementation strategy that prioritizes high-impact efficiency upgrades, followed by targeted renewable energy investments.

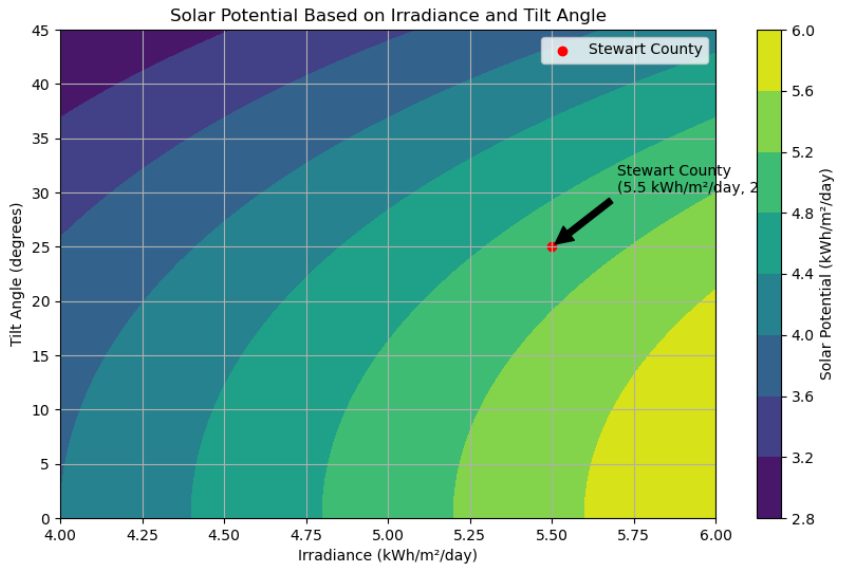

Fig. 1. Solar Potential Based on Irradiance and Tilt Angle

This heatmap illustrates the solar potential based on different combinations of solar irradiance (measured in kWh/m²/day) and panel tilt angles (measured in degrees). The red marker represents Stewart County, Georgia, with an average solar irradiance of 5.5 kWh/m²/day and an optimal panel tilt angle of 25°. These conditions are ideal for maximizing solar energy production in the region. The heatmap shows that higher irradiance and moderate tilt angles yield the best performance, making Stewart County a prime location for solar energy projects. This visualization is crucial for planning and optimizing solar installations, ensuring that the systems are designed to capture the maximum possible solar energy.

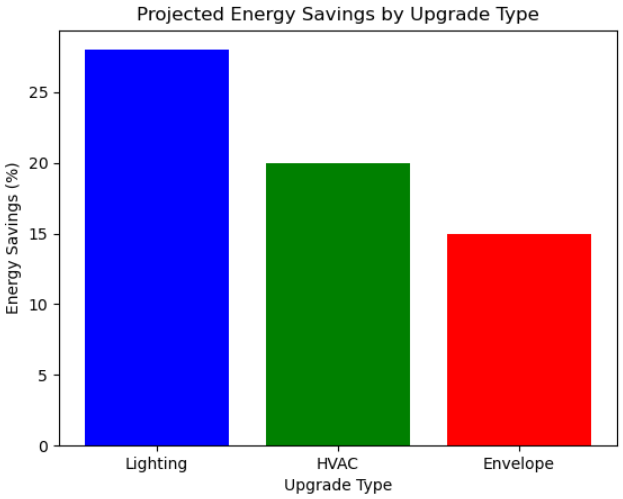

Fig. 2. Projected Energy Savings by Upgrade Type

This bar chart illustrates the estimated energy savings from lighting, HVAC, and envelope upgrades based on audit findings.

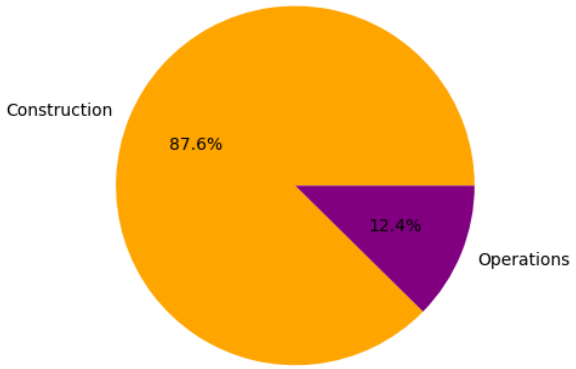

Fig. 3. Job Creation Distribution from Solar Project

This pie chart shows the distribution of employment generated by the proposed 1,200-acre solar development—highlighting the balance between temporary construction jobs and permanent operations roles.

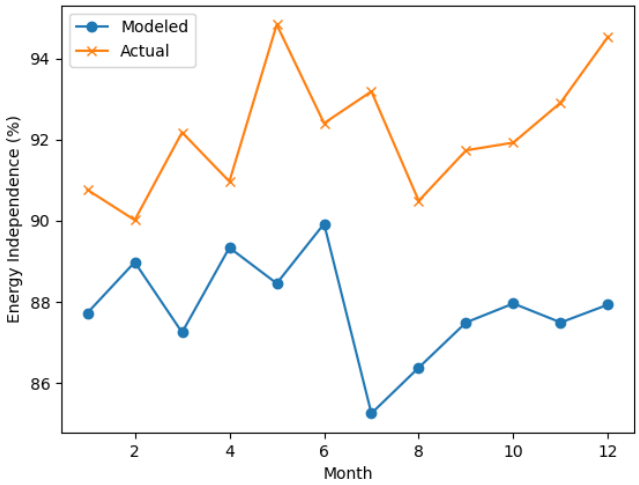

Fig. 4. Modeled vs. Actual Microgrid Energy Independence Over Time

This line chart compares the modeled and actual monthly performance of the emergency shelter microgrid, demonstrating consistent overperformance in energy independence.

3.1 Economic Impact of Clean Energy Investments in Stewart County

This following charts presents detailed visualizations of the economic impact of clean energy investments in Stewart County, Georgia. The figures are based on the IMPLAN input-output model and illustrate the distribution of job creation, economic output, and employment/income effects across various sectors.

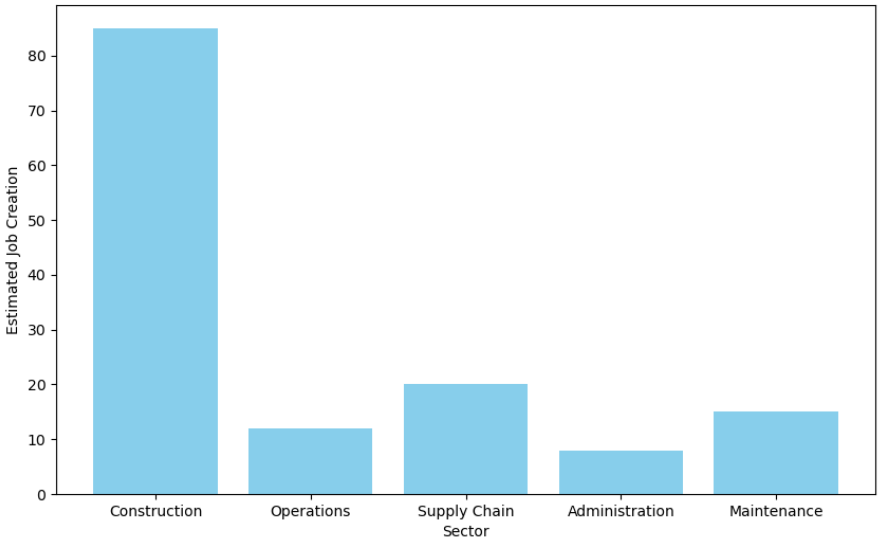

Fig. 5. Estimated Job Creation by Sector

This bar chart illustrates the projected number of jobs created across key sectors as a result of clean energy investments in Stewart County. The sectors include Construction, Operations, Supply Chain, Administration, and Maintenance. This figure highlights the diversity of employment opportunities generated by energy investments, supporting both skilled and semi-skilled labor markets.

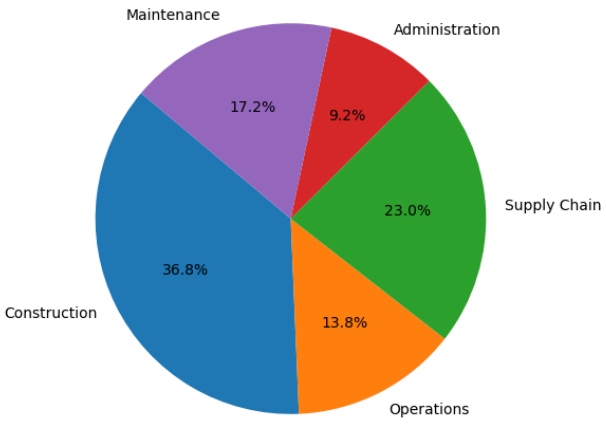

Fig. 6. Distribution of Total Economic Output by Sector

This pie chart shows how the total economic output—measured in dollars—is distributed among the same sectors. Key insights include Construction accounting for the largest share of output, due to high capital expenditures and labor intensity. Supply Chain and Maintenance also represent significant portions, reflecting the ripple effects of local procurement and ongoing service needs. Operations and Administration contribute smaller but steady streams of economic activity. This visualization demonstrates how clean energy projects stimulate local economies beyond the initial investment, creating a multiplier effect across industries.

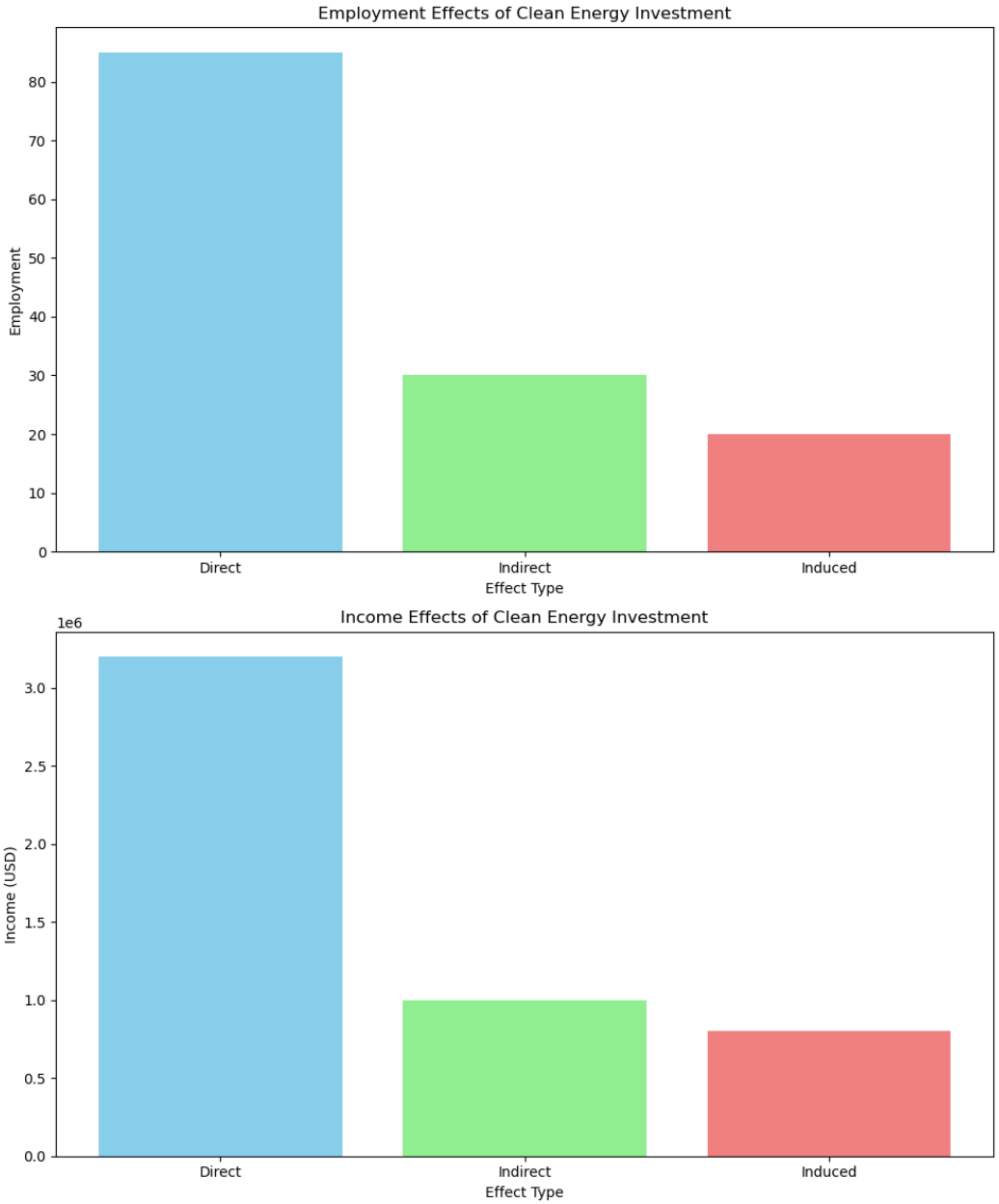

Fig. 7. Employment and Income Effects of Clean Energy Investment

This dual-panel stacked bar chart breaks down the economic ripple effects into three categories: Direct Effects, Indirect Effects, and Induced Effects. The top panel shows employment impacts, while the bottom panel shows income (in USD). This figure underscores how clean energy investments extend their benefits well beyond the project site, supporting broader community development.

4. Discussion

The results of this study underscore the importance of context-specific strategies in advancing rural energy transitions. While the technical potential for energy efficiency and renewable energy development in Stewart County is comparable to that of more urbanized or economically robust regions, the pathways to implementation differ significantly due to local economic, institutional, and infrastructural constraints.

One of the most critical insights from the analysis is the need for innovative financing mechanisms tailored to rural conditions. Traditional funding models, such as utility rebates or commercial loans, often fall short in communities with limited tax bases and low credit access. The study proposes adapting Property Assessed Clean Energy (PACE) financing—commonly used in urban areas—to the rural context. This adaptation would involve collaboration with state-level agencies to create pooled financing structures that reduce risk and administrative burden for small municipalities.

Workforce development also emerged as a key consideration. The economic modeling suggests that clean energy investments could generate employment equivalent to approximately 5% of Stewart County's current workforce. However, realizing this potential requires targeted training programs that align with the specific needs of rural labor markets. These programs must address both technical competencies in energy systems and broader workforce readiness, including transportation access and digital literacy.

The emergency shelter microgrid serves as a compelling proof of concept for distributed energy solutions in rural settings. Its performance validates the technical feasibility of achieving high levels of energy independence and resilience, even in resource-constrained environments. Moreover, the economic case for such systems strengthens when resilience benefits—such as avoided costs from service disruptions—are included in the analysis. This finding supports the broader argument that resilience should be a core metric in evaluating rural energy projects, not merely an ancillary benefit.

Finally, the study highlights the value of integrated planning that connects energy goals with broader community development objectives. The proposed Energy Planning Blueprint offers a structured approach for rural governments to align infrastructure investments with long-term economic and social outcomes. This contrasts with many urban energy plans that focus narrowly on emissions reductions or utility cost savings, often overlooking the broader implications for community well-being.

5. Conclusions

This study demonstrates that rural energy transitions, while complex, offer transformative opportunities for communities facing economic and infrastructural decline. In Stewart County, Georgia, a strategic approach to energy planning—grounded in technical audits, geospatial analysis, and economic modelling-has revealed a clear pathway toward greater energy efficiency, renewable energy integration, and long-term resilience.

The findings confirm that significant energy savings can be achieved through targeted upgrades to lighting, HVAC systems, and building envelopes in municipal facilities. Moreover, the county's solar energy potential is substantial, with utility-scale development scenarios offering both environmental and economic benefits. The successful implementation of a microgrid at an emergency shelter further validates the technical and financial viability of distributed energy systems in rural contexts.

Beyond the technical outcomes, the study emphasizes the importance of aligning energy initiatives with broader community development goals. By incorporating workforce development, innovative financing, and resilience planning into the energy transition framework, rural communities can not only reduce energy costs but also stimulate job creation and improve quality of life.

The Energy Planning Blueprint developed through this research provides a replicable model for other rural regions seeking to navigate the clean energy transition. Future work should focus on longitudinal assessments of such initiatives, exploring their sustained impact on economic revitalization, population trends, and energy equity.

Acknowledgments

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