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Rooftop Solar Development in Bali's Energy Transition: Policy Implementation and Governance Challenges

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Abstract

Bali, as a major tourist destination, has experienced a significant increase in energy consumption due to the growth of the tourism industry, leading to increased energy demand. Consequently, Bali needs to achieve energy self-sufficiency, as energy self-sufficiency not only contributes to environmental sustainability but is also a pillar of sustainable development. Bali Governor Regulation No. 45 of 2019 on Bali Energi Bersih (BEB) is a policy aimed at strengthening Bali's energy supply through the promotion of renewable energy development, including rooftop solar power plants. However, the expansion of rooftop solar systems in Bali remains limited. Previous studies have mainly focused on technical and economic aspects, while limited attention has been given to the gap between policy ambition and implementation outcomes. This study aims to analyze the development of rooftop solar power plants before and after the Bali Clean Energy policy, and to identify the driving and inhibiting factors affecting their role in achieving energy self-sufficient in Bali Province. This study employs a qualitative descriptive research method. The data collection methods used include observation, interviews, and documentation. The findings show that the policy has increased awareness and encouraged initial rooftop solar adoption. However, implementation has not yet been optimal. The main barriers include high upfront investment costs, limited financing access, shortages of competent installation personnel, and regulatory uncertainty caused by changes in central government policies. These challenges have reduced public confidence and slowed adoption rates. This study fills the gap in local level policy implementation of energy transition by showing that renewable energy transition depends not only on technological readiness, but also on regulatory consistency, institutional capacity, and effective coordination between provincial and central governments.

Keywords: Policy; Clean Energy; Rooftop Solar Power Plants; Energy Self-Sufficiency.

Introduction

The energy crisis is a critical global issue that has garnered significant attention worldwide. Continuous global population growth and rapid economic expansion in many countries have led to an increasing demand for energy resources. However, conventional energy sources such as petroleum, natural gas, and coal are becoming increasingly scarce, raising concerns about future energy security. Furthermore, the environmental impacts of exploiting these conventional energy sources are becoming increasingly alarming. The use of fossil fuels significantly contributes to rising greenhouse gas emissions and global climate change, resulting in an environmental crisis that not only disrupts ecosystems but also poses serious risks to human health and the sustainability of life on Earth (Tira et al., 2017).

One way to address this energy crisis is by utilizing available alternatives through a shift toward renewable energy sources such as solar power, wind power, and bioenergy, which is becoming increasingly important. Additionally, improving energy efficiency and developing environmen-

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tally friendly technologies are crucial components in addressing the global energy crisis. This shift not only has the potential to mitigate environmental degradation but also offers opportunities to build more sustainable and resilient energy infrastructure for the future. In this context, it is important to explore the challenges, opportunities, and potential solutions associated with the transition to renewable energy. In line with this, the Ministry of Energy and Mineral Resources of the Republic of Indonesia states that Indonesia possesses significant New and Renewable Energy (NRE) potential, amounting to 3,686 gigawatts (GW). This energy transition is essential to support national energy security and the achievement of NRE mix targets. Indonesia has vast, widespread, and diverse NRE potential, as shown in the following table:

Table 1. Renewable Energy Potential in Indonesia

ENERGI	POTENSI (GW)	PEMANFAATAN (GW)
SURYA	3.295	0,27
HIDRO	95	6,69
BIOENERGI	57	3,09
BAYU	155	0,15
PANAS BUMI	24	2,34
LAUT	60	0
TOTAL	3.686	12,54

Source: Ministry of Energy and Mineral Resources of the Republic of Indonesia, 2023

In the National Energy Strategic Plan, the Ministry of Energy and Mineral Resources has designated solar power plants (SPPs) as a priority program to increase the share of new and renewable energy (NRE) to 23% by 2025; solar power plants are one of the fastest methods to achieve clean energy targets, ebtke.esdm.go.id (2021). This energy transition issue was also discussed at the G20 Summit held in Bali in 2022, where the energy transition was a priority issue and resulted in agreements as outlined in the Leaders' Declaration, particularly points 11 and 12. These two points emphasize the importance of achieving net-zero emissions or carbon neutrality by 2060 and fulfilling Sustainable Development Goal (SDG) 7 affordable and clean energy to ensure energy stability, transparency, and affordability for all citizens. The issue of energy transition was also a key topic of discussion at the G20 Summit held in Bali in 2022. At this summit, energy transition was designated as a priority issue, leading to agreements outlined in the Leaders' Declaration, specifically in points 11 and 12. These points emphasize the importance of achieving net-zero emissions by 2060 and fulfilling Sustainable Development Goal (SDG) 7, which aims to ensure access to affordable and clean energy. This commitment underscores the need to provide energy that is stable, transparent, and accessible to all segments of society.

Bali, as a major tourist destination, has experienced a significant increase in energy consumption driven by economic growth and the expansion of the tourism industry. The growth of these sectors has led to increased energy demand, necessitating efforts to achieve energy self- sufficiency in Bali. One policy addressing energy supply in Bali is Bali Governor Regulation No. 45 of 2019 on Clean Energy Bali (BEB), initiated by the Bali Provincial Department of Manpower and Energy and Mineral Resources, The purpose of this Governor's Regulation is to serve as a guideline for ensuring the fulfillment of all energy needs in a self-reliant, environmentally friendly, sustainable, and equitable manner using Clean Energy. Based on the presentation regarding the regional action plan toward a clean energy-independent Bali in the Province of Bali by 2020, Bali must have power plants capable of meeting long-term needs (Pemerintah Provinsi Bali, 2025).

Based on the potential table below, it shows that solar power plants have the greatest potential to become a source of New and Renewable Energy (NRE) compared to other energy types in

Bali Province. The utilization of renewable energy sources, such as solar energy, can help meet sustainable and environmentally friendly energy needs. Based on Governor Regulation No. 45 of 2019 on Clean Energy in Bali, Articles 21 and 22 specifically address rooftop solar power plants (PLTS Atap). Additionally, Bali Provincial Regulation No. 9 of 2020 on the Bali Regional Energy Master Plan (RUED) has set a target for the primary energy mix of Renewable Energy (EBT) at 11.15% by 2025 in Appendix I, Section IV.2 B, which states that one of the priorities for clean energy development is the use of rooftop solar power plants (RUED Provinsi Bali, 2020).

Table 2. Potential for Renewable Energy (EBT) Generation in Bali Province

JENIS	ENERGI LAUT	BAYU	BIOGAS	BIOMASSA	SURYA	AIR	PANAS BUMI	MINIHIDRO/ MIKROHIDRO
KAPASITAS TERPASANG (MW)	320	1.019	44.7	146.9	**1.254**	624	262	15
TOTAL (MW)	3.685,6							

Source: RUEN and RUED of Bali Province 2020–2050, December 21, 2023

In line with this initiative, the Governor of Bali issued Circular Letter No. 5 of 2022 on the Utilization of Rooftop Solar Power Plants (PLTS) in the Province of Bali. This policy aligns with the development vision of the Province of Bali, "Nangun Sat Kerti Loka Bali," which is implemented through the framework of the "Pola Pembangunan Semesta Berencana" to advance Bali toward a New Era, as outlined in Presentation as Part of the Regional Action Plan Toward Energy-Self- Reliant Bali with Clean Energy in the Province of Bali, 2020 . The 21st mission of this vision emphasizes the development of a sustainable way of life for the Balinese people (Krama Bali) by fostering a clean, green, and aesthetically harmonious environment, which will be realized through the Clean Energy Bali program. Roof-mounted solar power systems (PLTS Atap) have been identified as a strategic solution to accelerate the expansion of solar energy in Bali. This approach is highly relevant given the geographical and demographic characteristics of Bali Province, where limited land availability and relatively high population density present significant potential for solar energy utilization through the rooftops of residential and commercial buildings. Additionally, the use of rooftop photovoltaic systems (PLTS Atap) in homes can reduce dependence on the fossil fuel-dependent power grid and contribute to carbon emission reductions (Almomani et al., 2024).

Table 3. Data on the Increase in Rooftop Solar Power System Users in Bali Before the Implementation of the Bali Clean Energy Policy

No.	District	Year/Customers					Total
		2015	2016	2017	2018	2019	
1.	Kota Denpasar	3	1	2	10	4	20
2.	Badung	2	4	2	7	22	37
3.	Tabanan		2		1	3	6
4.	Gianyar		1	1	1	3	6
5.	Klungkung			1			1
6.	Karangasem					1	1
7.	Bangli						
8.	Buleleng				3	3	6
9.	Jembrana				1		1
	Jumlah	5	8	6	23	36	78

Source: PLN UID Bali, May 2024

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The data presented in the previous table provides an initial overview of the phenomenon under study. To support the relevance of this research, several previous studies have addressed similar topics. According to (Guna & Mubarak, 2021), it states that Renewable Energy has been developed by the West Sumatra Provincial ESDM Office in the South Solok region since 2013. In implementing this development, the West Sumatra Provincial ESDM Office still faces several challenges because some members of the community have not yet felt its benefits. The findings indicate that the implementation of the Micro- Hydro Power Plant (PLTMH) Renewable Energy Development by the West Sumatra Provincial ESDM Office in South Solok has not yet proceeded as intended, as several obstacles related to communication, organizational characteristics, the economic environment, and human resources remain as barriers to the development of New Energy.

Furthermore, (Kalpikajati & Hermawan, 2022) reveals that there are two main obstacles to the implementation of renewable energy policies in Indonesia: social issues and legal issues. From a legal perspective, the first issue arises from the absence of a specific law that systematically and comprehensively regulates renewable energy management, while from a social perspective, a favorable investment climate has not yet been established to support the financing of renewable energy management, and there is a lack of adequate data for investors to facilitate the investment process.

In line with this, preliminary observations conducted by researchers at the Bali Provincial Department of Manpower and Energy and Mineral Resources indicate a mismatch between regulations and reality. In Minister of Energy and Mineral Resources Regulation No. 19 of 2016 on the Purchase of Electricity from Photovoltaic Solar Power Plants by PT Perusahaan Listrik Negara (Persero), the Minister tasked PT PLN (Persero) with purchasing electricity from photovoltaic solar power plants managed by business entities designated as photovoltaic solar power plant developers, but in reality, this has not been implemented. Subsequently, Minister of Energy and Mineral Resources Regulation No. 26 of 2021 on Grid-Connected Rooftop Solar Power Plants of License Holders for the Supply of Electricity for Public Interest was issued. Under this regulation, PT Perusahaan Listrik Negara (Persero) is no longer required to purchase electricity from photovoltaic solar power plants managed by business entities designated as photovoltaic solar power plant developers. The main contents ofof Energy and Mineral Resources No. 26 of 2021 and Minister of Energy and Mineral Resources No. 2 of 2024 are as follows:

Table 4. Minister of Energy and Mineral Resources Regulation No. 26 of 2021 and Regulation of the Minister of Energy and Mineral Resources No. 2 of 2024

No	Aspect	Ministerial Regulation No. 26 of 2021	Ministerial Regulation No. 2 of 2024
1	Energy Exports and Imports	Electricity export-import mechanism implemented. Electricity export (kWh) increased from 65% to 100%	The energy export-import mechanism has been abolished. Excess electricity from rooftop solar power plants fed into the grid is not counted as a reduction in the electricity bill
2	System Focus	The system allows for on-site consumption (self consumption) and energy export to the power grid	The system is focused on on-site consumption (self-consumption) without energy export
3	Capacity Limits	The installation capacity for rooftop solar power plants is limited to a maximum of 100% of the connected power from PLN	The 100% limit has been removed, but installation capacity is subject to the quota set by PLN

4	Quota System	There is no rooftop solar power plant installation quota system	A rooftop solar power plant capacity quota per cluster (UP3 PLN) is enforced, as determined by the Director General of Electricity every 5
5	Accumulated Exported Energy	Accumulated surplus energy can be applied as a credit against the bill and remains valid for up to 6 months	There is no longer any accumulation of exported energy because the export-import mechanism has been abolished
6	Application Process	The application process for rooftop solar power plant installation has been shortened to 5 days without changes to the PJBL and 12 days with changes to the PJBL	The application process has been simplified using a First In First Serve (FIFS) mechanism
7	Capacity Fees	Capacity fees still apply for certain customers	Capacity charges have been eliminated for all types of PLN customers
8	Electricity Meter	Use of import-export kWh meters	Replaced with advanced meters; procurement costs borne by IUPLT holders
9	Service System	App-based service mechanism for submitting applications, reporting, and monitoring rooftop solar power plants	Continue using the app-based service to facilitate applications and monitoring
10	Regulatory Scope	Applies to PLN customers and IUPTL holders	

Source: *Menteri ESDM Terbitkan Aturan mengenai PLTS Atap, 2022*

Based on data on rooftop solar power plant users in Bali prior to the issuance of the Clean Energy Bali policy, as well as empirical evidence showing regulatory changes at the national level, the development of New and Renewable Energy in Indonesia continues to face various implementation challenges. Several previous studies have also shown that renewable energy development in Indonesia is often constrained by regulatory uncertainty, investment barriers, limited institutional capacity, and weak implementation mechanisms. These conditions indicate that the development of rooftop solar power plants in Bali should not only be understood as a technical or economic issue, but also as a matter of policy implementation and energy governance.

Although several previous studies have examined renewable energy development in Indonesia, most of them have focused on technical feasibility, economic benefits, investment barriers, and regulatory constraints. Limited attention has been given to how local governments implement clean energy policies, how institutional coordination affects policy outcomes, and how political commitment shapes the success of regional energy transition. In the case of Bali, this gap is important because the provincial government has established ambitious clean energy policies, yet the actual expansion of rooftop solar power plants remains limited and uneven across districts.

This condition shows that the issue of rooftop solar development in Bali is not merely a technical or economic matter, but also a governance and policy implementation issue. The gap between policy targets and implementation outcomes reflects the need to examine the interaction between local government commitment, central government regulation, institutional capacity, actor coordination, and public acceptance. Therefore, this study positions rooftop solar development as part of the politics and governance of local energy transition. Based on this background, this study addresses the following research questions: (a) How is the clean development policy for rooftop solar power plants implemented in achieving energy self-sufficiency in Bali Province, and

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(b) What are the driving and inhibiting factors in the development of rooftop solar power plants in achieving energy self-sufficiency in Bali Province. This study aims to analyze the implementation of rooftop solar power plant policy in Bali Province and to identify the driving and inhibiting factors affecting its role in achieving energy self-sufficiency. Through this focus, the study is expected to contribute to the discussion on local energy transition by highlighting the importance of policy implementation, institutional coordination, political commitment, and governance capacity in renewable energy development.

Method

This study employs a qualitative descriptive approach. Qualitative research is an approach used to understand social phenomena by exploring the meanings attributed by individuals or groups to a social or humanitarian issue (Creswell & Creswell, 2018). In this study, a qualitative approach was chosen because it allows for the detailed exploration and analysis of data and information regarding the rooftop solar power plant (PLTS Atap) policy for energy independence in Bali. To deepen the data analysis in this study, the researcher utilized two types of data: primary data and secondary data. Primary data was obtained through interviews, observations, or field documentation. In this study, the primary data collected consisted of information gathered from informants via observation and interviews. The sources of primary data in this study were: two representatives from the Energy and Electricity Sector at the Department of Energy and Mineral Resources of Bali Province and PLN Bali Distribution Main Unit, one representative from the Regional Development Planning Agency (BAPPEDA) of Bali Province, and one representative from the Asosiasi Panel Surya Abadi (APSA). These informants were selected purposively because they have knowledge, authority, or practical experience related to clean energy policy, rooftop solar implementation, and energy planning in Bali.

Secondary data is data obtained or collected by the researcher from existing sources. Secondary data is used to support the primary information obtained; typically, secondary data can be obtained from third parties, such as previous research findings, books, or existing documentation related to the study. In this research, secondary data was obtained from institutions or agencies related to this study to gather information, including both previous research findings and literature reviews from documents and official archives, such as: the Bali UID Solar Power Plant (PLTS) documents from PLN UID Bali, documents on the role of RUED in the energy transition at the Bali Provincial Ministry of Energy and Mineral Resources (ESDM), as well as other documents, archives, and reports related to this research. In this study, to obtain the desired data, the researcher employed three data collection techniques.

First, observation is used in this study to gain an understanding of how clean energy development policies focused on rooftop solar power plants are implemented in Bali Province. The researcher will correlate all information obtained with on-site conditions. Second, an interview is an event or a process of interaction between an interviewer and an information source or interviewee through direct communication. Interviews are one of the data collection techniques used in this study to obtain verbal information and data from informants. The interviews conducted are in-depth interviews using a semi-structured question and-answer format, meaning that while several main questions are prepared, there is still room for informants to elaborate more broadly based on their own experiences and knowledge. This technique allows researchers to delve deeper into information regarding the phenomenon under study (Flick, 2018). Last, documentation involves analyzing various documents relevant to the research, such as official reports, policy archives, government regulations, or other documents related to the study (Merriam & Tisdell, 2016).

Data analysis in qualitative research is conducted through a systematic data processing process, ranging from data organization, coding, category grouping, to theme extraction and interpretation of the meaning of data obtained from the field (Creswell & Poth, 2018). To ensure data validity, this study used triangulation. Source triangulation was conducted by comparing information obtained from the Energy and Electricity Sector at the Department of Energy and Mineral

Resources of Bali Province and PLN Bali Distribution Main Unit, BAPPEDA, APSA, and official documents. Technique triangulation was conducted by comparing data obtained through interviews, observation, and documentation. Through this process, the findings were verified to ensure consistency, credibility, and relevance to the research focus.

Result

Development of Rooftop Solar Power Plants Before and After the Clean Energy Policy

As part of global efforts to reduce carbon emissions and increase the use of clean energy, the Province of Bali has garnered significant attention for its ambitious initiatives in the adoption of rooftop solar power plants (PLTS). Prior to the implementation of clean energy policies in the Province of Bali, the regional energy mix was still dominated by fossil fuels. According to data from the Regional Energy Master Plan (RUED), petroleum remained the primary energy source in Bali Province, accounting for 58.12% in 2021 and increasing to 63.03% in 2022. Meanwhile, coal usage decreased by 7.43% over the same period.

Tabel 5. Data Calculations by the National Energy Council (DEN):
Bali Province Energy Mix 2021–2023

NO	URAIAN	2021				2023			
		BOE	TOE	MTOE	%	BOE	TOE	MTOE	%
1	EBT	174.457,38	24.424,03	0,02	1,29	630.499,07	88.269,87	0,09	3,80%
2	MINYAK BUMI	7.884.200,35	1.103.788,05	1,10	58,12	10.467.243,82	1.465.414,14	1,47	63,03%
3	GAS BUMI	1.354,99	189,70	0,00	0,01	1.524,42	213,42	0,00	0,01%
4	BATUBARA	5.506.071,93	770.850,07	0,77	40,59	5.506.720,00	770.940,80	0,77	33,16%

Source: secondary data from several relevant agencies, First Semester of 2023 and DEN Formula Calculations, (data from the Regional General Energy Plan (RUED), 2023

On the other hand, the use of renewable energy (RE) increased from 1.29% in 2021 to 3.80% in 2022. Detailed data can be found in the following table and figure from:

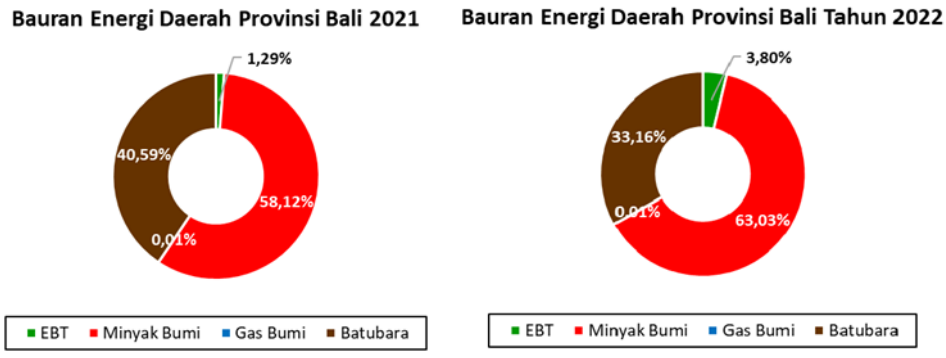

Figure 1. Bali Province's Energy Mix in 2021 and 2022

Based on data from the Regional Energy Master Plan (RUED) report, Bali Province has experienced changes in its energy mix, with efforts to reduce dependence on petroleum and coal and increase the use of renewable energy. However, as stipulated in the National Energy Policy (KEN) and the National Energy Master Plan (RUEN), the national primary energy mix targets for 2022 are as follows:

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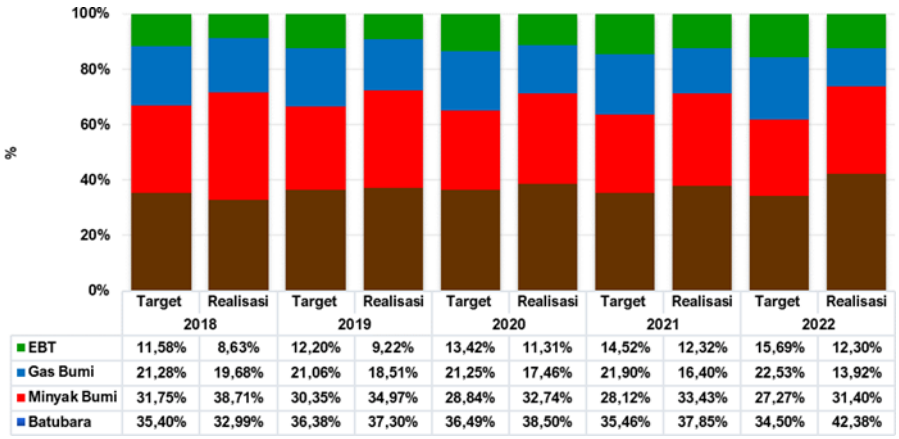
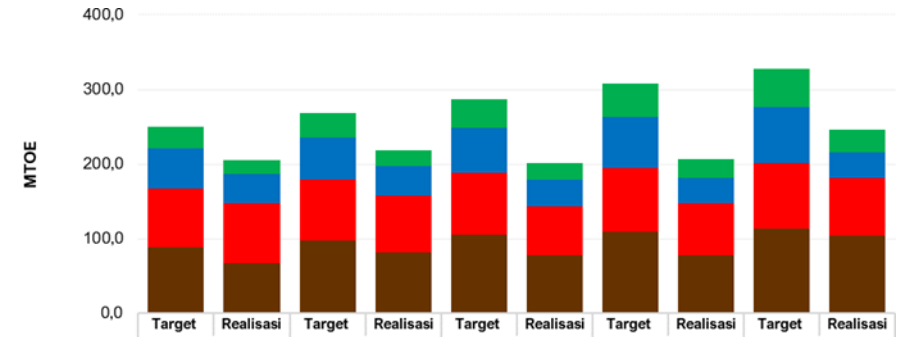


	Target 2018	Realisasi 2018	Target 2019	Realisasi 2019	Target 2020	Realisasi 2020	Target 2021	Realisasi 2021	Target 2022	Realisasi 2022
EBT	11,58%	8,63%	12,20%	9,22%	13,42%	11,31%	14,52%	12,32%	15,69%	12,30%
Gas Bumi	21,28%	19,68%	21,06%	18,51%	21,25%	17,46%	21,90%	16,40%	22,53%	13,92%
Minyak Bumi	31,75%	38,71%	30,35%	34,97%	28,84%	32,74%	28,12%	33,43%	27,27%	31,40%
Batubara	35,40%	32,99%	36,38%	37,30%	36,49%	38,50%	35,46%	37,85%	34,50%	42,38%



	Target 2018	Realisasi 2018	Target 2019	Realisasi 2019	Target 2020	Realisasi 2020	Target 2021	Realisasi 2021	Target 2022	Realisasi 2022
EBT	28,9	17,7	32,8	20,1	38,6	22,8	44,7	25,5	51,3	30,3
Gas Bumi	53,2	40,4	56,5	40,4	61,1	35,2	67,3	33,9	73,7	34,3
Minyak Bumi	79,3	79,4	81,5	76,3	82,9	65,9	86,5	69,1	89,2	77,3
Batubara	88,5	67,7	97,6	81,4	104,9	77,5	109,0	78,2	112,9	104,4
Total	249,9	205,1	268,4	218,2	287,4	201,4	307,4	206,7	327,1	246,4

Figure 2. 2018-2022 Energy Mix Target and Realization
Source: Dewan Energi Nasional, 2023

Crude oil: 89.2 MTOE (27.27%); natural gas: 73.7 MTOE (22.53%); coal 112.9 MTOE (34.50%); and renewable energy (EBT) 51.3 MTOE (15.69%), with a national primary energy supply target of 327.1 MTOE ( ). Based on an evaluation of the 2022 national primary energy mix, total energy supply was as follows: crude oil at 77.3 MTOE (31.40%); natural gas at 34.3 MTOE (13.92%); coal at 104.4 MTOE (42.38%); and renewable energy at 30.3 MTOE (12.30%), den.go.id (2023). Based on these data, it can be concluded that the 2022 national primary energy mix target was not met. This situation indicates that despite efforts toward energy transition, dependence on fossil fuels in Bali Province remains quite high. Therefore, the local government is promoting the development of clean energy through various policies, one of which is the utilization of rooftop solar power plants (PLTS).

In line with this, data obtained from PLN UID Bali shows that before the 2019 Regulation No. 45 on Clean Energy in Bali was implemented, rooftop solar power plants in Bali had already begun to be used by a number of parties. Following the issuance of the Clean Energy in Bali policy, there was an increase in the number of rooftop solar power plant installations in Bali, as shown in the following table:

Table 6. Data on Rooftop Solar Power System Users in Bali Before the Bali Clean Energy Policy

No.	District	Year/Customers					**Total Customers 2015-2019**
		2015	2016	2017	2018	2019	
1.	Denpasar City	3	4	6	16	20	
2.	Badung	2	6	8	15	37	
3.	Tabanan		2		3	6	
4.	Gianyar		1	2	3	6	
5.	Klungkung			1	1	1	
6.	Karangasem					1	
7.	Bangli						**78**
8.	Buleleng				3	6	
9.	Jembrana				1	1	
	Jumlah	**5**	**13**	**17**	**42**	**78**	

Source: PLN UID Bali, 2024

Between 2015 and 2019, the total number of rooftop solar power system users in Bali was 78 customers. Table 6, which presents data on rooftop solar power system users in Bali, shows that Badung Regency is recorded as the region with the highest number of users, totaling 22 customers. Although the number of customers has increased annually, when viewed by regency, the annual growth in the number of rooftop solar power system users in Bali tends to fluctuate.

Table 7. Data on Rooftop Solar Power System Users in Bali Following the Implementation of the Bali Clean Energy Policy

No.	District	Year/Customers					**Total Customers 2020-2024**
		2020	2021	2022	2023	2024	
1.	Denpasar City	33	51	75	82	82	
2.	Badung	17	63	99	132	144	
3.	Tabanan	4	8	12	15	16	
4.	Gianyar	5	18	26	42	49	
5.	Klungkung	1	3	3	6	6	
6.	Karangasem		2	3	4	9	
7.	Bangli						**338**
8.	Buleleng	1	9	12	22	22	
9.	Jembrana	1	4	9	10	10	
	Jumlah	**62**	**158**	**239**	**313**	**338**	

Source: PLN UID Bali, 2024

Following the implementation of the Bali Clean Energy policy, the number of rooftop solar power system users has increased significantly. Between 2020 and 2024, the number of rooftop solar system users rose to 338 customers. The areas with the highest number of users are Denpasar City and Badung Regency, which serve as the economic and tourism hubs of Bali Province. In addition to the increase in users, interviews with informants also indicate that the use of rooftop solar systems provides economic benefits to users. Several informants stated that the use of rooftop solar power systems can reduce electricity costs by approximately 10–30%, depending on energy consumption levels. However, the research findings also indicate several challenges in the implementation of rooftop solar power systems, such as frequent regulatory changes, limited public outreach, and technical challenges in operating the rooftop solar power system.

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Factors Influencing the Development of Rooftop Solar Power Systems in Bali

The implementation of rooftop solar power plant development policies in Bali Province is influenced by various factors that can act as either enablers or barriers. From a policy perspective, the Bali Provincial Government has established various regulations to promote the use of clean energy, including the Bali Governor's Regulation on Clean Energy in Bali and the Bali Governor's Circular Letter regarding the utilization of rooftop solar power plants. These policies aim to promote the use of new and renewable energy as part of efforts to achieve energy independence in Bali Province. In addition to policy support, the implementation of rooftop solar power plants is also supported by cooperation among various stakeholders, such as local governments, PLN, solar energy associations, academics, and international organizations. This cooperation includes outreach activities, training, discussion forums, and clean energy development programs.

However, several factors continue to hinder the development of rooftop solar power plants in Bali. One of the main obstacles is the high initial investment cost for installing rooftop solar power plants, meaning that not all members of the public can afford to access this technology. Additionally, the limited availability of human resources with expertise in renewable energy poses a challenge to the implementation of this policy. Several government agencies still lack experts in the field of clean energy. Technical obstacles have also been encountered in the use of rooftop solar power plants, such as disruptions to energy storage systems and repair processes that require coordination with the state-owned electricity company (PLN). Furthermore, the distribution of rooftop solar power plant usage in Bali remains uneven and is still concentrated in Southern Bali, which has higher levels of economic and tourism activity.

The increase in rooftop solar users from 78 customers before the Bali Clean Energy policy to 338 customers after the policy indicates that the policy has encouraged initial adoption of rooftop solar systems. However, this increase should not be interpreted as full policy effectiveness. The adoption remains uneven and is concentrated mainly in Denpasar and Badung, which are the economic and tourism centers of Bali. This shows that policy implementation is still influenced by local economic capacity, public awareness, and access to renewable energy infrastructure. Therefore, the development of rooftop solar in Bali reflects not only technical progress, but also governance challenges in ensuring equitable energy transition across districts.

Based on the comparison between the data before and after the implementation of the Bali Clean Energy policy, rooftop solar adoption shows a significant increase. The number of rooftop solar users increased from 78 customers before the policy to 338 customers after the policy. However, from the perspective of policy implementation theory, this increase does not automatically indicate successful implementation. The growth of users demonstrates that the policy has created initial awareness and acceptance, but the uneven distribution of rooftop solar users across districts shows that implementation outcomes remain unequal. Denpasar and Badung dominate rooftop solar adoption because these areas have stronger economic capacity, higher electricity demand, and closer links to the tourism sector. In contrast, other districts show slower adoption, indicating that policy implementation is still constrained by differences in local capacity, access to technology, and public readiness. Using Van Meter and Van Horn's policy implementation framework, these findings indicate that the implementation of rooftop solar policy in Bali is influenced by policy standards and objectives, resources, inter-organizational coordination, implementer commitment, and socio-economic conditions. Although Bali has established a clear policy direction through Governor Regulation No. 45 of 2019 on Bali Energi Bersih, implementation outcomes remain limited due to financial constraints, limited technical human resources, regulatory uncertainty, and uneven coordination among relevant actors.

Discussion

This study was analyzed using the policy implementation theory of Donald Van Meter and Carl Van Horn, which posits that the success of policy implementation is influenced by several key

variables. First, policy standards and targets have been established through various regulations related to clean energy development. These policies provide clear direction for local governments and stakeholders in developing renewable energy, particularly through the utilization of rooftop solar power plants. Second, from a resource perspective, policy implementation still faces several constraints, particularly regarding budget limitations and the high investment costs of solar energy technology. This situation indicates that financial support and economic incentives are still needed to accelerate the adoption of rooftop solar power systems in the community. Third, the characteristics of implementing organizations also influence policy implementation. In this context, various local government agencies have demonstrated a commitment to clean energy development by installing rooftop solar power plants on several government buildings as pilot projects. Fourth, communication and coordination among organizations are critical factors in policy implementation. Collaboration between local governments, PLN, solar energy associations, and international organizations demonstrates that the implementation of clean energy policies requires a collaborative approach involving various stakeholders.

Research findings indicate that the clean energy development policy in Bali Province has had a positive impact on the increased adoption of rooftop solar power systems. The rise in the number of rooftop solar power system users following the issuance of the Bali Clean Energy policy demonstrates that local government policies play a strategic role in driving the adoption of renewable energy technologies at the local level. The use and installation of rooftop PV systems represent an important strategy to support Indonesia in achieving its renewable energy targets. However, before encouraging the wider implementation of renewable energy technologies, it is necessary to assess the extent of public acceptance, especially among Indonesian residents who are still largely familiar with fossil-based energy systems (Eliva et al., 2025). In the context of Bali, this argument strengthens the finding that rooftop solar development depends not only on policy support and technological availability, but also on public readiness, awareness, and acceptance of clean energy innovation.

These findings align with an energy policy perspective that positions local governments as key actors in accelerating the energy transition through adaptive and context-specific policies. On the other research Bayu & Windarta, (2021) reveals that the development of solar power in Indonesia generally still faces various regulatory and policy challenges, such as the Build-Operate-Own-Transfer (BOOT) scheme, the electricity pricing mechanism based on Generation Cost (BPP), and limitations in the electricity buy-sell scheme between consumers-producers and PLN. These conditions are considered to hinder public and investor interest in solar power plant (PLTS) development. A similar finding from Panjidinata (2024) notes that renewable energy development in Indonesia still faces various structural challenges, particularly regarding regulatory complexity and bureaucracy. Investment in the renewable energy sector is still frequently hindered by overlapping regulations between the central and local governments, as well as lengthy and multi-layered permitting processes. Additionally, certain policies regarding restrictions on the export–import mechanisms of electricity generated by consumers, along with changes to the net metering scheme, are seen as reducing the appeal of rooftop solar power systems for both the public and the industrial sector. These restrictions not only result in low interest in rooftop solar power systems but also have the potential to slow down the achievement of the national renewable energy mix targets set by the government. However, experience in Bali Province demonstrates that the commitment of the local government through the Bali Clean Energy policy can serve as a catalyst for expanding the adoption of rooftop solar power systems. Thus, local policies can play a crucial role in accelerating the energy transition and promoting increased use of renewable energy, even though various regulatory challenges in solar energy development persist at the national level.

In addition to internal policy factors, the social, economic, and political environment also influences the implementation of energy-related policies; for example, some electricity consumers still do not have access to electricity services of adequate quality. Although Java generally rarely experiences power outages of significant duration or frequency, this situation contrasts with many regions outside Java that still do not receive electricity supplies meeting the expected quality

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standards (*Menerangi Indonesia*, 2017). This is linked to various challenges in energy infrastructure that have the potential to hinder economic growth. Consequently, ensuring equitable and adequate electricity infrastructure for the entire population remains a challenge that must be continuously addressed (Corio et al., 2023). Research on community-based renewable energy resource management as a strategy for energy security while promoting local economic growth indicates that community involvement can strengthen energy self-reliance, reduce dependence on fossil fuels, and mitigate risks stemming from global energy price fluctuations. This model also contributes to job creation, the strengthening of small businesses, and the improvement of local economic well-being. However, its success is highly dependent on regulatory support, access to financing, and technological capacity. Thus, community-based renewable energy management becomes a crucial strategy in supporting a sustainable energy transition while strengthening the people's economy (Nurhidayanti, 2025).

Public support for the use of clean energy indicates a growing awareness of the importance of environmental sustainability. However, economic factors remain a major challenge in the development of rooftop solar power plants, particularly the high initial investment costs required for installing solar power systems (Hidayat et al., 2019). Although the use of solar power systems has the potential to reduce household electricity expenses in the long term, the prices of key components in solar power system installations—such as solar panels, inverters, energy storage batteries—as well as installation costs remain relatively high, making them not yet fully affordable for the majority of the population (Suprianto, 2023; Manahara et al., 2023). . Limited public access to government-provided subsidy programs and incentives also poses a challenge in promoting the adoption of rooftop solar power systems at the household level. Additionally, the public's low technical understanding regarding the operation, management, and maintenance of solar panels is a significant barrier (Zainuddin et al., 2025). High installation costs and limited local government budgets pose barriers to expanding public access to renewable energy technologies. Thus, although policies for the development of rooftop solar power plants in Bali Province have shown positive progress, continued efforts are still needed to enhance policy support, strengthen human resource capacity, and provide more inclusive financing schemes to accelerate the transition toward energy independence in Bali Province.

Conclusion

This study concludes that the clean energy development policy for Rooftop Solar Power Plants (PLTS) has been implemented but has not yet been fully effective in achieving energy independence in Bali Province, despite an annual increase in the number of Rooftop Solar Power Plant (PLTS) customers; based on interview results and observations, the target achievement indicator of 11.15% in the implementation of this policy has not yet been met as it is still in the awareness-raising phase. Furthermore, the supporting factors for the implementation of clean energy development policies for Rooftop Solar Power Plants in achieving energy independence in Bali include cooperation and training conducted by the government, the private sector, and the community, as well as public enthusiasm for using Rooftop Solar Power Plants and the government's commitment, evident in the use of Rooftop Solar Power Plants in several government buildings in Bali. Meanwhile, the inhibiting factors include financial resource constraints and the limited number of competent human resources available to install rooftop solar power plants in Bali, a lack of outreach efforts, and constantly changing central government policies, which complicate installation procedures for the Bali Provincial Energy and Mineral Resources Office and prospective customers of rooftop solar power plants.

The scientific contribution of this study lies in its effort to fill the gap in local-level energy transition studies by analyzing rooftop solar development through the lens of policy implementation and governance. The Bali case demonstrates that the success of rooftop solar development depends on the interaction between policy targets, actor coordination, institutional resources, public acceptance, and regulatory consistency. Therefore, this study contributes on clean energy

governance by highlighting that local energy transition requires not only technological readiness, but also strong policy implementation, stable regulation, and collaborative governance.

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