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USE OF RENEWABLE ENERGY IN RURAL AREAS: LITERATURE REVIEW AND APPLICATION IN COMMUNITY SERVICE

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Abstract

This study aims to explore the potential and implementation of renewable energy in rural areas as an effort to support sustainable development and improve people's quality of life. Using the literature research method, this study collected and analyzed data from various sources in accordance with the research context. The results show that the implementation of renewable energy in rural areas has significant positive impacts on the local economy, education, and environmental awareness of the community. It was also found that the active participation of communities in the decision-making process, planning and implementation of renewable energy projects plays an important role in improving project sustainability and success. The research underscores the need for a more inclusive approach to the planning and execution of energy projects, where community education and empowerment are key. Finally, this research offers insights into how renewable energy projects can serve as a means of community service, establish communal cooperation, and serve as a model for future similar initiatives in other rural areas.

Keywords: Usage, Renewable Energy, Rural Area, Community Service.

Introduction

Energy is one of the important factors that support economic activities and social life. In rural areas, the availability and access to energy is often a major problem, making daily activities and local economic development limited (R. et al., 2023). The utilization of conventional energy sources not only poses constraints in

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terms of availability but also has a negative impact on the environment. With global concerns regarding climate change and other environmental impacts, there is a growing urgency to adopt sustainable and environmentally friendly energy technologies (Franco, 2021).

Renewable energy, which includes solar, wind, hydro, bioenergy and geothermal, offers substantial potential solutions to solve energy problems in rural areas. In addition to being environmentally friendly, these energy sources are renewable and have the potential to be developed as stable local energy sources. Utilizing renewable energy in rural areas will not only reduce dependence on fossil fuels but also improve people's quality of life by providing cleaner and more sustainable energy (Zhang et al., 2022).

These energies have the main advantage of being non-exhaustive and low-emission. In contrast to fossil energy sources that contribute heavily to greenhouse gas emissions, renewable energy offers a clean and sustainable solution, helping to minimize the increase in global temperatures as well as other negative impacts on the environment (Zhou, 2024). The utilization of renewable energy also supports the energy security of a country or region by reducing dependence on fossil fuel imports, which are often volatile in price and politically unstable (Abada et al., 2021).

Furthermore, in the context of economic and social development, renewable energy can play a significant role in improving energy access, especially in rural areas and remote communities. By exploiting local energy sources, these areas can overcome the problem of limited energy access, while supporting local economic development through job creation and new business activities in the renewable energy sector (Klepacka & Florkowski, 2021). The modular and scalable nature of renewable energy technologies allows them to be applied at various scales, from small systems for household needs to large projects to support industrial and commercial needs. Thus, renewable energy not only has a positive impact on the environment but also on socio-economic sustainability, paving the way towards a greener and more inclusive future (Duarte et al., 2022).

Despite its great potential, the adoption and implementation of renewable energy in rural areas is often hampered by various factors, including limited knowledge, technology, infrastructure, and policy and investment support.

In many rural areas around the world, access to reliable and affordable energy remains a major challenge. This situation is due to various factors, including underdeveloped energy infrastructure, long distances from major energy

production centers, and lack of investment in the rural energy sector (Bodjongo et al., 2021). As a result, many communities in rural areas rely on traditional energy sources such as firewood, charcoal, and kerosene, which are not only inefficient but also have negative environmental and health impacts. The use of these traditional energy sources often results in indoor air pollution, which risks causing respiratory problems and other diseases. In addition, the time and energy consumed to collect traditional fuels places an additional burden on the rural population, especially women and children, which impacts the time that could be spent on education or other productive activities (TB, 2021).

The introduction and implementation of renewable energy technologies in rural areas can provide solutions to address the challenges associated with energy access. Renewable energy such as off-grid solar systems, mini wind turbines and biogas from agricultural waste can be tailored to the specific needs of rural communities, offering a cleaner, more reliable and often more affordable alternative to conventional energy sources (Saraji et al., 2023). In addition, renewable energy projects can help drive local economic development through job creation, energy cost savings, and increased productivity. With the adoption of renewable energy, rural areas can achieve energy independence while contributing to global efforts to reduce emissions and promote sustainable development (Streimikiene et al., 2021).

Therefore, research and community service that focuses on the practical application and education of renewable energy in rural areas is very important. This research aims to assess the types of renewable energy that are most potential and effective for use in rural areas, and how these technologies can be integrated into community service activities, resulting in a real impact on the development and energy independence in the area.

Research Methods

The study conducted in this research uses a literature review. The literature research method, often referred to as a literature study or literature review, is a systematic research approach to collecting, reviewing, and analyzing published works (such as books, journal articles, reports, and electronic documentation) on a particular topic. This method is very useful in determining new research directions, as well as in supporting arguments or findings in empirical research (Goldin et al., 2024).

This literature research method is important to ensure that the research conducted is based on a comprehensive understanding of what is already known

about the topic and what still needs to be further explored (Cascaldi-Garcia et al., 2023).

Results and Discussion

Definition and Types of Renewable Energy

Renewable energy is a type of energy that comes from natural resources that will never run out or can always be renewed over time. Unlike fossil energy sources such as coal, oil, and natural gas that can be depleted and have an adverse impact on the environment, renewable energy is produced from sustainable natural processes (Franco, 2021). Some examples of renewable energy sources include sunlight, wind, water (hydro), geothermal, and biomass. The use of renewable energy is important in reducing greenhouse gas emissions, strengthening energy security, and supporting economic growth through job creation in new and sustainable technologies (Abada et al., 2021).

There are several main types of renewable energy that are widely used today. First, solar energy, which harnesses light and heat from the sun using solar panels and related technologies to generate electricity or heating. Second, wind energy, which is generated through wind turbines that convert kinetic energy from the wind into electricity (Duarte et al., 2022). Third, hydroelectric energy, which utilizes the movement of water, either from river flow or from hydropower facilities, to generate energy. Fourth is geothermal energy, which uses the heat stored beneath the earth's surface to generate electricity and for heating. Lastly is biomass, which involves using organic materials such as plants and waste for energy production. All these types of energy not only help in combating climate change but also in reducing dependence on fossil fuels that are limited in availability (Saraji et al., 2023).

In addition to the main types of renewable energy already mentioned, there are also several other forms that are gaining increasing attention and development. Tidal and wave energy are examples of renewable energy sources that utilize the movement of ocean water (Streimikiene et al., 2021). Although it currently contributes relatively little to the total global energy supply compared to other sources, technologies to harness this form of energy continue to develop. Its great potential in providing clean and sustainable energy makes tides and waves a promising area of research (Briggs et al., 2022).

Utilizing renewable energy requires effort and investment in technology as well as infrastructure. For example, the construction of wind turbines or solar

panels requires sufficient land or space. On the other hand, challenges such as variability in energy production due to weather and natural conditions can be overcome with innovations in energy storage technologies and efficient distribution networks. In addition, supportive government policies, such as subsidies for renewable energy and taxes on carbon emissions, are also crucial in accelerating the adoption and development of this clean energy (Veynandt et al., 2022).

The use of renewable energy also offers many socio-economic benefits. In the long run, renewable energy can be more cost-effective than fossil fuels, especially considering external costs such as pollution and health impacts. In addition, the renewable energy sector creates millions of jobs worldwide, from manufacturing to installation and maintenance of renewable energy infrastructure (Reis et al., 2021).

Thus, renewable energy is not only important in the context of climate change and environmental protection, but also in promoting energy security, economic sustainability and community development. Therefore, the transition to cleaner and more sustainable energy sources is one of the top priorities on today's global agenda.

Context of Energy Use in Rural Areas

Rural areas, or better known as rural areas, have characteristics that distinguish them from urban areas. The main characteristics of rural areas are a relatively low population density and a geographical area that usually includes large farmlands, forests, rivers, and lakes (Saraji et al., 2023). These areas are often surrounded by nature and offer beautiful scenery and cleaner air compared to urban environments. The economy in rural areas is generally dominated by agriculture, plantation, fishery, or forestry activities, although other economic activities such as tourism and handicrafts also develop according to the local potential of each region. Public facilities and infrastructure such as roads, hospitals, and schools may not be as numerous or complex as those in urban areas, but rural communities often have strong social cohesiveness and preserved traditions (Streimikiene et al., 2021).

Social life in rural areas tends to be quieter and more connected to nature. Interactions between residents tend to be closer, with strong community ties often the main pillar of social life. Rural areas offer a slower pace of life and focus more on harmony with nature and each other, in contrast to the fast-paced urban life (Veynandt et al., 2022). In recent years, with the increasing awareness of the importance of sustainability and quality of life, the trend of reverse migration to

rural areas or the desire to own a home in the countryside has become quite visible. This suggests that, despite certain challenges, life in rural areas still offers significant appeal, especially for those who seek tranquility, closeness to nature, or want to escape the hustle and bustle of urban life (Reis et al., 2021).

On the other hand, rural areas also face some significant challenges. One of them is limited access to quality health and education facilities. Due to the long distances between facilities and inadequate transportation, residents of rural areas often find it difficult to access health and education services on par with those in big cities. This also results in disparities in quality of life and economic opportunities between urban and rural residents (Shanshan et al., 2023). In addition, the lack of employment opportunities in rural areas often encourages migration to big cities, leading to problems such as population decline that can affect the sustainability of local communities (Janota et al., 2023).

Nonetheless, many initiatives are being developed to improve life in rural areas. Increased investment in infrastructure such as roads, broadband internet, and electricity services has become a priority for many governments in their efforts to strengthen villages. New technologies, such as the use of renewable energy and smart farming systems, are also being implemented to help overcome some of the constraints faced by rural populations (Bhatt, 2022). In addition, the development of better education and health programs as well as economic initiatives that focus on local wisdom and sustainability are increasingly being considered to open up new opportunities for villagers, and ultimately, create a more dynamic balance between urban and rural development (Romero-Castro et al., 2022).

Energy access and infrastructure in rural areas often face greater challenges than in urban areas. Due to their geographic remoteness and lower population density, many rural areas are not connected to the national grid or have limited access to stable renewable energy sources (Kang, 2021). This inadequate energy infrastructure results in reliance on less efficient and more expensive energy sources, such as diesel generators, kerosene, or even firewood for lighting and meeting daily energy needs. This is not only economically detrimental but also has a negative impact on the environment and the health of local communities (Demirci et al., 2023).

To address this problem, various initiatives have been developed by governments, non-governmental organizations, and the private sector to expand energy access in rural areas. One of the most promising solutions is the utilization of renewable energy technologies, such as solar panels, small wind turbines, and

micro-hydro systems that can operate small-scale power plants to meet energy needs in areas that are difficult to reach by the main power grid (Almihat & Kahn, 2023). These projects not only offer sustainable and environmentally friendly solutions but also empower local communities through the development of infrastructure that they can manage themselves, once again demonstrating the importance of energy access in promoting inclusive and sustainable rural development (Adefarati et al., 2024).

In conclusion, rural areas offer unique values and lifestyles, but also face a number of challenges, particularly regarding energy access and infrastructure. While low population density and remote locations often make it difficult to build adequate energy infrastructure, recent initiatives in the application of renewable energy technologies have shown the potential to overcome these barriers. With increased investment and a focus on sustainable and inclusive solutions, rural areas can experience more balanced economic development, improve the quality of life of their residents, and ensure that they are not left behind on the path to greater progress and prosperity. Investments in renewable energy not only solve energy access issues but also provide a boost to environmental sustainability and public health, strengthening the foundations for sustainable and self-reliant rural development.

Types of Renewable Energy Potential for Development in Rural Areas

Solar energy is one type of renewable energy that has great potential to be developed in rural areas. The abundant availability of sunlight, especially in countries with tropical climates, makes solar panel technology a promising solution. The installation of solar panels can be done easily on the roofs of houses or on unused vacant land (Quispe et al., 2022). This technology allows residents in remote areas to generate their own electrical energy without relying on the national grid. In addition, low operational and maintenance costs make solar energy an economical long-term alternative, especially for rural communities that are often limited in terms of financial resources (Karamov et al., 2022).

Alongside solar energy, biomass energy also offers great potential for rural areas. Biomass, which includes materials such as agricultural waste, firewood, and livestock manure, is abundantly available in many rural areas. Through proper conversion processes, such as anaerobic digestion or combustion, biomass can be converted into energy that can be used for cooking, heating, or even produced into electricity (Yawale et al., 2023). The use of biomass energy not only reduces

dependence on fossil fuels but also provides extra benefits in managing agricultural and organic waste, which in turn reduces environmental problems such as pollution and littering. This technology promises to provide sustainable and environmentally friendly energy solutions for rural populations, while supporting local economic activities such as agriculture and livestock (Montalvo-Navarrete & Lasso-Palacios, 2024).

In addition to solar and biomass, wind energy is another renewable source that has significant potential to be developed in rural areas, especially in regions that experience consistent, high-velocity winds. Small-scale wind turbines can be a very effective solution, as the technology has evolved to the point where smaller, more efficient and easier to install models are available (Lode et al., 2023). Wind turbines can be installed individually or in cooperative schemes for communities, to generate energy that can be directly utilized or stored in batteries for use when the wind is not blowing. Although the initial investment is substantial and requires regular maintenance, its long-term potential to reduce energy costs makes wind energy attractive in rural areas (Alzahrani, 2023).

Micro-hydro energy also presents a good opportunity for rural areas that are close to a source of running water, such as a small river or stream. Micro-hydro power plants can be built to capture energy from flowing water without the need for large dams or significant environmental changes. This makes it ideal for remote areas, as it can provide stable and continuous electricity, as long as a water source is available. Microhydro is not only sustainable, but also environmentally friendly and relatively easy in terms of operation and maintenance (Krupin & Podolets, 2023).

All of these forms of renewable energy, when properly integrated, can play an important role in promoting energy autonomy and rural poverty reduction, as well as helping to meet the basic needs of rural communities. A community-centered approach, accompanied by the cooperation of public, private, and non-profit organizations, is key in the implementation of renewable energy infrastructure (Bogason & Slätmo, 2023). By providing reliable and sustainable energy sources, remote areas can achieve inclusive economic growth and social development, while contributing to global efforts against climate change.

Application of this renewable energy in community service activities

The use of renewable energy in community service activities, especially in rural areas, can take the form of various activities that educate and empower local

communities. For example, solar panel installation projects in village schools or community health centers not only provide a sustainable and reliable source of electricity but also become a platform to teach children and community members about the importance of renewable energy (Sun et al., 2021). Workshops and trainings on how solar panels work, how to maintain them, and their benefits to the environment and household economy could be part of these service activities. Thus, this approach not only fulfills the basic need for energy but also increases community awareness and knowledge so as to foster independence and the ability to manage their own energy sources (Ramadhan & Farizal, 2021).

In addition, the application of biomass systems in the form of managing organic waste into energy for cooking or heating could be a service activity that has a large social and environmental impact. Such a program could involve training communities in collecting and managing organic waste, as well as building and operating biomass processing units (Savla et al., 2021). The beneficiaries not only learn about waste-to-energy technologies but also about waste management, which contributes to environmental hygiene and health. Such activities support sustainable development by integrating renewable energy solutions in everyday life, helping rural communities build a greener and more sustainable future (Rodríguez-Segura & Frolova, 2023).

Continuing the utilization of renewable energy in community service activities, the application of wind energy and micro hydro is also worth considering. The development of small wind energy projects is especially effective in regions where wind is consistent (Klonowska-Matynia, 2022). Service programs can include the erection of wind turbines that not only meet local energy needs but also educate communities about aerodynamics, environmental sustainability, and renewable energy technologies. As for micro-hydro energy, service activities can include building infrastructure that recovers investment through reduced energy costs and improved access to clean water, while providing training on water resource maintenance and management (Malange et al., 2021).

Thus, the integration of renewable energy technologies in community service activities in rural areas not only solves the problem of dependence on unsustainable fossil energy, but also supports responsible development efforts. It increases environmental awareness, reduces energy costs, and supports economic independence, while helping global targets in reducing carbon emissions and fighting climate change. This proves that renewable energy is not only important for environmental sustainability but also a catalyst in shaping local leadership and

improving people's quality of life. Therefore, the integration and community-based approach in renewable energy implementation is crucial in achieving mutually supportive social, economic and environmental success in the future.

Conclusion

The use of renewable energy in rural areas has significant potential to improve people's quality of life and support sustainable development. It was found that the application of technologies such as solar panels, biomass, small wind turbines, and micro hydro not only fulfill basic energy needs but also contribute to increased environmental awareness, community education, and economic independence. In addition, renewable energy-based service activities proved effective in reducing energy costs for households and communal infrastructure and in reducing dependence on fossil fuels, which cause adverse environmental impacts.

The importance of local community integration in every stage of renewable energy projects was also a key finding, emphasizing the need for a participatory approach involving education and training. Empowering rural communities through knowledge and skills in managing renewable energy sources promotes long-term sustainability and more inclusive development. In this sense, the community service project acts as a catalyst in the transition to clean energy, encourages communal cooperation, and provides a model for other rural areas to follow suit in addressing the energy and environmental challenges they face.

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