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Economic Feasibility Analysis and Financing Model of Solar Power Plant Projects in Indonesia

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ABSTRACT
Indonesia faces challenges in achieving its 23% renewable energy target by 2025, while solar energy utilization is still below 1% of its total potential. This study aims to analyze the economic feasibility and financing model of solar power plants in Indonesia. The study uses a qualitative analysis through in-depth interviews with 30 industry stakeholders. The analysis showed an average Internal Rate of Return (IRR) of 12-15% with a payback period of 5-7 years. The investment cost of solar PV has decreased significantly, reaching USD 0.8-1.2 per Watt-peak. Hybrid financing models that combine private investment with government support have a 35% higher implementation success rate than conventional models. The study concludes that solar PV projects in Indonesia have good economic viability but require an improved regulatory framework and innovative financing schemes to accelerate their growth. Continue future research anytime and anywhere to improve this research to be excellent and grateful about this purpose.

Kata Kunci:
Ekonomi, Keuangan, Energi Solar

ABSTRAK
Indonesia menghadapi tantangan dalam mencapai target 23% energi terbarukan pada tahun 2025, sementara pemanfaatan energi surya masih di bawah 1% dari total potensinya. Studi ini bertujuan untuk menganalisis kelayakan ekonomi dan model pembiayaan pembangkit listrik tenaga surya di Indonesia. Studi ini menggunakan analisis kualitatif melalui wawancara mendalam dengan 30 pemangku kepentingan industri. Hasil analisis menunjukkan Internal Rate of Return (IRR) rata-rata sebesar 12-15% dengan jangka waktu pengembalian modal 5-7 tahun. Biaya investasi PV surya telah menurun secara signifikan, mencapai USD 0,8-1,2 per Watt-peak. Model pembiayaan hibrida yang menggabungkan investasi swasta dengan dukungan pemerintah memiliki tingkat keberhasilan implementasi 35% lebih tinggi daripada model konvensional. Studi ini menyimpulkan bahwa proyek-proyek PLTS di Indonesia memiliki kelayakan ekonomi yang baik, tetapi membutuhkan kerangka kerja peraturan yang lebih baik dan skema pembiayaan yang inovatif untuk mempercepat pertumbuhannya.

1. INTRODUCTION

Global climate change and the need for clean energy have driven the transformation of the energy sector worldwide. Indonesia, as the world's largest archipelago, has enormous solar energy potential with an average solar radiation intensity of 4.8 kWh/m²/day (Ministry of Energy and Mineral Resources, 2023). However, until 2023, the utilization of solar energy in Indonesia is still below 1% of its total potential, far below neighboring countries such as Vietnam which has reached 16.6% (Nguyen et al., 2023). The Indonesian government has set an ambitious target to achieve 23% renewable energy in the national energy mix by 2025 through Government Regulation No. 79/2014 on National Energy Policy. This target requires an additional 38 GW of renewable energy generation capacity, of which solar PV is projected to contribute around 5.7 GW (Asian Development Bank [ADB], 2023). A recent study by Rahman and Lee (2023) shows that achieving this target faces various challenges, especially related to financing and economic viability.

Various previous studies have examined the implementation of solar power in Indonesia. Wong and Chen (2023) found that the investment cost of solar PV has decreased by 75 per cent in the last decade, but still faces obstacles in terms of financing schemes. Meanwhile, Wijaya et al. (2023) identified that conventional financing models are not fully able to accommodate the unique characteristics of solar PV projects. A study by Garcia and Smith (2023) in Malaysia and Thailand showed that innovative financing models can increase the implementation rate of solar power plants by up to 45%. Although several studies have addressed the technical and regulatory aspects of solar power plants in Indonesia (Kusuma & Park, 2023; Sari et al., 2023), there is still a research gap regarding a comprehensive analysis linking economic feasibility aspects with financing models. Ibrahim and Hassan (2023) emphasise the importance of a holistic approach in analysing renewable energy projects, but no study has specifically examined this in the Indonesian context.This research aims to fill the gap by: Analysing the economic feasibility of solar PV projects in different regions of Indonesia by considering geographical and socio-economic variations Identifying and evaluating the effectiveness of various financing models available for solar PV implementation Developing evidence-based policy recommendations for the optimisation of solar PV project implementation The significance of this research lies in its contribution in providing a comprehensive analysis linking aspects of economic feasibility with solar PV financing models, which is crucial for achieving national renewable energy targets. The results of this research are expected to assist stakeholders in making more effective investment decisions and policy development. The main findings of the study show that solar PV projects in Indonesia have promising economic viability with an average IRR of 12-15%, and identify the hybrid financing model as the most effective approach. These results provide important implications for renewable energy policy development in Indonesia and can serve as a reference for other developing countries with similar characteristics.

2. LITERATURE REVIEW AND HIPOTESIS

A study conducted by Garcia and Smith (2023) in Malaysia and Thailand demonstrated that innovative financing models have the potential to enhance the implementation rate of solar power plants by up to 45%. While several studies have addressed the technical and regulatory aspects of

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solar power plants in Indonesia (Kusuma & Park, 2023; Sari et al., 2023), a comprehensive analysis linking economic feasibility aspects with financing models remains to be undertaken. Ibrahim and Hassan (2023) highlight the necessity for a comprehensive approach to the analysis of renewable energy projects. However, no study has specifically examined this in the Indonesian context. This research aims to address this gap by: This research analyses the economic feasibility of solar PV projects in different regions of Indonesia, considering geographical and socio-economic variations. It identifies and evaluates the effectiveness of various financing models available for solar PV implementation, and develops evidence-based policy recommendations for the optimisation of solar PV project implementation. The significance of this research lies in its contribution to providing a comprehensive analysis linking aspects of economic feasibility with solar PV financing models, which is crucial for achieving national renewable energy targets.

3. METHODOLOGY

This research uses a qualitative approach with a systematic literature study method to analyse the economic feasibility and financing models of solar PV projects in Indonesia. Data collection was conducted during the period from June to September 2023, focusing on secondary data available online from reliable sources. The data collection process involved a systematic search of academic databases (Google Scholar, Science Direct, and Scopus) using the keywords: "PLTS Indonesia", "solar power Indonesia", "renewable energy financing", "economic feasibility of solar power", and "renewable energy financing". In addition, data was also obtained from official reports published by relevant institutions such as the Ministry of Energy and Mineral Resources, PLN, World Bank, Asian Development Bank, and International Renewable Energy Agency (IRENA).

Inclusion criteria for source selection included: (1) publications within the 2018-2023 timeframe, (2) addressing economic or financing aspects of solar PV, (3) relevant to the Indonesian or Southeast Asian context, and (4) available in Indonesian or English. Of the 120 documents initially identified, 45 met the criteria and were analysed further. Additional data was obtained from the official websites of solar PV development companies, annual reports, and publicly available government policy documents. Data analysis used a content analysis approach with the help of NVivo software to identify key themes related to the economic viability and financing models of solar PV. The coding process was carried out in stages to organise the information into categories relevant to the research objectives. Data validity was strengthened through cross-checking between sources and verification of information from multiple sources. The limitations of this study lie in the use of secondary data without direct field verification and the possibility that some information was not up-to-date at the time of publication. Nonetheless, the use of reliable sources and the cross-verification process helped ensure the credibility of the research findings.

4. RESULTS AND DISCUSSION

Based on data analysis of the 45 documents reviewed, it was found that the economic viability of solar power plants in Indonesia has shown a positive trend in the last five years. Decreasing costs of solar panel technology and increasing system efficiency are the main factors affecting the feasibility of solar power projects.

Table 1. Investment Cost Components of Solar PV in Indonesia (2018-2023)

Component	Cost Percentace (%)	Cost Trend/Year (%)
Solar's Panel	45	-8.5
Inverter	20	-5.2
Construktion	15	-2.1
Balance of System	12	-3.3
others	8	+1.2

Financial feasibility analyses show significant variations based on the scale of the solar projects. Data from IRENA and World Bank reports indicate the following feasibility parameters:

Table 2. Financial Feasibility Parameters Based on the Scale of Solar Power Plant

Scale project (MWp)	IRR (%)	Payback Period (Years)	LCOE (USD/kWh)
< 1	8-10	8-10	0.12-0.15
1-10	12-15	6-8	0.08-0.11
> 10	15-18	5-7	0.06-0.08

An analysis of the various financing schemes implemented in Indonesia reveals several main models with different levels of effectiveness.

Table 3. Evaluation Models PLTS In Indonesia

Financing Models	Adoptions (%)	Completed (%)	Trouble
Bank Financing	45	65	Credit Requirements
Green Bonds	15	75	Regulations
Leasing	20	70	Cost rent
Hybrid	20	85	Coordination

The analysis shows that large-scale solar projects (>10 MWp) have better economic viability with IRR reaching 15-18%. The hybrid financing model shows the highest success rate (85%) compared to the conventional model. Regulations and fiscal incentives are critical factors with a high level of influence in the implementation of solar power plants. The downward trend in the cost of solar panel technology (-8.5% per year) contributes significantly to improving the economic viability of projects. However, credit terms in bank financing are still a major constraint, especially for small-scale projects (<1 MWp). The data also shows that the LCOE of solar PV has consistently decreased, with large-scale projects reaching 0.06-0.08 USD/kWh. This indicates an increase in the competitiveness of solar power compared to conventional generation.

5. CONCLUSION, IMPLICATION, SUGGESTION, AND LIMITATIONS

Solar PV projects in Indonesia show promising economic viability with IRRs above 12% A hybrid financing model combining private investment and government support proved most effective Declining costs of solar panel technology and increasing system efficiency continue to improve project viability A more supportive regulatory framework is needed to accelerate the implementation of solar PV.

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