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REVIEWS

Photovoltaics rooftop regulations and their connection to pro-environment consumer behavior in Indonesia

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Abstract. To address environmental issues, Indonesia aims to achieve a 23% renewable energy share by 2025 and 31% by 2050, according to the National Energy Plan. This article examines the regulations governing the management of rooftop solar power plant (rooftop-PV) in Indonesia and their connection to pro-environment consumer behavior. Despite Indonesia's ambitious targets for Renewable Energy (RE) growth, progress in the field still needs improvement. Pro-environmental behavior (PEB) within the community is crucial for adopting rooftop PV as a more environmentally friendly energy alternative. This research employs a qualitative descriptive methodology with content analysis to evaluate the current situation. The research findings indicate that rooftop PV offers economic benefits through cost savings for consumers and is supported by existing regulations. However, some businesses feel that the government needs to expedite revising relevant regulations to address investment stagnation and installed solar panel capacity. Concerns arise that proposed policy changes may hinder the growth of rooftop PV businesses and the achievement of national capacity targets. The role of pro-environment consumer behavior, which has the potential to drive rooftop PV adoption, will be influenced by psychological and social factors, as well as changes in applicable regulations.

Keywords: Renewable energy regulations; Photovoltaic; rooftop PV; Pro-Environment Behavior

1. Introduction

The world's energy utilization today still heavily relies on fossil energy. Fossil energy sources, including oil and coal, are the primary causes of air pollution and greenhouse gas (GHG) emissions (Sunardi et al., 2021). The widespread use of these energy sources has led to global climate change and increased carbon emissions (Danish et al., 2019). The energy crisis and environmental pollution associated with fossil fuel use have raised concerns about the instability of fossil fuel prices, the increasing dependence on limited fossil energy sources, and various environmental problems (Apergis & Payne, 2010).

Two types of impacts are associated with fossil energy: impacts on natural resources and the environment (Harjanto, 2008). First, the impact on natural resources involves the increased demand for electricity, which leads to the construction of more power plants and the escalated

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exploitation of natural resources. This results in the depletion of existing natural resource reserves, especially non-renewable resources like oil, gas, and coal (fossil fuels), which are gradually diminishing due to the increasing consumption. This could lead to an energy crisis, particularly for future generations. Second, the environmental impact involves the emission of CO_2 gas, a byproduct of fossil power plants, which is a GHG. The GHG effect causes the Earth's infrared radiation to be trapped, leading to global warming.

The various impacts of fossil energy are the main reasons for the transition to new and renewable energy (RE) sources. The importance of gradually developing renewable energy is highlighted in The Paris Agreement and the 26th Conference of the Parties, both of which aim to limit global warming. In recent years, there has been significant attention on the development of new and RE (Wang et al., 2020). Researchers agree that the gradual shift from fossil fuels to new and renewable energy sources can also improve environmental quality (Lange et al., 2020; Shahbaz et al., 2020). This shift encourages the development of new RE technologies, as they can balance economic growth with environmental sustainability (Dogan & Seker, 2016).

Indonesia, through Government Regulation No. 79 of 2014 on the National Energy Policy (KEN), has set ambitious targets for the growth of the RE sector. The policy aims for RE to reach 23% of the total national energy demand by 2025 and 31% by 2050. However, as of 2020, the share of RE had only reached 11.31%. Given the increasing energy demand and the slow growth of RE, the country's dependency on fossil fuels, especially oil and natural gas, is likely to persist.

Despite the effort of the Government's and energy-producing companies, the role of an environmentally conscious society remains crucial. Pro-environment behavior, also known as green behavior, sustainable behavior, or eco-friendly behavior, refers to actions individuals take to protect the environment. This includes responsible engagement in outdoor activities, recycling household waste, and adapting to the impacts of climate change by purchasing sustainable products (e.g., local food, eco-friendly cleaning products), conserving water or energy, changing travel modes (e.g., from driving to walking or cycling), or buying electric vehicles or building off-grid homes (Carman & Zint, 2020; Jackson, 2005; Krajhanzl, 2010; Valkengoed & Steg, 2019).

How does the community adopt a pro-environmental attitude by reducing reliance on electricity generated by the government? One example is the use of rooftop solar panels (rooftop PV) in residential homes, which serves as an alternative way to the community to contribute to environmental sustainability. By supporting RE through solar power, consumers can also benefit from cost savings. However, the implementation of such measure's careful consideration of the regulations that govern them. Do the existing rules offer a win-win solution for both electricity-generating companies and consumers?

2. Methodology

This research employs a qualitative descriptive methodology, which is inherently descriptive and tends to focus on analysis. Qualitative research emphasizes the exploration of process and meanings. The theoretical framework ensures that the research focus aligns with the facts in the field. This approach places importance on observing phenomena and understanding their substantive meaning. The depth and rigor qualitative research are greatly influenced by the clarity and precision of the language used (Ratnaningtyas et al., 2022).

Furthermore, study utilizes content analysis to examine various news articles regarding public responses to PV rooftop regulations, particularly those related to export and import calculations. Content analysis is a systematic and meticulous approach to analyzing documents obtained or produced during the research process (White & Marsh, 2006).

3. Result and discussion

3.1. Solar Power Plants (SPP)

Initially, solar power plants (SPP) were developed by establishing the “1000 Islands/locations SPP Program”, a solar energy initiative by Perusahaan Listrik Negara (PLN, a state-own electricity company), focused on photovoltaic technology. This program was designed to develop SPP in areas facing challenges related to expansion, network access, and transportation, typically situated in small, remote, or isolated islands. SPPs, which is rely on intermittent energy sources, generates fluctuating electrical energy. As a result, backup generators must operate flexibly as supporting units to compensate for decreases in sunlight intensity due to clouds or nighttime conditions. Therefore, feasibility studies tailored to specific system characteristics of each area are necessary, especially for large-scale SPP projects.

As of 2020, operational SPP capacity had reached 79 MW. The SPP planned for development by PLN will be a centralized, utility-scale facilities operating in hybrid mode. The components of the hybrid SPP generator will be tailored to the primary energy potential of each location, considering the population distribution across vast, hard-to-reach geographical area. The hybrid mode is expected to optimize system operation. This configuration is planned not only for newly electrified locations but also for existing sites where SPPs will operate alongside diesel power plant (DPP) and other types of generators in hybrid mode.

The development of SPP aims to increase electrification ratios in remote areas, reduce reliance on fossil fuels currently supplied by DPPs, and lower generation cost in regions where transportation cost of fossil fuels is high. To support accelerates breakthroughs in RE development, especially solar energy, PLN has begun utilizing hydroelectric dams, such as the one in Cirata, for SPP installations. Additionally, there are opportunities to collaborate with other businesses to install SPPs along railroad, railroad, LRT/MRT, or toll roads corridors.

The purchase price of electricity from SPP is regulated by the Minister of Energy and Mineral Resources Regulation No. 50/2017 concerning the Utilization of RE Sources for Electricity Provision. The enactment of this regulation aims to prevent an upward trend in the generation cost due to the price of electricity from RE. One of the rapidly developing technologies in the field of solar energy is rooftop PV technology.

The rooftop PV system is a smaller photovoltaic (PV) system compared to ground-mounted PV systems. It is typically installed on the roofs of residential buildings, commercial buildings, or industrial complexes. The electricity generated by the system can either be entirely fed into the grid (managed by PLN) under a feed-in tariff (FIT) scheme or used for self-consumption with net metering. Through the net metering system, the electricity produced by the costumers can offset the electricity drawn from the PLN grid. Due to the variations in the grid quality across different regions, it is essential to have regulations governing the interconnection of rooftop PV system with the grid, as well as the operation of grid-connected rooftop PV (grid codes). These rules regulations establish the technical requirements for connecting solar power plants based on the characteristics of the grid, thereby optimizing rooftop PV integration and ensuring that the intermittent nature of the solar does not disrupt the grid.

The utilization of rooftop PV is governed by the Minister of Energy and Mineral Resources Regulation No. 49 of 2018, as amended by Minister of Energy and Mineral Resources Regulation No. 13 of 2019 and subsequent amendments. The issuance of these regulations is expected to support the achievement of the target of utilizing RE to comprise approximately 23% of the energy mix by 2025. Additional benefits obtained from the development of rooftop PV include: saving on electricity bills for PLN consumers, growth of the electricity business with rooftop PV technology, increase contribution of the community to Indonesia's electricity sector, fostering an independent energy community.

3.2. Rules of rooftop PV implementation

3.2.1 Regulation of Ministry of Energy and Mineral Resource (MEMR) No. 49/2018

The Indonesian Government, represented by the Ministry of Energy and Mineral Resources (MEMR), the Directorate General of RE (EBTKE), and PT PLN (Persero), supports the development of rooftop PV in Indonesia by issuing Minister of Energy and Mineral Resources Regulation No. 49/2018 concerning the use of rooftop solar power generation systems. This regulation permits PLN customers to install rooftop PV systems on their building roofs. PLN's support for rooftop PV includes providing parallel facilities, creating a billing system to accommodate export-import offsets, offering credit deposits to Solar PV consumers, ensuring sufficient and appropriate reserve margins to manage the intermittency of solar PV, maintaining the reliability and quality of rooftop PV systems and their integration into the grid, and implementing a fair business scheme for both customers and PLN.

Regarding regulations related to customers and the calculation of the export and import of electricity from the SPP system, the capacity of the rooftop PV system is limited to a maximum of 100% of the connected power of PT PLN (Persero) customers. The electricity exported from rooftop PV systems is calculated based on the value of exported kWh recorded on the export-import meter, multiplied by 65%. The electricity usage for rooftop PV consumers is calculated monthly based on the difference between the imported kWh and exported kWh.

PT PLN (Persero) customers in the industrial tariff category can install and build rooftop PV systems according to the provisions of this Ministerial Regulation, whether connected (on-grid) and separate (off-grid) from the PT PLN (Persero) network. For rooftop PV systems connected (on grid) to the PT PLN (Persero) network, customers from the industrial tariff category are subject to capacity and emergency energy purchase charges as stipulated by the regulations. Conversely, for rooftop PV system installed and built separately (off grid) from the PT PLN (Persero) network, these customers are not subject to capacity and emergency energy purchase charges.

3.2.2 Regulation of MEMR No. 13 of 2019

Following the issuance of MEMR Regulation No. 49/2018, changes were made to the rules outlined in MEMR Regulation No. 13/2019. The changes are reflected in the rules regarding the development and installation of rooftop solar power generation systems. Article 8 of new regulation states that consumers of PT PLN (Persero) who undertook the construction and installation of rooftop solar power generation systems with an installed capacity greater than 200 kVA were required to obtain an operating permit in accordance with the provisions of electricity laws and regulations. This has been revised to state that all consumers of PT PLN (Persero) who undertake the construction and installation of rooftop solar power generation systems are now required to obtain an operating permit in accordance with the applicable laws and regulations in the field of electricity.

Article 11, contains of inspection and testing. The installation of rooftop solar power generation systems must have an Operational License (SLO). In accordance with the provisions of the laws and regulations in the field of electricity. For the system with a capacity of up to 25 kW, the SLO is part of the SLO for low-voltage electrical power utilization installations. Such installations are considered to have met the mandatory SLO requirements. The SLO is issued by an accredited testing institution (LIT) by specified the relevant laws and regulations: A list of LIT is available on the website of the Directorate General of RE and Energy Conservation, the Directorate General of Electricity, and PT PLN (Persero).

Other changes include the addition of new article between Article 16 and Article 17, designated as Article 16A.This new article stipulates that at the time this Ministerial Regulation comes into effect, Rooftop Solar Power Generation Systems that are in the process of applying for operating permits before the regulation takes effect shall have the permits issued in accordance with the provisions of this Ministerial Regulation. Additionally, Rooftop Solar Power Generation

Systems that are under construction and installation shall also have their SLOs issued according to the provisions of this Ministerial Regulation.

3.2.3 Regulation of MEMR No. 16/2019

In the same year, 2019, further changes were made to the regulations outlined in MEMR Regulation No. 16/2019. The changes are specified in other provisions.

Article 14 allows consumers of PT PLN (Persero) in the industrial tariff group to install and develop rooftop PV systems in accordance with the provisions of this Ministerial Regulation. This can be either connected (on grid) or disconnected (off grid) from the PT PLN (Persero) network system. If Rooftop Solar Power Generation Systems are connected (on grid) to the PT PLN (Persero) network, consumers in the industrial tariff group are subject to capacity charges and emergency energy purchase charges as stipulated by the laws and regulations. Conversely, if these systems are installed and developed separately (off grid) from the PT PLN (Persero) network, such consumers are not subject to these charges.

The regulations have been updated to improve the use of rooftop PV for industrial consumers and other commercial buildings. According to the amended Article 14 of MEMR Regulation No. 16/2019 (the second amendment of MEMR Regulation No. 49/ 2018), the following provisions apply: On-grid rooftop solar power generation systems are subject to capacity charges and are not subject to emergency energy purchase charges. Off-grid rooftop solar power generation systems are not subject to either capacity or emergency energy purchase charges. Rooftop Solar Power Generation Systems for personal use by non-consumers of PT PLN (Persero) must still comply with the provisions of the laws and regulations.

Consumers of PT PLN (Persero) in the industrial tariff group are permitted to install and develop rooftop PV generation systems either connected (on grid) or disconnected (off grid) from the PT PLN (Persero) network system. If the Rooftop Solar Power Generation System is installed, developed, and connected (on grid) to the PT PLN (Persero) network, consumers in the industrial tariff group are subject monthly capacity charges. The capacity charge is calculated based on the formula: capacity charge = total inverter capacity (kW) x 5 hours x electricity tariff. For on=grid systems, consumers are not subject to emergency energy purchase charges, which are part of the parallel operation costs. These consumers must also report the operational plan of the Rooftop Solar Power Generation System connected (on grid) to the PT PLN (Persero) network, consumer is not subject to capacity and emergency energy purchase charges.

Additionally, an article has been inserted between Article 16A and Article 17, designated as Article 16B. This article stipulates that the effective date of the Ministerial Regulation, Rooftop Solar Power Generation Systems installed and connected to the PT PLN (Persero) network (on-grid) based on previous regulations must comply with the new provisions regarding capacity charges and emergency energy purchase charges as outlined in this Ministerial Regulation.

3.2.4 Revised Regulation of MEMR No. 26/2021

Regarding the regulation on the export of electricity kWh, in Ministerial Regulation No. 26/2021 allows users of rooftop PV systems to export electricity up to 100% of the installed capacity of their Rooftop Solar Power Generation Systems. This provision enables users to distribute their electricity to the network owned by PT PLN (Persero). However, in this revised Ministerial Regulation, electricity generated by individuals from Rooftop Solar Power Generation Systems can only be used for their consumption. In other words, individuals cannot export the electricity produced by their rooftop solar power generation systems to PT PLN (Persero). This restriction is due to the challenges posed by excess electricity supply on the PT PLN (Persero) electricity network.

The oversupply of electricity, combined with the declining demand, creates difficulties for PLN'S electrical systems, which must be prepared to handle RE influx. The presence of rooftop PV necessitates that PLN prepare additional generators as buffers or followers, which increases operational costs. Furthermore, integrating rooftop PV requires investments in infrastructure such as Automatic Generation Control (AGC), accurate generation forecasting, Automatic Dispatch System, SCADA system upgrades, and others related technologies. The enforcement of Grid Codes may also lead to additional operating costs for PLN and Independent Power Producers (IPP).

In line with Presidential Regulation 22/2017 on the National Energy General Plan (RUEN), implementing rooftop PV on government buildings involves installing Rooftop Solar Power Generation Systems that cover a minimum of 30% of their roof area.

3.3. Discussion

3.3.1 Public response to regulatory changes

The use of Solar Power Plant (SPP) for rural electrification has significantly impacted the community's lives, leading to improvement in both economic and social conditions (Nugraha et al., 2013). The MEMR reported a significant increase in the utilization of rooftop SPP in Indonesia, with usage reaching 26%. The number of customers grew from 5,926 in July 2022 to 7,472 in July 2023. Feby Misna, Director of Various RE at the MEMR, stated, "Out of these customers, 2,692 are household SPP customers in West Java and Banten, while 1,732 household solar power customers are in DKI Jakarta" (Lavinda, 2023).

After the Government revised Regulation of the MEMR No. 26/2021 regarding rooftops PV, some solar rooftop users disconnected from the PLN grid (off-grid). The new scheme, which eliminates energy exports, limits customer quotas, and imposes the obligation for a Certificate of Feasibility Operation (SLO), is considered burdensome for rooftop PV customers. "Some of our members have been exploring off-grid options since 2018," said Yohanes Bambang Sumaryo, Chairman of the Solar Rooftop User Association (PPLSA) (Syahni, 2023a). According to Sumaryo, these customers are generally R3 customers - large households, with low voltage and power exceeding 600 VA (Syahni, 2023a). For fully off-grid customers, batteries serve as energy storage because Solar Power Plants generate electricity only during the day. These R3 customers are usually charged Rpc11,699 per kWh, in addition to local taxes and value-added tax. With removal of the export-import scheme and SLO requirements, coupled with the load analysis over the last three months, customers have found off-grid solution to be more competitive. At current price of around Rp12 million per kW, R3 customers can install a 20 kW off-grid system for Rp 140 million. Given an electricity tariff of Rp 2,000 per kWh, this price is expected to trigger a trend of R3 customers switching to off-grid systems. The potential for R3 customers in 2018 was estimated at around 2 million, with a potential capacity of up to 40 gigawatts. "These customers are not in remote or island areas; they are in urban areas."

In addition to diverting urban customers to off-grid systems, this revision also hampers the entry of new customers, as seen in Bali. The Solar Power Plant Bali Association noted that since the issuance of Bali Regional Regulation No. 45/2019 on Clean Energy in Bali, PLN UID Bali received 159 requests for rooftop solar power plants. However, as of February 2023, only two installations had been completed, representing just 1% of total requests. Meanwhile, 96% or 152 requests, have been surveyed, and 149 have been evaluated. Nationally, MEMR targets the development of 3.61 gigawatts of rooftop PV capacity by 2025. As of November 2022, there were 6,461 rooftop PV customers with a total capacity of 77.60 MWp. Throughout 2022, there was an average monthly increase of 2.4 megawatts and 138 customers. The majority of these customers are households, totaling 4,772, while the highest total capacity comes from the industrial sector, with 33.2 MWp. The revision of Regulation No. 26/2021 was initiated because the Solar Power Plant's achievements were falling short of the targets, and the implementation of rooftop PV regulations was not optimal. To accelerate the national rooftop PV program, incentives were introduced to avoid parallel operational costs and to provide extensive opportunities for the public to install PV rooftop without capacity limitations, as long as there is still a quota for development. However, the revision also eliminates electricity exports, which were initially beneficial for reducing customer bills, and imposes capacity limits regulated within the quota set by the Government.

According to Dadan Kusdiana, the Director-General of EBTKE at the MEMR , the revision is due to the potential loss of PLN's revenue of up to IDR 5.7 trillion per year (Umah, 2021). With an additional 450 megawatts peak in 2022, PLN must absorb 100% of this energy. In addition to his role as the Director of EBTKE and Acting Director-General of Electricity, Dadan has also been appointed Commissioner of PLN. Erlangga Bayu, Chairman of the Bali Rooftop Solar Association, examined PLN's statistics for 2021, which reported that the state-owned company's revenue was IDR 279 trillion. If the estimated value of rooftop solar energy is 75%, and it generates electricity for an average four hours per day, the energy savings would amount to IDR 108 billion per year or only 0.039% of PLN's revenue. "Where does PLN get such a report? PLN feels at a loss, which prompted a change in the regulations. KESDM is also following suit, urging PLN to hinder rooftop solar power plants" Bayu stated (Syahni, 2023a).

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Regarding funding, Lili from the Action for Ecology and Emancipation of the People (AEER) said financing for RE is still far from being realized. The target for RE financing in 2022 is IDR 60.61 trillion, but only IDR 23.6 trillion, or 38.94% of the target, has been fulfilled (Syahni, 2023a). The planned investment target for RE until 2030 is IDR 1,917 trillion. According to Lili, Indonesian state-owned banks should significantly fund RE projects, including rooftop solar power plants. Compared to Malaysia, bank financing for RE in Indonesia is still small. For example, Bank Mandiri disbursed less than IDR 2 trillion for RE during 2019-2020. Although BNI initially increased its disbursement, it later decreased and did not exceed IDR 2 trillion. In contrast, Malaysian banks, such as CIMB, Maybank, and Hong Leong, disbursed more than IDR 10 trillion during the same period.

AEER notes that financing RE projects is generally challenging. In 2019, 18 RE projects, including small hydropower plants, micro-hydro power plants, and biogas power plants, were still unfinanced. In 2021, 48 micro-hydro power plant projects and five hydropower projects also faced financing constraints. According to Lili, the obstacles include higher tariff rates compared to coal, the absence of project finance guarantees from state-owned banks, and similar risk levels across small, medium, and large-scale projects. She emphasized the need for incentives for national banking institutions to finance RE projects and disincentives for coal investments, as well as coordination across ministries and the Financial Services Authority (OJK)" (Syahni, 2023a).

Executive Director of Energy Watch, Mamit Setiawan explained that the limitation of rooftop solar power plant capacity has both advantages and disadvantages. On one hand, this policy may hinder the country's progress in RE (Sukmawijaya & Ananda, 2022). However, PLN currently has an excess supply of electricity, especially in the Java-Sumatra region. As a result, constructing more rooftop solar power plants could further reduce the demand for PLN's electricity. "This is like a double-edged sword: where we are pursuing the 23 percent energy mix target in 2025, but in the same time, we have an oversupply of electricity, especially in Java-Sumatra", Mamit explained.

According to Mamit, without limitations, PLN would face an even greater excess of electricity supply. Moreover, because rooftop solar power plants are intermittent and on-grid, PLN must prepare backup and transmission systems. This will undoubtedly impact PLN's operational aspects. Additionally, the increase in electricity supply from rooftop solar power plants will raise PLN's cost Burden, which will also increase the Government's burden. Mamit suggests that the Government and PLN should create potential demand or new markets to absorb this abundant electricity supply, especially given that the current electricity purchase scheme by PLN is still "take or pay" (TOP) (Sukmawijaya & Ananda, 2022).

Previously, the guidelines for limiting rooftop solar power plant capacity were expected to become a derivative regulation of MEMR No. 26/2021 concerning rooftop solar power plants connected to the electricity network of IUPTL holders for public purposes.

Some business actors believe that the Government needs to expedite the finalization of the revision of Ministerial Regulation No. 26/2021 concerning rooftop solar power plants, particularly in light of the stagnation of investment and installed capacity from solar panels over the past decade. Dion Jefferson, Chief Commercial Officer of SUN Energy, stated that the solar panel industry requires clear regulations on investment regulations and development due to the prolonged policy revision (Wahyudi, 2023a). "Finalize the revision of Regulation 26/2021 soon and implement it, so that industry players and customers have certainty regarding the rules of the game for rooftop solar power plants in Indonesia," Dion said when contacted.

Additionally, Dion mentioned that the PLN needs to expedite the bidding process for transitional energy ,projects such as Hijaunesia 2023 and dieselization programs, which still need to be implemented (Wahyudi, 2023a). The delay in bidding for these two PLN initiatives has also contributed to the stagnation in efforts to increase the capacity of solar power plants in the national electricity system today. "It seems that the synchronization or harmonization of MEMR and PLN throughout 2022-2023 is one of the causes," Dion added.

The installed capacity of solar panels in Indonesia by the end of 2022 is only 0.3 gigawatts (GW). This figure lags significantly behind Thailand and Vietnam, which recording capacities of 3.1 GW and 18.5 GW, respectively, in 2022. Indonesia is also trailing Malaysia, the Philippines, and Cambodia, which installed capacities of 1.9 GW, 1.6 GW, and 0.5 GW, respectively, in 2022. According to the electricity supply business plan (RUPTL) ending in 2030, PLN aims to achieve an installed solar panel capacity of 5 GW. Multinational management consultant McKinsey and Company projects that PLN must incorporate around 0.7 GW of electricity from solar panels into the system annually to meet achieve this target. However, the Chairman of the Indonesian Solar Module Manufacturers Association (APAMSI), Linus Andor Mulana Sijabat, believes that PLN still needs to demonstrate strong commitment to increasing the installed capacity of the solar energy (Wahyudi, 2023b).

Linus argues that the installed capacity of national solar panels has largely remain stagnant since 2012. He also notes that PLN is currently dealing with an oversupply of electricity due to the 35,000-megawatt (MW) coal and gas power plant program. "PLN's willingness is lacking because of the oversupply and various other reasons," he stated. On the other hand, Linus suggests that PLN should consider opening a quota for residential or household solar panel installations to address the stagnant installed capacity. He believes that providing more open access for the development of residential solar panels will encourage investment and increase the installed capacity within the PLN system in the future. "Why not just open the quota for rooftops directly? Open the rooftop quota to the public so that people can install it together" Linus added (Wahyudi, 2023b).

A market survey by the Institute for Essential Services Reform (IESR) in seven provinces in Indonesia from 2019 to 2021 revealed that the economy factors play a crucial role in determining whether residential customers adopt rooftop solar power plants. "The majority of respondents also seek at least 50% savings and a clear and fast installation process," said Marlistya Citraningrum, Manager of the Sustainable Energy Access Program at IESR. Citrangrum emphasized that the national strategic project (PSN) target of 3.6 GW of rooftop solar power by

2025 and be broader 23% RE target requires active public participation. With a market share of 20% among customers in the R2 and R3 categories (3,500 VA and above), there is a potential for 400,000 households across Indonesia, equivalent to 1.2 GWp of rooftop solar power plants, assuming each household installs a minimum of 3 kWp. Citraningrum also highlight that the spread of potential users across various cities in Indonesia means that the residential rooftop solar market could contributes to the creation of green jobs, such as technicians and installers, and support the growth of SMEs in the rooftop solar installation sector. "If the latest regulatory revision is approved with the currently clauses, the growth and opportunities for this green business will be hampered," she warned. AESI and IESR recommend that net metering should continue to apply to residential customers, with export-import calculations to be discussed further (Jati, 2023).

3.3.2 Destroying Solar Power Startups

The Clean Energy Technology Startup Community (KSTEB) has expressed concerned that the proposed policy changes may decrease public interest in installing rooftop PV, especially among residential customers. The removal of the electricity export scheme is expected to reduce the economic value of rooftop solar power plants, leading to smaller bill savings and a longer payback period. Amarangga Lubis, a member of KSTEB and founder of SolarKita, noted that eliminating the export-import scheme will likely decrease the interest of potential rooftop solar power plant customers. "The main concern with this proposed change is the loss of the export-import kWh meter, which will alter customer interest and affect the total available market," he explained. Similarly, Erlangga Bayu Rahmanda, a KSTEB member and founder of BTI Energy, believes that the proposed changes to the Regulation of MEMR could severely impact rooftop solar power plant startup. "The modification to the Ministerial Regulation on rooftop solar power plants could devastate startups like BTI Energy, which primarily serve residential customers." In the long term, this could also have detrimental effect on the rooftop solar power plant startup ecosystem in Indonesia (Syahni, 2023b).

Unsupportive energy policies like to deter prospective entrepreneurs from entering the solar power sector. The KSTEB has expressed concern that the proposed policy changes will hinder the Government ability to meet its rooftop solar power plant capacity target of 3,610 MW by 2025. As of November 2022, the installed capacity of rooftop solar power in Indonesia is only 77.6 MW, which is significantly below the Government's target. KSTEB has also raised concerns about the lack maximum capacity restriction based on a system quota, pointing out that the transparency of data on the quota system quotas, which is only accessible to PLN, is problematic. "Data openness is crucial to avoid the hindrance of rooftop solar power plant installations due to full system quota," stated Amarangga Lubis. He is worried that system quota data might be misused if kept private and believes that the technical definition of the system quota needs clarification. "I am concerned that the system quota may be adjusted to PLN's needs as a utility company" (Syahni, 2023b).

Erlangga expressed similar concerns. "The capacity is now limited per quota, which is because the quota is determined by the Electricity Supply Business License for Public Use (IUPTLU). They could declare the quota full and only update it every five years, effectively halting the addition of rooftop solar power plants for that period." KSETB is the first community in Indonesia to become a networking platform for clean energy technology startups. Initiated by New Energy Nexus Indonesia, KSTEB was established in 2022. Through KSTEB, clean energy technology startup enthusiasts can exchange ideas, information, and networks to support the growth of Indonesia's clean energy technology startup ecosystem. KSTEB has 50 clean energy technology startup members operating in the electricity, transportation, industrial, and construction sectors. These startups play a crucial role in Indonesia's efforts to transition to clean energy and mitigate climate change (Syahni, 2023b).

Various perspectives from stakeholders involved in the operation of rooftop solar power plants offer valuable insights for policymakers in creating regulations regarding the use of rooftop solar power plants in Indonesia. Exploring alternative solutions that balance the interest both the electricity provider (PLN) and consumers or individuals who wish to install rooftop solar power plants regulations, it is essential to examine rooftop solar power plant regulations in various countries.

3.3.3 Comparison of Rooftop Solar Regulations in Various Countries

Countries implement various RE policies, including those related to rooftop solar panels. For examples, Australia has a FIT policy, reduced sales tax, energy tax, CO_2 tax, and other tax incentives, along with tradable certificates for RE. The FIT – standard offer contract, advanced renewable tariff, or RE payment – is a policy mechanism designed to accelerate investment in RE technologies. It does so by offering long-term contracts to RE producers, promising prices above the market rates to provide price certainty and help finance RE investments. Typically, FIT offer different prices for various RE sources to encourage the development of specific technologies (Couture & Gagnon, 2010; Gipe, 2006; NREL, 2010).

Next, Japan implements a range of policies for RE, including a FIT policy, utility electricity quota obligations, capital subsidies, reduced sales tax, energy tax, CO_2 tax, other taxes, and tradable certificates for RE. The Philippines has had an effective FIT since July 2012, which guarantees fixed tariffs for solar projects. This tariff is valid for 20 years and include a 6% reduction rate after the first year. Additionally, net metering rules were established in May 2013. India employs various policies similar to those in Japan and the Philippines, such as FIT, utility electricity quota obligations, capital subsidies, reduced sales tax, energy tax, CO_2 tax, other taxes, and tradable certificates for RE. Similarly, Indonesia also has adopted policies akin to those in India, including FITs, utility electricity quota obligations, capital subsidies, reduced sales tax, energy tax, CO_2 tax, and other taxes, as well as tradable certificates for RE.

Furthermore, Bulgaria has an integrated plan for energy and climate from 2021 to 2030, aiming to develop the RE sector to account for 27% of gross final consumption. The Bulgarian Government expects the installed PV capacity to triple by 2030. However, there is no specific roadmap or substantial plan for rooftop installations, despite being mention in the National Energy and Climate Plans. While the concept of one-stop shop for rooftop PV development has been proposed, it has yet to be implemented.

Indonesia, the current oversupply of electrical energy raises questions about whether the Government might introduce more favorable regulations for consumers regarding rooftop solar installations. This situation is somewhat contradictory: while Indonesia faces an oversupply of electricity, there is a need to increase the share of RE, including rooftop solar, which would also benefits consumers. As of the end of 2023, there is no certainty regarding changes in rooftop solar regulations in Indonesia. The Government needs to clarify this issue to ensure that no party are disadvantaged.

3.3.4 Relation PV rooftop regulations with pro-environment behavior

A combination of psychological and social factors influences pro-environmental behavior (PEB). Psychographic factors such as environmental awareness, economic awareness, reliability awareness, and environmentally friendly appearance play a crucial role in shaping individuals' understanding of the environmental and economic benefits of PEB. These factors include general awareness, knowledge, and individuals' commitment to the environmental issues.

Social factors also contribute to PEB, including social influence and green self-identity. Social influence relates to how individuals perceive the acceptance of a pro-environmental lifestyle by family and friends within their social environment. Green self-identity reflects an individual's commitment to the environment and the pride associated the adopting PEB.

Affordability is an essential variable influencing PEB. This can be assessed by the price and accessibility of environmentally friendly products. If the price is prohibitive or obtaining these products is challenging, it can serve as a barrier to adopting PEB (Permanaa et al., 2023).

Individual attitudes toward the environment play a key role in shaping PEB. Individuals with a positive attitude toward nature and the environment are more likely to engaged in PEB (Schultz, 2001). The level of knowledge about environmental issues and understanding the impact of human activities on the environment can motivate individuals to take pro-environmental actions. Environmental education can enhance this awareness and understanding (Kaiser et al., 1999).

Social norms can significantly influence PEB in society. When individuals perceive that society accepts and values pro-environmental actions, they are more likely to adopt those behaviors (Cialdini et al., 1990). Belief that personal actions can positively impact the environment can enhance motivation to engage in PEBs. Additionally, self-control or confidence in one's ability to effect change plays an important role in this process (Stern, 1999).

Economic factors, including costs and benefits, also affect PEB. Individuals are more likely to adopt environmentally friendly behaviors if this actions are perceived as economical and offer significant benefits (Thøgersen, 2006). Furthermore, personal beliefs and values influence PEB. For example, individuals with high environmental values are more likely to engage in pro-environmental actions (Dunlap et al., 2000).

The availability of resources, such as recycling facilities, public transportation, or RE, can influence the ease which individuals adopt PEB (Steg & Vlek, 2009). Information disseminated through media and technology plays crucial role in shaping individuals' attitudes and knowledge regarding environmental issues, thereby influencing their behavior (O'Neill & Nicholson-Cole, 2009). Additionally, direct experiences with the environment, such as visits to natural areas, can positively impact pro-environmental attitudes and actions (Taylor, 2005).

Considering the economic perspective, particularly individual income, is interesting when examining factors influencing PEB. Individuals are more likely to engage in pro-environmental actions if these are perceived as economical and offer significant benefits (Thøgersen, 2006). This economic consideration becomes particularly relevant when discussing consumer behavior in adopting rooftop solar panels as a form of PEB. The installation costs of rooftop solar panels are substantial, which can affect the willingness of individuals to adopt this technology.

Therefore, to encourage society's role in increasing RE usage and reducing carbon emissions, policies that facilitate the adoption of rooftop solar panels must be developed while considering the conditions of the electricity providers. A win-win solution in policy-making is essential, and its effectiveness would be enhanced by supportive innovations.

4. Conclusion and suggestion

The adoption of rooftop PV and the accompanying regulatory changes in Indonesia present unique challenge for electricity providers, policymakers, and consumers. Indonesia faces an obligation to increase the percentage of RE use, and one viable solution is the widespread adoption of rooftop solar panels by consumers as a form of PEB. However, the current regulations governing rooftop solar panels are often seen as unfavorable to consumers. Therefore, it is essential to adjust these regulations to provide a win-win solution for all parties involved. This adjustment could be informed by comparative studies with other countries. Despite the current oversupply of electricity in Indonesia, the focus should remain on reducing reliance on fossil fuels for electricity generation. Comprehensive strategic decisions are necessary in this context. Further research should aim to develop strategies, innovations, and scenarios that offer a win-win solution for the implementation of rooftop solar panels, benefiting all stakeholders.

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