Barriers to the Implementation of Renewable Energy Policies in Indonesia: A Case Study of Solar Energy in Improving Energy Security

Yusril Yudi Safaat[1*], Palupi Lindiasari Samputra[2]
[1,2]Graduate School of Sustainable Development, Universitas Indonesia

Corresponding Author's e-mail : *yusrilyudisafaat@gmail.com*

ARMADA
JURNAL PENELITIAN MULTIDISIPLIN

e-ISSN: 2964-2981

ARMADA : Jurnal Penelitian Multidisiplin

https://ejournal.45mataram.ac.id/index.php/armada

Vol. 04, No. 05 Mei, 2026

Page: 455-463

DOI:

https://doi.org/10.55681/armada.v4i5.2038

Article History:

Received: Mei 02, 2026

Revised: Mei 14, 2026

Accepted: Mei 20, 2026

Abstract : *The transition to renewable energy has become an urgent necessity to address the climate crisis and strengthen national energy security. Solar energy, as the most abundant renewable energy source in Indonesia, possesses significant potential to support energy security and the clean energy mix. However, its utilization remains very limited compared to its overall potential. This study aims to identify the barriers to renewable energy policy implementation in Indonesia, with a particular focus on solar energy development as part of efforts to enhance national energy security. A systematic review was conducted on 25 scientific publications screened from the databases ScienceDirect, Scopus, and SpringerLink. The findings indicate that the barriers to solar energy development include unfavorable regulations for investors, lack of financial and non-financial institutional support, low energy literacy among end-users, and high upfront costs. Furthermore, the study reveals that these barriers are geographically uneven. In Java, the predominant challenges are related to regulatory and technical aspects, while in regions such as Kalimantan, Nusa Tenggara, and Papua, the dominant issues involve institutional coordination, limited technical services, and unequal access to information. These findings underscore that solar energy policies have not yet been designed or implemented in a manner responsive to local contexts, thereby constraining their potential contribution to strengthening national energy security.*

Keywords *: Solar Energy, Renewable Energy, Energy Security, Energy Policy*

INTRODUCTION

In recent decades, the transition to renewable energy has become an urgent global agenda in response to the climate crisis and dependence on fossil fuels. Based on existing studies, switching to renewable energy sources significantly reduces risks to energy security. This is because renewable resources are less vulnerable to supply disruptions than fossil fuels, (Aslam et al., 2024; Bashir et al., 2025). This transition can reduce risks associated with global oil market volatility and geopolitical conflicts, (Borovsky, 2021). Therefore, policymakers need to balance the urgent need for energy security with long-term sustainability goals, (Hussain et al., 2023). One of the renewable energies considered to have the largest energy source is solar energy. Solar energy has unlimited resources to meet human needs in a sustainable manner, (Hosseinpour et al., 2023; Shaik et al., 2023). And compared to other renewable energy sources, solar energy is the largest, (Güney, 2022). In addition, this energy offers advantages in terms of sustainability, supply stability, and serves as a promising alternative to fossil-based energy, (Khan et al., 2023; Manoo et al., 2024; Turk et al., 2022).

Indonesia, with its geographical characteristics spread across the tropics, has enormous solar energy reserves. Solar energy accounts for approximately 48.2% of the total national renewable

energy potential, making it one of the main contributors to Indonesia's clean energy mix (IESR, 2019). Despite its enormous potential, the development of solar energy in Indonesia is still not running at full capacity. Currently, Indonesia utilizes only 270 megawatts of solar energy out of a total potential of 3,295 gigawatts (Ministry of Energy and Mineral Resources, 2024). The installed capacity of solar energy in Indonesia continues to increase, but it is still very small compared to the total national energy mix, namely 0.02 percent in 2018, 0.03 percent in 2019, 0.05 percent in 2020 and 2021, then rising to 0.09 percent in 2022, and reaching 0.16 percent in 2023 (Ministry of Energy and Mineral Resources, 2023). These data reflect a significant gap between the realization of solar energy utilization and Indonesia's potential. This gap indicates that efforts to develop renewable energy, particularly solar energy, still face various obstacles. Therefore, this study aims to identify and analyze various factors that hinder the development of solar energy in Indonesia.

METHODS

This study uses a systematic review approach. A systematic review is intended to provide an overview of a particular study (Elsevier, 2024). This study uses secondary data as the type of research data. Secondary data is data that has been collected by other parties previously, (Adler & Clark, 2011). The data used in this study are articles published in journal databases. The flow in this systematic review is carried out through the following stages. The first stage is searching the Science Direct, Scopus, and Springer Nature Link databases with the search keywords "barriers to the implementation of solar energy development policies in Indonesia" or "solar AND energy AND challenges AND Indonesia", or "solar energy policies in Indonesia", or "Indonesia AND solar AND energy" with the article publication time range of 2015-2025. After the articles were collected, the second stage was carried out, which was to identify them based on the year of publication, type of article, relevance of the title, relevance of the abstract, and relevance of the article content. The third stage was to determine the final articles to be reviewed. The fourth stage was to analyze the content of the final articles. The fifth stage was to draw conclusions. The outline of this research is as follows: the first section discusses the background, the second section discusses previous literature, the third section discusses the methods, the fourth section discusses the results and discussion, and the fifth section discusses the conclusions.

To understand in more detail the types of obstacles to the implementation of solar energy in Indonesia, this study conducted a systematic review of 25 scientific articles discussing the challenges in the development of solar energy in Indonesia. The articles analyzed are: Sumarsono et al. (2022); Gunawan et al. (2021); Burke et al. (2019); Ha & Kumar (2021); Pramadya & Kim (2024); Rudolph et al. (2025); Wang et al. (2023); Setyawati (2020); Tarigan (2025); Arifin & Whulanza (2024); Kennedy (2018); Hidayatno et al. (2020); Asnawi et al. (2024); Halimatussadiah et al. (2024); Ordonez et al. (2022); Mulyani et al. (2024); Adiansyah et al. (2025); Irsyad et al. (2019); Triana et al. (2024); Siregar (2022); Hermawan et al. (2023); Yudiartono et al. (2023); Ansori et al. (2023); Langer et al. (2023); Aggarwal et al. (2023).

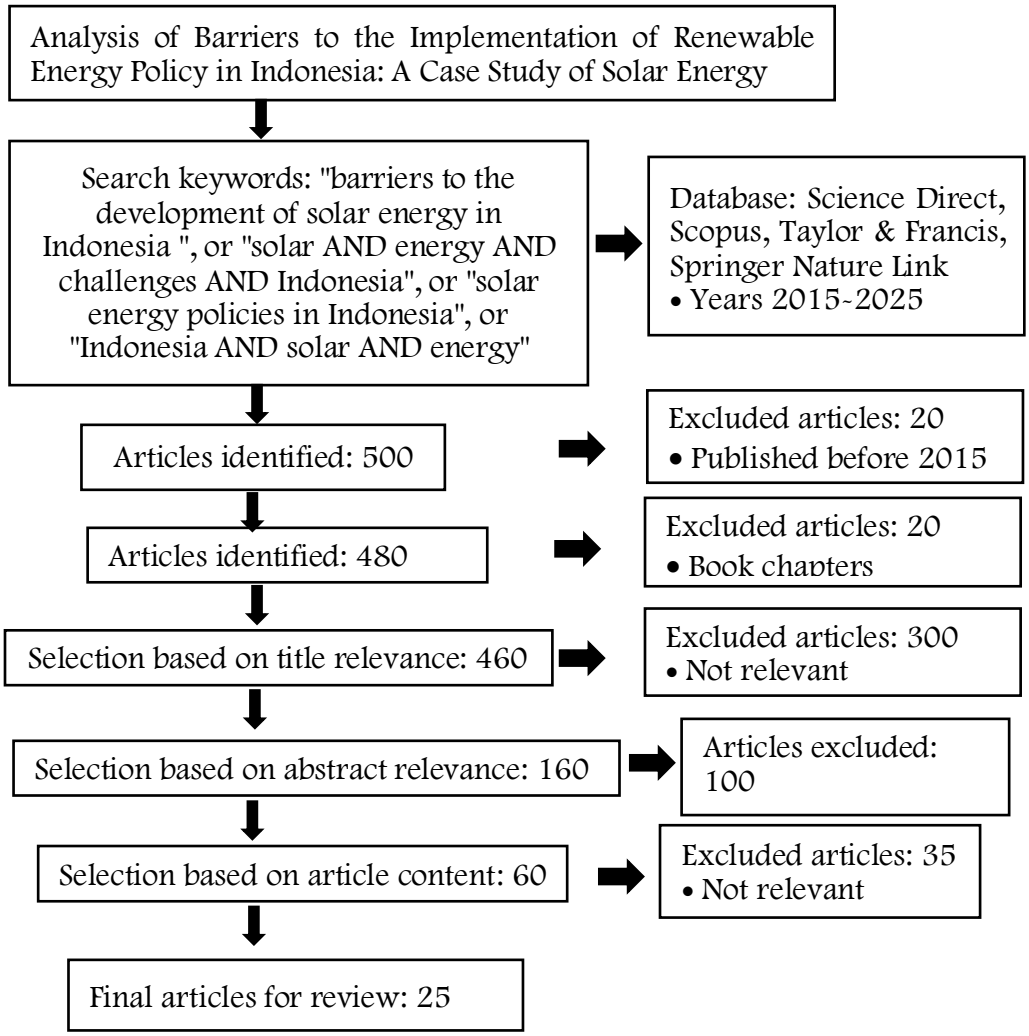

Figure 1. Flowchart of this systematic review
Source: Processed based on Deirmentzoglou et al. (2024)

RESULTS AND DISCUSSION

As one of the main pillars in the global energy transition, the development of renewable energy is not only an effort to mitigate climate change, but also an important part of strengthening national energy security. Solar energy, with its enormous potential in Indonesia, is expected to be a strategic solution in the national energy mix.

Financial and economic barriers

Research by Aggarwal et al. (2023) and Ansori et al. (2023) notes that high initial costs and long investment payback periods are major barriers to the adoption of PV systems at the household level. In Surabaya, the triangular rooftop solar model for 900 VA household customers is still not economically viable without strong fiscal incentives. In Jakarta, Pramadya & Kim (2024) show that household customers are very sensitive to incentive structures, finding that net metering schemes have a much more positive impact than net billing in attracting interest in rooftop PV adoption Hermawan et al. (2023) through national-level simulations, show that even if PV module costs are reduced by 50%, the economic tariff for solar power projects remains at USD 0.149/kWh, a figure considered uncompetitive in the Indonesian electricity market. In the Nusantara Capital Region (IKN), Arifin & Whulanza (2024) found that a number of technical problems, such as damage to PV array modules and disruptions to the control system, have caused the solar power generation system to not function optimally. This condition has also caused investment losses and shows that even though IKN is promoted as a green city of the future, basic technical issues remain a real

challenge in the development of solar energy in the region. The high initial installation costs, coupled with a relatively long investment payback period, make rooftop PV systems unattractive to the majority of the population, especially those in the low-power segment. Without strong and sustainable fiscal incentives, adoption of these systems is likely to remain stagnant, even in urban areas with better access to information and infrastructure.

Households' sensitivity to incentive structures underscores that the success of the program depends on the extent to which financial benefits can be felt directly and in the short term. Complex or non-transparent incentive schemes will only add to uncertainty and slow down adoption. In addition, the decline in the price of PV devices alone has proven insufficient to drive the financial viability of projects, as the energy cost structure in Indonesia is still heavily influenced by fossil fuel subsidies and inflexible tariff policies. On the other hand, technical challenges such as poor installation quality, system damage, and lack of maintenance capabilities are also often overlooked obstacles. System failures during the operational phase are not only economically detrimental, but also undermine public confidence in the reliability of solar energy as an alternative. This highlights the importance of adequate technical support, ranging from installation standards and training for local technicians to reliable monitoring systems.

Regulations and governance failures

A number of studies show that energy policy in Indonesia still faces many fundamental problems. Unfavorable regulations, complicated bureaucratic processes, and the strong dominance of fossil fuels, especially coal, are major obstacles to the development of solar energy. Burke et al. (2019) and Halimatussadiah et al. (2024) highlight that the dominance of coal, supported by the significant role of PLN and private power companies (IPP), systematically limits the space for solar energy to develop within the national electricity system. In Jakarta, Hidayatno et al. (2020) found that although the government has introduced a net metering scheme to encourage the use of solar panels in households, its implementation is still hampered by various technical obstacles and a lack of public awareness. Meanwhile, Ha & Kumar (2021) revealed the failure of a number of renewable energy projects in the regions, which have not yet become operational even though they have already been built. This is because decisions are made entirely by the central government, without involving local governments or communities. Cases like this have been found in Central Sulawesi and East Nusa Tenggara, where solar mini-grid projects have been abandoned because there is no clear handover mechanism between the central and regional governments.

These problems show that the failure of solar energy development in Indonesia is not solely due to technological or funding issues, but is more fundamental: namely, governance and energy policy architecture that is not oriented towards a just and participatory transition. Complex bureaucratic processes slow down program implementation, while the lack of regional and community involvement means that programs do not have strong social roots. This is evident in the failure of mini-grid projects in the regions, which are essentially not only technical failures but also failures in establishing collaborative governance. When local governments and communities are not involved from the outset, the projects tend to lack sustainability because there is no sense of ownership or post-construction management mechanisms.

Social barriers and lack of energy literacy

Gunawan et al. (2021), through an online survey of PLN customers and solar panel owners in West Java and Kalimantan, found that many people still do not fully understand the benefits of solar panels and how they work. Many of them also find it difficult to obtain clear and reliable information. This inequality in access to information is a problem in itself, especially since most respondents know more about solar energy from social media or private parties than from the government. Similar findings were reported by Mulyani et al. (2024), which analyzed conversations on social media. They found that in Jakarta and its surrounding areas, many people still view solar energy negatively. Issues that often arise include the high cost of installation, unclear government incentives, and the assumption that solar energy is only suitable for certain groups, not for the general public. These findings confirm that the issue of solar energy adoption is not only related to technical or economic aspects, but is also closely related to social dimensions and public communication by the government to encourage the use of solar energy. Perception gaps between

regions, as seen from the differences between respondents in Jakarta and other regions, also indicate that communication strategies have not been designed contextually.

Technical and infrastructure constraints

At the ITN Malang Campus, Asnawi et al. (2024) found that the construction of an on-grid solar power plant (PLTS) carried out independently by the campus was not as easy as imagined. Although the intention was good, the project faced obstacles in terms of costs and operations. The limited technical personnel within the campus and the difficulty of accessing financial support from the government were the two main obstacles faced. Meanwhile, in Jakarta, Triana et al. (2024) showed that technically, the potential for solar energy, especially through rooftop panels, is enormous. However, this potential has not been maximized due to numerous management and infrastructure obstacles. One of these is the PLN grid connection system, which is not yet ready or flexible enough to accommodate electricity from solar panels. In island regions such as the Thousand Islands and Southeast Maluku, Adiansyah et al. (2025) found slightly different challenges. In these areas, the development of solar energy is constrained by environmental and logistical issues. For example, there are no facilities for recycling damaged solar panels, and transporting equipment to project sites remains difficult due to the lack of adequate transportation infrastructure. These findings make it clear that the challenges of solar energy development in Indonesia are contextual and multi-layered, depending on geographical characteristics, institutions, and local technical capacity. In educational institutions such as campuses, for example, enthusiasm for initiatives does not always match the availability of resources.

The absence of internal technical personnel and limited access to financing schemes indicate that even actors with strong motivation to contribute to the energy transition still face systemic obstacles that have yet to be overcome. In urban areas such as Jakarta, the obstacles are more related to the readiness of the electricity grid infrastructure and the coordination of electricity system management. The limitations of the grid system to absorb energy from rooftop PV indicate that Indonesia's electricity infrastructure has not been designed to support the massive integration of decentralized energy sources. This serves as a reminder that the success of solar energy requires not only an increase in production capacity or technology adoption, but also structural reforms to the national electricity distribution and transmission systems to make them more adaptive to renewable energy needs.

Social inequality and energy justice issues

The study Rudolph et al. (2025) found that the construction of a floating solar power plant at the Cirata Reservoir, which was initially promoted as a major leap forward in renewable energy development, has actually created new problems in the field. This project has triggered social conflict because it has reduced the access of local communities to their livelihoods, such as fishing and agriculture. The lack of proper consultation with local residents, coupled with the absence of a fair compensation scheme, shows that even clean energy projects can cause inequality if they are not managed inclusively. A similar finding is seen in the study Kennedy (2018) , which highlights large-scale solar power plant projects in eastern Indonesia, such as Maluku and East Nusa Tenggara. These projects, funded by foreign investors, have indeed succeeded in increasing electricity capacity, but the economic benefits are not felt evenly by the local community. Profits tend to flow abroad, while local residents are rarely involved in the planning and implementation processes, leaving them on the sidelines of the ongoing energy transition. This phenomenon underscores that a sustainable energy transition is not only about replacing energy sources, but also about how to manage the accompanying socio-economic transformation. An approach that integrates the principles of social justice, local community empowerment, and governance transparency is key to ensuring that renewable energy projects become a tool for empowerment, rather than a source of social tension. Therefore, it is necessary to formulate a policy framework and engagement mechanisms that ensure that local communities are not only the objects of development, but also active partners and fair beneficiaries in the national energy transition journey.

Incentive schemes and minimal government intervention

According to the study Hidayatno et al. (2020), the net metering scheme has proven to have a more positive impact than net billing in encouraging the use of rooftop solar panels in Jakarta.

This scheme provides clearer incentives for consumers because excess energy generated can directly reduce electricity bills. Unfortunately, this policy has not been widely implemented and its application in other regions is still uneven. In several provinces, such as West Java and Kalimantan, the public does not yet have equal access to this scheme, both in terms of information and supporting regulations. This is in line with the findings of Ordonez et al. (2022), which emphasize that incentives are very important to make the price of solar power systems more competitive compared to energy from coal. Without strong fiscal support, the adoption of solar power systems will be difficult to develop, especially in the household sector. Fiscal incentives can boost the competitiveness of solar energy compared to fossil fuels, particularly coal, which remains dominant in the national energy mix. Without adequate incentives, the initial cost of installing solar PV systems remains a major obstacle, especially for the lower-middle household segment. Therefore, more progressive fiscal policies are needed, such as installation subsidies, tax breaks, or soft financing schemes, which can expand access and accelerate the adoption of this technology more evenly.

The dominance and protectionism of fossil fuels

The results of a study from Burke et al. (2019) show that one of the main obstacles to the development of solar energy in Indonesia is the dominance of fossil fuels, particularly coal, which remains very strong in the national energy system. Coal not only dominates in terms of electricity generation capacity, but is also reinforced by policy structures that do not favor renewable energy. The study identifies that coal-fired power plants receive greater support in terms of regulation and market access. These findings are in line with Halimatussadiah et al. (2024), which highlights that Indonesia's dependence on fossil fuels is not only due to shortterm energy needs but also because of policies that have not actively encouraged the transition to clean energy. Both studies confirm that the dominance of coal not only hinders investment in the solar energy sector, but also creates a situation where fossil fuels remain the top priority in national energy policy. This condition creates structural imbalances that make it difficult for solar energy to develop, even though its technical potential is enormous. The dominance of coal in the national energy system reflects a systemic structural imbalance rooted in long-term policies that have not favored energy transition. Coal's advantageous position is not solely due to economic factors, but rather because of policy support that facilitates access to capital, market certainty, and explicit and implicit fiscal incentives. This creates distortions in the energy market, where renewable energy such as solar must compete under unbalanced conditions from the outset. Dependence on coal is also reinforced by an energy planning structure that still prioritizes short-term supply security, without taking into account the long-term impact on the environment and the sustainability of the energy system. In this context, solar energy is often positioned as a complement or symbol of commitment to clean energy, rather than as a key part of the national energy mix strategy. As a result, solar energy development tends to be sporadic and not systematically integrated into medium- and long-term energy planning

CONCLUSION

The implementation of renewable energy policies in Indonesia, particularly in the development of solar energy, has not been effective in improving national energy security. Various obstacles still hinder its potential realization, including financial constraints such as 9 high initial costs and weak incentives, unsupportive regulations and governance, and the continued dominance of coal in the national energy system. In addition, technical limitations, unprepared electricity grid infrastructure, and low energy literacy among the public further slow down the development of solar energy. These conditions mean that solar energy's contribution to energy supply diversification and national system stability remains very limited. For solar energy policies to truly strengthen energy security, comprehensive policy reforms are needed through regulatory simplification, strengthened fiscal support, increased institutional and technical capacity in the regions, and active community involvement in the energy transition process.

ACKNOWLEDGEMENTS

The author would like to thank the Indonesia Endowment Fund for Education Agency (LPDP) for the financial support provided. This support has enabled this research to be carried out successfully

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