

Feasibility Study of Renewable Energy Implementation in Urban Industrial Areas

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Abstract

The growth of industrial areas in urban areas has consequences for increasing energy consumption and carbon emissions, which have an impact on environmental sustainability. Renewable energy such as solar power and biomass are considered as potential solutions to reduce dependence on fossil fuels in the industrial sector. This study aims to assess the feasibility of renewable energy implementation in urban industrial areas through analysis of technical, economic, and policy aspects. The approach used is qualitative-descriptive based on literature and documentation studies, with the object of study in three industrial areas in urban Indonesia: Pulogadung, Jababeka, and Rungkut. The results show that the potential for solar energy utilization is very high, especially through rooftop solar systems, with an estimated payback period of 4.5 to 6 years. In addition, biomass potential from organic industrial waste is also available but still limited to certain sectors. Infrastructure readiness is considered adequate, although technical integration and limited human resources are still a challenge. In terms of regulations, although there are supporting national policies, their implementation at the regional level still requires technical and institutional strengthening. Overall, the implementation of renewable energy in urban industrial areas is considered feasible and strategic, but requires a phased approach, incentive support, and synergy between the government, industry players, and clean energy providers.

Keywords: renewable energy, industrial estate, feasibility

Introduction

The development of industrial estates in urban areas shows a rapid upward trend in line with national economic growth and urbanization flows. Industrial estates are the driving force of the economy because they provide employment, support the production of goods, and encourage export activities (Ali & Johl, 2023). However, despite its contribution to development, the industrial estate is also a major contributor to energy consumption and greenhouse gas emissions (Raksakulkarn et al., 2023). High dependence on fossil-based energy, such as coal and fuel oil, exacerbates the already congested and pollution-prone urban environment. Therefore, the issue of sustainability in energy supply and consumption in urban industrial areas is increasingly urgent to be addressed comprehensively and systematically.

One strategic approach that is increasingly being studied and implemented in various countries is the utilization of renewable energy (Wang et al., 2022). Solar, wind, biomass and geothermal energy are considered as potential solutions to replace or at least reduce dependence on fossil fuels (Al-Ghaili et al., 2022). Apart from being environmentally friendly, renewable energy sources are also more sustainable in the long run as they will not be used up like conventional energy sources. At the global level, many industrial estates have adopted this clean energy technology as part of their energy efficiency strategy and corporate social environmental responsibility. However, in Indonesia, especially in industrial estates located in urban areas, the implementation of renewable energy is still relatively limited and sporadic

(Yudiartono et al., 2023). This indicates structural and technical barriers that need to be identified and addressed through a scientific approach.

Urban industrial estates have different characteristics from industrial estates in non-urban areas. The main challenge lies in the limited physical space, building density, and complexity of infrastructure systems that are already integrated with the city area (Gallotti et al., 2021). In addition, there are also challenges in terms of spatial policies, environmental regulations, and very high and continuous energy demand (Poggi & Amado, 2024). In this context, the implementation of renewable energy systems needs to go through a careful planning process, including the selection of the right type of technology, analysis of supply capacity and energy needs, and integration with the existing electricity grid. All these aspects need to be analyzed in depth so that the implementation of renewable energy is not only technically feasible, but also economically efficient and acceptable to all stakeholders.

Feasibility studies are an important instrument in bridging the idealism of clean energy implementation with the reality on the ground (Jewell & Cherp, 2023). Through the feasibility study, potential renewable energy sources available in the industrial area, barriers to implementation, investment needs, and projected long-term benefits can be identified (Kim, 2021). The study can also illustrate best practice scenarios by considering local conditions, such as solar radiation levels for solar panels, wind potential, or access to industrial biomass. With this approach, policy makers and industry players can get a complete and objective picture before making strategic decisions. Moreover, the results of the study can also serve as the basis for submitting proposals for funding support or incentives to financial institutions and the government.

In addition to the environmental benefits, the implementation of renewable energy also has a positive economic impact (Dirma et al., 2024). Utilizing local energy sources can reduce fuel import costs, reduce dependence on fluctuating world oil prices, and open up new opportunities in the green jobs sector. Industries that adopt environmentally friendly principles tend to be more competitive in the global market, especially amidst increasing demands for sustainable products and production processes (Bhattacharjee et al., 2025). In the long run, this transformation can strengthen the position of Indonesia's industrial estates as production centers that are not only efficient, but also socially and ecologically responsible. Therefore, investment in renewable energy is not only a technical necessity, but also a visionary business strategy.

Based on this background, it is important to conduct a feasibility study on the implementation of renewable energy in urban industrial areas to holistically assess its potential, challenges and impacts. This study is expected to contribute to formulating a sustainable and low-carbon industrial estate development strategy. In addition, the results of this study can also serve as a reference for policy makers, industrial estate managers, and the private sector in designing concrete steps towards a green energy transition. Thus, this study is not only relevant from an academic perspective, but also has practical urgency in addressing future energy and environmental challenges.

Method

This research uses a qualitative-descriptive approach with literature study and documentation analysis methods as the basis for assessing the feasibility of renewable energy

implementation in urban industrial areas. Data was obtained through searching secondary sources such as scientific journals, government agency reports, energy policy documents, and relevant case studies both from within and outside the country. In addition, SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis was used to evaluate internal and external factors that affect the implementation of renewable energy in industrial estates. The selection of study sites focused on industrial estates located in urban areas with consideration of infrastructure maturity, high energy demand, and potential available renewable energy resources. To enrich the analysis, a review of national and regional policies related to renewable energy, investment incentives, and technical regulation readiness was also conducted. The results of this method are expected to provide a comprehensive overview of the technical, economic, and policy feasibility of implementing renewable energy systems in urban industrial environments.

Results and Discussion

The research produced significant findings in four main dimensions: (1) potential renewable energy sources, (2) technical aspects and infrastructure readiness, (3) economic feasibility and cost efficiency, and (4) applicable regulatory and policy support. The study was conducted through document analysis, literature study, as well as policy mapping and secondary data from three industrial estates located in urban areas, namely Pulogadung Industrial Estate (Jakarta), Jababeka (Bekasi), and Rungkut (Surabaya).

1. Potential Renewable Energy Sources

From the results of BMKG and Ministry of Energy and Mineral Resources data searches, the three industrial areas studied have high solar energy potential, with an average solar radiation intensity of 4.6 to 5.1 kWh/m²/day. This potential allows the implementation of rooftop solar power systems in various industrial facilities, such as warehouses, production buildings and parking areas. In addition, biomass potential is also found, especially in the Rungkut Industrial Estate which has a concentration of food and beverage processing industries. Organic waste from the production process can be utilized to produce biogas through anaerobic reactors. Although the potential of wind and geothermal power is not significant in urban areas, the combination of solar power and biomass is considered realistic to be maximized according to the characteristics of each area.

2. Technical Aspects and Infrastructure Readiness

From a technical point of view, most of the industrial buildings in the three regions have solid and spacious roof structures, which are suitable for solar panel installation. Modeling simulations of PLTS design show that with a minimum roof area of 1,000 m², a factory can generate up to 100 kWp of power, which can reduce PLN electricity consumption by 15-30% depending on production patterns. However, the integration of PLTS with the existing power grid still faces technical challenges, especially in the aspects of power synchronization, dependence on the PLN grid, and the unavailability of an economical energy storage system (battery). In addition, for biomass utilization, standardized waste treatment infrastructure and organic waste separation systems are still not optimal in most factories. The lack of technical human resources who understand renewable energy management is also one of the obstacles in the initial implementation stage.

3. Economic Feasibility and Cost Efficiency

The economic feasibility analysis was conducted by simulating the investment cost and payback period. Simulation results on a 100 kWp scale solar PV scheme show that the total investment cost ranges from Rp950 million to Rp1.2 billion, depending on the quality of the panels and monitoring system. Assuming a constant production load, electricity bill savings are estimated at Rp20 million to Rp30 million per month. This results in a payback period of between 4.5 to 6 years. For biogas systems, the initial investment value is lower (around Rp300 million - Rp500 million) but is only relevant to certain types of industries that produce large and consistent amounts of organic waste. In addition, the government has provided a number of incentives such as tax deductions, import duty exemptions, and clean energy financing programs from green financial institutions. However, many industry players admit that they do not understand the technical and administrative mechanisms for applying for incentives.

4. Regulations, Policies, and Institutional Support

In terms of policy, Presidential Regulation No. 112 of 2022 is the main legal basis that supports the acceleration of renewable energy development. However, in practice, the implementation of this policy in urban industrial areas still faces obstacles of coordination between agencies and the unavailability of implementing technical regulations at the regional level. An examination of the Regional Energy General Plans (RUED) in three provinces shows that most policies are still macro in nature and have not specifically targeted the industrial sector. Industry players also stated that there is no integrated system for technical consultation, licensing, and feasibility evaluation of renewable energy projects. On the other hand, there are initiatives from the private sector, such as independent power producers (IPPs), which have begun to offer Power Purchase Agreement (PPA) systems with rental schemes, which are considered more flexible and attractive to industry players who want to avoid large upfront investments.

5. Analisis SWOT

To provide a strategic overview, a SWOT analysis of renewable energy implementation in urban industrial areas was conducted. Strengths include high technical potential (especially solar power), increasing industrial awareness of energy efficiency, and government incentives becoming available. Weaknesses include lack of energy storage infrastructure, lack of technical human resources, and high start-up costs. Opportunities include the development of clean energy technologies, global market pressure for environmentally friendly products, and collaboration opportunities with private investors. Threats include policy uncertainty, price fluctuations of imported components, and managerial resistance in small and medium industries.

6. General Discussion

Based on the results of the study, it can be concluded that the implementation of renewable energy in urban industrial areas has a fairly high level of feasibility, especially if the approach used is gradual, based on local potential, and accompanied by concrete policy support. Rooftop solar PV is considered the most practical option to be implemented in the near future, while biomass-based systems can be integrated selectively in certain types of industries. Successful implementation is largely determined by infrastructure readiness, energy literacy among industry managers, and administrative support from local governments. Synergy between industry players, financial institutions, and regulatory agencies is needed to

create an effective and sustainable renewable energy ecosystem in urban industrial environments. This study is expected to be the basis for developing a more specific and applicable clean energy development strategy for the industrial sector in the future.

Conclusion

Based on the results of the study, it can be concluded that the implementation of renewable energy in urban industrial areas in Indonesia has a high level of feasibility in terms of resource potential, infrastructure readiness, economic feasibility, and policy opportunities. Solar energy proves to be the most promising option to be implemented in the form of rooftop solar PV systems as it is supported by high solar radiation intensity and industrial building structures that allow the installation of such systems. In addition, biomass potential is also selectively available, especially in industrial estates engaged in the food processing and agriculture sectors. Technically, most industrial estates have building infrastructure and power grids that allow the integration of renewable energy, although support for energy storage systems and increased technical competence are still needed. From an economic perspective, the initial investment is relatively high, but analysis shows that long-term energy cost efficiency and competitive payback periods make the project financially viable, especially if supported by incentive schemes and partnerships with third parties such as IPPs. The study also found that national regulations have shown a positive direction, but their implementation at the regional level still requires strengthening in the form of derivative policies that are more technical and applicable. Thus, the implementation of renewable energy in urban industrial areas is a strategic step that not only supports the national energy transition, but also strengthens industrial competitiveness through cost efficiency, compliance with environmental standards, and improved corporate image. An integrated approach between the government, private sector, and financial institutions is needed to encourage wider and more sustainable adoption of clean energy technologies. This study is expected to serve as a basis for consideration in the formulation of renewable energy development policies that are more adaptive to the needs and characteristics of urban industrial areas in Indonesia.

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