International Journal of Progressive Sciences and Technologies (IJPSAT)
ISSN: 2509-0119.

Vol. 45 No. 2 July 2024, pp. 768-775

The Potential of Waste Power Plants (PLTSa) to Supporting Economic Growth and Enhance Sustainable Energy Security

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Abstract— This study examines the renewable energy potential of waste-to-energy plants and its relationship with economic growth. Renewable energy is gaining increasing attention in various countries as a solution to energy and environmental problems. One of the growing solutions is using waste as an energy source, so this study aims to analyze the economic impact of waste-to-energy plant development. How can the development of waste power plants (PLTSa) contribute to economic growth and national energy security? This research is a renewal of previous research that focused on the economic aspects of PLTSa, which are still under-researched compared to the technological aspects. To gain a better understanding of the dynamics involved in the development of PLTSa, this research utilized qualitative methods. Literature analysis, case studies, and semi-structured interviews were conducted with key stakeholders in the study, including the government, waste management companies, and communities. To find patterns and relationships between the development of PLTSa and economic growth, the data collected was thematically analyzed. The research shows that the creation of a Waste Power Plant (PLTSa) can create new jobs, reduce waste management costs, and increase revenue from the sale of electrical energy. The results also show that in the long run, investment in waste-to-energy plants can generate a positive return on investment. Waste-to-energy plants have great potential to address environmental concerns and drive economic growth. With the right strategy, it can become an important part of the renewable energy portfolio and support sustainable development. To maximize the economic benefits, policies such as tax incentives and subsidies are needed

Keywords: Waste Power Plant (PLTSa), Economic Growth Renewable Energy, Waste Management, Energy Security.

I. INTRODUCTION

Waste Power Plants (PLTSa) convert waste into usable renewable energy, providing a solution for waste management and energy production. These plants contribute to economic growth by creating jobs, generating energy security, and reducing waste management costs. Impacts on local and national economies Waste power plants play an important role in achieving energy conservation and emission reduction targets, supporting local economies by creating jobs and reducing energy costs (Levaggi et al., 2020). Waste power plants generate significant economic benefits by creating jobs in construction, operations, and maintenance. They also reduce waste management costs, thereby contributing to overall economic growth (Paulraj et al., 2019). The economic benefits and environmental impacts of waste power plants generate significant energy, reduce the need for fossil fuels, and lower greenhouse gas emissions. For example, in Germany, Sweden, the United Kingdom, and the United States, waste power plants have proven to be competitive with fossil fuel power plants in terms of energy production and waste management (Miranda & Hale, 1997).

Considering limited fossil energy resources, the development of waste power plants (PLTSa) is emerging as an innovative solution with great potential to support economic growth and national energy security. It offers an effective way to manage municipal waste while generating renewable energy, which in turn can reduce dependence on fossil fuels and lower greenhouse gas emissions. However, while the potential economic and environmental benefits of PLTSa are clear, its implementation still faces various barriers, including issues of high initial investment costs, technological limitations, and social resistance to the construction of these facilities. Therefore, it is important to understand how the development of PLTSa can concretely contribute to economic growth through job creation and reduced waste management costs, as well as how this technology can strengthen national energy security by providing a sustainable and reliable source of energy. This research aims to analyze the potential of PLTSa in supporting economic growth and explore the role of PLTSa in enhancing sustainable energy security so that sustainable development goals can be achieved.

In the European Union, waste-to-energy plants are highlighted for their role in sustainable waste management and energy production, integrating circular economy principles with economic and environmental benefits (Malinauskaite et al., 2017). Waste power generation supports the circular economy by recovering energy from waste and reducing landfill use. This contributes to resource efficiency and sustainable development (Okere et al., 2019). In Italy, biogas production from vegetable waste in a circular economy model showed economic feasibility and potential for sustainable energy production (Bentivoglio et al., 2022). The economic feasibility of waste power generation in Brazil, taking into account the national policy on solid waste, shows the potential for significant investment and development of renewable energy from municipal solid waste (Maier & Oliveira, 2014). In Norway, a life cycle assessment showed that WtE systems have better environmental performance compared to fossil energy systems, despite some trade-offs (Lausselet et al., 2016). The proposed agricultural WtE plant in Nigeria showed high energy and exergy efficiency, with a break-even point of 7.5 years and low per-unit energy costs (Ogorure et al., 2018).

Furthermore, regarding costs and profitability in China, waste-to-energy technologies are promoted for efficient waste disposal and energy production, demonstrating positive economic returns through investment in waste-to-energy projects (Zhao et al., 2016). An economic analysis of a WtE project in Pakistan showed an annual rate of return of 15.4%, emphasizing the economic viability of using waste for energy (Rasheed et al., 2019). In Thailand, WtE projects help reduce greenhouse gas emissions, conserve fossil resources, and show a substantial increase in financial returns through proper management practices (Menikpura et al., 2016). Waste power generation contributes to climate change mitigation by reducing greenhouse gas emissions. For example, in Japan, combining anaerobic digestion facilities with incineration can increase electricity production by 60% and reduce greenhouse gas emissions by 27% compared to traditional methods (Yano & Sakai, 2016).

Efficiency improvements to advances in landfill technologies, such as combined anaerobic digestion and gasification, have improved energy recovery and economic sustainability (Lausselet et al., 2016). Energos gasification technology, operating in several European countries, provides small communities with an economically efficient alternative to mass incineration, demonstrating low emissions and feedstock flexibility (Ellyin & Themelis, 2011). Improved energy efficiency measures at waste power plants in Europe have shown increased energy output, contributing to better economic performance and reduced emissions (Baxter, 2007).

II. Research Methodology

This study uses a qualitative method that explains the two variables involved in renewable energy and energy security and looks for reasons for the need to incorporate the concept of renewable energy into economic growth, with qualitative data collection techniques and literature sources. This is related to the realization of the government's energy utilization and supply target in 2023, which has not met the target. PP KEN sets the target of energy utilization and supply based on the assumption of economic growth of 7-8% per year. The low realization of economic growth from 2015-2020, which is only around 5%, is the cause of not achieving the target of energy utilization and supply, and the Government of Indonesia has committed to achieving Net Zero Emission by 2060. In PP KEN, the utilization of New Renewable Energy is targeted at 23% in 2025 and 31% in 2050, while the utilization of New Renewable Energy (EBT) in the KEN Update is higher than these targets.

Supporting Theory:

a. Energy Economic includes the study of energy production, consumption, and its impact on the economic system. Energy flows were first conceptualized in economics by Slavcho Zagorov, who emphasised that national income was an “energy movement” that was measured in terms of fundamental energy sources.

b. Economic Growth can be interpreted as an increase in the production capacity of a country that leads to an increase in the output of goods and services. It reflects improvements in production efficiency and more optimal use of resources. Sustainable and significant economic growth is essential to improve people's welfare, create jobs, and encourage more equitable and inclusive development

c. Energy Security is an important aspect, includes the availability, accessibility, affordability, and acceptability of energy supplies. This concept has evolved over time, reflecting changes in global energy markets, geopolitical dynamics, and environmental concerns.

III. Result and Discussion

3.1 Economic potential of waste-to-energy plant development

The development of waste power plants presents significant economic potential globally. Waste power plants can reduce carbon emissions, generate electricity, and contribute to waste management while providing economic benefits. Studies show that integrating solar collectors, utilizing landfill gas, and converting organic waste into energy can improve energy efficiency, reduce environmental impact, and financial returns. The economic analysis revealed that waste power plants can achieve a quick return on investment, with some projects breaking even within a few years and offering large net present values. These findings emphasize the economic viability and potential of waste power plants to contribute to sustainable development and energy diversification (Weiping, Huang et al (2023),. Mohammad, Soleh et al., (2020)., Tetiana, Kurbatova et al (2022)., M, Saleh., et al (2021)., Emmanuel, Ugochukwu, Unaegbu et al (2019)). Waste power plants play an important role in sustainable development by addressing environmental and energy challenges. Municipal waste incineration power plants have optimized their systems for energy-efficient design (Meng, Lv 2022), while contributing to freshwater conservation through innovative approaches such as reusing waste water from the power generation process (Muhammad, Umar, Mushtaq., et al., 2023). In addition, waste-to-energy (WTE) power plants using incineration systems can significantly reduce the volume of waste and generate large amounts of electricity, thereby aiding waste management efficiency and renewable energy production (Rizal, Bagja, Wiguna et al., 2021). In addition, integrating heat pumps with traditional power plants, such as Combined Cycle Gas Turbine (CCGT) plants, enables the recovery of low-energy waste heat, improves plant viability, reduces emissions, and provides economic savings in the long term (T., Grisolia., 2022). These initiatives collectively demonstrate how waste power plants can positively impact sustainable development by promoting energy efficiency, resource conservation, and renewable energy generation.

A life cycle assessment model to assess the environmental impacts of waste recycling, composting, incineration, and landfilling with gas recovery (LFG) in 34 capital cities in Indonesia in 2025. Scenarios A (12.5% recycling + 12.5% composting + 37.5% incineration + 37.5% LFG), B (15% recycling + 10% composting + 50% incineration + 25% LFG), C (10% recycling + 15% composting + 25% incineration + 50% LFG), D (20% recycling + 5% composting + 75% incineration), and E (20% recycling + 5% composting + 75% LFG) were developed to measure the future environmental impact and energy generation potential of waste-to-energy (WtE). According to United Nations Environment Programmethe 2016 energy economy plays a critical role in achieving the sustainable development goals (SDGs) by facilitating the transition towards renewable and environmentally friendly energy sources. This is important not only from an environmental perspective but also to ensure economic stability and social well-being.

Investment in sustainable energy is critical to reducing dependence on fossil fuels and mitigating the impacts of climate change. Reducing fossil fuel use through investment in renewable energy sources such as solar, wind and biomass can significantly reduce greenhouse gas emissions and help in meeting global climate targets (Lestari & Trihadiningrum 2019). The use of smart grids and advanced energy technologies (EnergyTech) can optimize energy production and distribution. Smart grids enable better integration of various renewable energy sources into the power grid, thereby improving the efficiency and stability of the energy system. EnergyTech also supports real-time management of energy demand, which in turn promotes sustainable development in a more efficient and cost-effective way (Liu, Dong & Cao 2021). The impact of energy economic factors on sustainable development shows a strong correlation between economic policies and environmental outcomes. Economic policies that support investments in clean energy technologies and energy efficiency can improve overall environmental performance and contribute to the achievement of sustainable development goals (Vinti, Bauza, & Clasen 2021). According to Ministry of National Planning and Development Indonesia forecasting the balance between energy production and consumption is an important step in sustainable energy planning. By predicting future energy needs and adjusting energy production accordingly, countries can ensure a stable energy supply and reduce energy waste. The implementation of comprehensive energy efficiency strategies can also help in achieving a more sustainable economy and meeting sustainable development goals related to clean energy, climate action, and responsible production and consumption. Also, WtE has the potential to be part of a circular economy, where waste is not only processed into energy, but also produces useful by-products, such as building materials from ash (MacArthur, E. 2013).

3.2 The impact of waste-to-energy plants on sustainable energy security

The increasing number of population and economic activities as well as the increasing difficulty of obtaining land for landfills (TPA) is a real problem faced that raises ideas for other utilization, namely the Waste Power Plant (PLTSa). Waste Power Plant (PLTSa) is one of the proposed solutions to overcome the problem of waste accumulation and at the same time produce clean and renewable energy. This study aims to analyze the impact of PLTSa on sustainable energy security in Indonesia. Waste piles cause many problems and risks of environmental pollution, and waste is one of the contributors to greenhouse gas (GHG) and carbon dioxide (CO_2) emissions generated from waste piled up in landfills. Bad odors and the threat of pollution and environmental health are the main problems for the surrounding communities who live around the garbage piles.

Waste-to-Energy (WtE) plants play an important role in energy sustainability by converting waste into electricity, heat, or transportation fuel. This helps reduce dependence on fossil fuels and reduces the volume of waste sent to landfills. Traditional WtE processes such as incineration can indeed cause high emissions of air pollutants. However, alternative approaches that are more environmentally friendly have been developed. One method is to convert syngas, the product of waste gasification, into fuel or other commercial products. This offers a more sustainable solution, especially in areas that have air quality issues. The implementation of WtE systems is particularly relevant in developing countries that face challenges in achieving sustainable development goals related to energy access, environmental impact reduction, and promotion of a circular economy. WtE plants can integrate waste management with power generation, provide additional economic value, and reduce the growing waste problem. WtE plants have the potential to deliver economic value through job creation and new business opportunities in waste management and renewable energy. By converting waste into useful resources, WtE plants support the production of renewable energy in an environmentally friendly way and contribute to the circular economy.

Waste-to-Energy (WtE) plants play an important role in supporting the Sustainable Development Goals (SDGs) by addressing environmental and energy sustainability challenges. WtE plants, particularly incinerators, offer technical excellence, economic viability, and environmental benefits by reducing waste volumes, emissions, and public health risks (Yuliana et al 2021), (Alao et al 2022). In contrast, traditional thermal power plants pose significant environmental hazards, including heavy metal pollution, increased radioactivity, and ecosystem disruption (Butenova et al 2022). The application of WtE technologies not only helps in achieving SDG 7 (Affordable and Clean Energy) and SDG 11 (Sustainable Cities and Communities) but also contributes to sustainable waste management and renewable energy generation, aligning with the principles of the circular economy. However, it is important to address challenges such as logistics, education, and finance to fully utilize the potential of WtE plants for sustainable development and energy sustainability. In addition, strict emission standards ensure that WtE plants minimize toxic emissions, promoting environmental protection and human health (Paul & Breeze 2018). The transition to sustainable energy sources, such as Waste-to-Energy Plants (WTe Plants), plays an important role in supporting the Sustainable Development Goals (SDGs) by addressing various aspects of sustainability. While dams are considered a relatively cheap source of electricity, the ecological damage they cause makes them unsustainable (Dave & Flynn 2012), (Frank & Zarb 2012). On the other hand, WtE plants have shown potential in Indonesia by converting waste into electrical energy, supporting the SDGs related to clean and affordable energy, economic growth, responsible consumption and production, and climate change mitigation.

The Sustainable Development Goals Impact Assessment Framework for Energy Projects (SDGS-IAE) can help identify synergies and trade-offs in energy projects, guiding stakeholders towards social, environmental, and economic sustainability (Jennifer et al 2020). By embracing low-carbon initiatives and innovative technologies, the shift towards sustainable energy sources such as WtE Plants can contribute significantly to achieving global sustainability goals. WtE generally has lower energy conversion efficiencies compared to other renewable energy technologies such as solar or wind power (Pires, A et al., 2011).

WtE plays an important role in contributing to sustainable energy security by converting waste into heat and energy, thereby reducing dependence on conventional fossil fuels and promoting a circular economy (Jaroslav, Pluskal et al (2022)., Sachindri, Rana., et al (2020)., Asam, Ahmed., et al (2022)). These plants utilize various technologies such as gasification, incineration, pyrolysis, and anaerobic digestion to convert municipal solid waste (MSW) into valuable energy sources, thereby reducing the environmental impact of waste generation (Sachindri, Rana., et al (2020)., M.A., Alao et al (2022)). By recovering energy from waste, WtE not only aids waste management but also provides alternative renewable energy, addressing the challenge of access to affordable and reliable energy in developing countries (M.A., Alao et al (2022). In addition, a strategic planning model for WtE capacity expansion shows the economic benefits and environmental advantages of increasing energy recovery capacity to meet regulatory directives and achieve sustainable development goals.

IV. Conclusion

This research shows that the development of Waste Power Plants (PLTSa) has great potential to support economic growth and strengthen sustainable energy security. The study results show that waste-to-energy plants can create new jobs, reduce waste management costs, and increase revenue from the sale of electrical energy. In addition, investment in PLTSa has been shown to provide positive returns in the long term. With the right strategy, solar power plants can become an important part of the renewable energy portfolio and support sustainable development. In order to maximize the economic benefits from the development of waste-to-energy plants, supportive policies such as tax incentives and subsidies are required. Government support is essential to overcome the constraints of high initial investment costs and social resistance to the construction of these facilities. In addition, there needs to be improvements in waste management and energy generation technologies to ensure higher efficiency and lower environmental impact. Future research is recommended to focus on a more in-depth cost benefit analysis related to the implementation of PLTSa in various regions, especially in developing countries that have different challenges in terms of waste management and energy production. In addition, a comparative study on the effectiveness of various PLTSa technologies in reducing greenhouse gas emissions and improving energy efficiency should be conducted. Finally, it is important to explore the social aspects of the implementation of PLTSa, including public perception and socio-economic impacts on local communities.

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