Analysis of Stakeholder Roles in On-Grid Rooftop Solar PV Implementation in Klaten Regency

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Abstract

This study aims to map the implementation of on-grid rooftop solar photovoltaic (PV) in Klaten Regency by 2026 and analyze the relationships and roles of stakeholders involved. The study used a mixed methods approach, combining qualitative and quantitative approaches. Primary data were obtained through field observations and interviews, while secondary data came from scientific literature, government policy documents, and official publications. Data analysis was conducted using ATLAS.ti to map rooftop solar power plant implementation and the MACTOR method to analyze the dynamics of relationships between identified actors based on the pentahelix concept, including academics, business actors, the community, government, and the media. The results show that the mapping of rooftop solar power plant implementation in Klaten Regency yielded five categories: regulations, licensing mechanisms, customer sectors, installation objectives, and barriers. Based on the MACTOR analysis, PLN UP3 Klaten and Cabang Dinas ESDM Wilayah Merapi are the actors with the highest influence and the strongest levels of convergence and divergence among all actors involved. Overall, actors are divided into four roles: regulator, executor, supporting institution, and end user. Collaboration between actors, particularly in terms of outreach and licensing, needs to be continuously maximized to encourage more equitable implementation of rooftop solar photovoltaic across all sectors in Klaten Regency. In addition, incentive support and affordable financing schemes for households and small businesses are needed, more consistent regulatory alignment at the national and regional levels, and additional quotas to accommodate increasing demand from the industrial sector.

Keywords: rooftop solar photovoltaic, renewable energy, stakeholder, MACTOR, ATLAS.ti, Klaten Regency

INTRODUCTION

Electrical energy plays a vital role in supporting economic, social, and daily life activities. The availability of reliable and sustainable electricity is key to driving national growth and development (Yana et al., 2022). However, fossil fuels will still dominate the national electricity supply by 2024, accounting for more than 85% of the total national energy supply (Kementerian Energi dan Sumber Daya Mineral, 2025). This makes the energy system vulnerable to price and supply fluctuations (Permana & Puspitaningsih, 2026). It also triggers greenhouse gas emissions, air pollution, and global climate change.

Responding to this and supporting the Paris Agreement commitment, the government set a target for the renewable energy mix through Government Regulation (PP) No. 40/2025 concerning national energy policy (KEN), namely 19-23% in 2030, 36-40% in 2040, 53-55% in 2050, and 70-72% in

2060. This regulation is a revision of Government Regulation (PP) No. 79/2014, which previously targeted a 23% EBT mix in 2025 and a minimum of 31% in 2050, but only achieved 15.75% in 2025 (Kementerian Energi dan Sumber Daya Mineral, 2026).

To address this, efforts are needed to optimize the use of renewable energy resources. Solar energy is a viable option given Indonesia's equatorial location (Kadang & Windarta, 2021), with a potential of up to 7,700 GW (IESR, 2025). One implementation of solar energy utilization is rooftop solar PV, often referred to as Rooftop Photovoltaic (PV), which are specifically regulated in Permen ESDM No. 2/2024.

Rooftop solar PV can save up to 57-100% on electricity bills per month (Prasetio et al., 2025). However, their adoption is still hampered by high initial investment costs (Prasetio et al., 2025) and limited public understanding of rooftop solar PV (Nurjaman & Purnama, 2022). Therefore, accelerating the development of rooftop solar PV requires multi-stakeholder collaboration between the government, industry, financial institutions, and civil society (Wiriana, 2025).

Central Java Province demonstrated a strong commitment to solar energy development through the "Central Java Solar Province" forum in 2019. Based on data from the Central Java Provincial Statistics Agency (BPS), rooftop solar power plant capacity continues to increase from 12.61 MWp in 2021 to 85.84 MWp in 2025. This increase reflects the support of various stakeholders in driving the energy transition at the regional level.

Klaten Regency is one of the regions with outstanding achievements in the implementation of rooftop solar PV in various sectors. In the industrial sector, Danone Group through PT Tirta Investama installed a rooftop solar power plant with a capacity of 2.9 MWp in 2020 and became a pioneer and pilot industrial sector in Central Java Province (IESR, 2020), which was then followed by PT Sarihusada Generasi Mahardhika with a capacity of 828 kWp in 2025 (PT Sarihusada Generasi Mahardhika, 2025).

In the public facilities sector, Pasar Gedhe Klaten with a capacity of 207.9 kWp installed in 2023 was recorded as the first traditional market in Indonesia to use rooftop solar PV and was designated as a national pilot (KR Jogja, 2023). Rooftop solar PV are also implemented in the retail sector through the Amigo Group, with a capacity of 20.52 kWp at its store branch (Espos, 2017). Furthermore, several communities have also implemented rooftop solar PV on a household scale.

Research on rooftop PV in Indonesia has been examined from various perspectives, encompassing technical-economic aspects such as investment feasibility and payback period (Zulni & Bandri, 2023; Prasetio et al., 2025), as well as social aspects such as drivers and barriers to adoption among the community (Haryadi et al., 2021; Afifi et al., 2025).

These findings emphasize the importance of multi-stakeholder engagement, as demonstrated in a study of renewable energy stakeholder mapping, which demonstrated the interconnected roles of the Ministry of Energy and Mineral Resources (ESDM), PLN (State Electricity Company), local governments, business actors, financial institutions, and the community (Yudha & Tjahjono, 2019). At the national level, Chairahman et al. (2024) further identified the Ministry of ESDM as the most influential actor in Indonesia's rooftop solar ecosystem, while contractors demonstrated the highest dependence on other actors such as central and regional government agencies, electricity grid operators, and financial institutions.

Similar patterns are also found internationally; in Shanghai, interactions between actors in residential rooftop solar development are still dominated by government and industry actors, with limited community involvement, accompanied by obstacles such as ineffective top-down policy implementation and high initial investment

costs (Sheng & Liu, 2023). In line with this, the stakeholder classification study using Mendelow's Power-Interest Matrix places local governments, regional energy development agencies, and local communities as key players with high interest and power, while financial institutions and market players have high power but relatively low interest (Dutta & Das, 2020).

However, these studies generally focus on the national level or the context of large cities, while similar studies at the district/city level in Indonesia are still very limited. This gap underlies this research, given that Klaten Regency is a region with a proven track record of rooftop solar PV implementation, serving as a model at both the provincial and national levels. However, there has been no specific study on the roles and relationships between stakeholders within it.

RESEARCH METHODOLOGY

This study uses a combined qualitative and quantitative approach in Klaten Regency, Central Java Province, in 2026. Primary data were obtained from field observations and interviews with stakeholders. Secondary data were sourced from literature, policy documents, and publications from BPS, the Ministry of ESDM, and PLN. The sample was determined using the Penta Helix approach, consisting of 11 actors representing:

1. Academics (Economics/ekonomi, Environment/lingkungan, Electrical engineering/teknik elektro)
2. Business (PT Tirta Investama, CV Amigo Mangesti Utomo, Pasar Gedhe Klaten)
3. Community (Masyarakat)
4. Government (Cabang Dinas ESDM Merapi or Merapi Regional Branch of the Energy and Mineral Resources Office, PLN UP3 Klaten, Bapperida Klaten)
5. Media (Radar Solo).

Data were analyzed using ATLAS.ti to map the implementation of rooftop solar PV, and the MACTOR method to examine the relationships among stakeholders. The analysis of inter-actor relationships uses the Matrix of Direct Influences (MDI), which is assessed based on four dimensions: communication (information exchange and policy dissemination), coordination (alignment of actions between actors), licensing (compliance with installation requirements, reporting, and quota approval), and facilities (provision of supporting facilities for access to information and licensing).

Meanwhile, the analysis of actor interests uses the Matrix of Actors x Objectives (MAO) based on nine objectives: 1) reducing electricity bills, 2) creating jobs in the renewable energy sector, 3) increasing public awareness, 4) increasing human resource capacity, 5) improving agency/institution image, 6) reducing dependence on fossil fuels, 7) reducing greenhouse gas emissions, 8) increasing the utilization of solar energy potential, and 9) strengthening regional energy independence and resilience.

RESULTS AND DISCUSSION

1. Mapping the Implementation of Rooftop Solar PV

The national regulation governing rooftop solar PV is Minister of Energy and Mineral Resources Regulation (Permen ESDM) No. 2/2024, which regulates the quota mechanism for prospective customers. At the regional level, energy management in Central Java is governed by Regional Regulation (Perda) No. 12/2018 on the Regional General Energy Plan (RUED-P), which sets a phased regional energy mix target ranging from 10.32% (2018) to 28.82% (2050) as the region's contribution toward the national target.

As a follow-up, the Governor's Circular Letter (Surat Edaran Gubernur) and the Regional Secretary's Letter (Surat Sekretaris Daerah) of Central Java (2019) urged government and private buildings to utilize rooftop solar PV to accelerate the achievement of this target. As regencies/cities have no authority over the energy sector,

rooftop solar PV policy in Klaten Regency fully refers to national and provincial regulations.

The licensing mechanism for rooftop solar PV in Klaten Regency follows the provisions of Minister of Energy and Mineral Resources Regulation (Permen ESDM) No. 2/2024, beginning with a quota application to PLN UP3 Klaten via the PLN Mobile application, which is open every January and July. Once the quota is obtained, customers proceed with licensing according to installation capacity: a Mandatory Report (Wajib Lapor) for capacities ≤500 kW (kilowatt), submitted through the SIGANTENG system or, if there are issues, directly at the Cabang Dinas ESDM Wilayah Merapi.

For capacities >500 kW, customers must obtain a Business License for Self-Use Electricity Supply (IUPTLS) through OSS-RBA. Installation is then carried out by a contractor certified with an Electricity Supply Services Business License (IUJPTL), followed by an operational feasibility test (SLO/Sertifikat Laik Operasi), before the system is finally connected to the PLN grid through the replacement of the meter with an advanced meter.

In addition to its licensing function, the Cabang Dinas ESDM Wilayah Merapi also carries out supervision and control (Wasdal) of electrical safety for operating rooftop solar PV installations, covering both administrative aspects (completeness of licensing and SLO) and technical aspects (physical condition of the installation). Wasdal is conducted randomly and conditionally, with its scope limited to installations that have reported through Wajib Lapor or IUPTLS, meaning that unreported installations are potentially left unmonitored. So far, findings have been minor, such as poorly maintained inverters or dirty panels, with no significant technical issues identified.

Rooftop solar PV customers in Klaten Regency come from four sectors: industry (bottled drinking water/AMDK, nutritional products, garment, textile, and footwear), business (markets & clothing stores), social (schools & hospitals), and households (community members). Of the 37 total customers, the business sector has the highest number of customers (11), followed by the industrial sector (10), while the social and household sectors each account for 8 customers.

In terms of installed capacity, however, the industrial sector dominates with a total of 4,766.6 kWp (90.8%) out of the overall capacity of 5,250.57 kWp, far surpassing the business sector (376.37 kWp; 7.2%), the social sector (84.5 kWp; 1.6%), and the household sector (23.1 kWp; 0.4%). This dominance in installed capacity aligns with quota application trends, which are similarly led by the industrial sector, driven by growing demands among businesses to shift toward environmentally friendly energy.

The installation of rooftop solar PV in Klaten Regency is driven by five main objectives. Savings on electricity bills is the biggest motivation, with savings of around 11% at PT Tirta Investama, 20–30% at Amigo Group, and 30–40% at Pasar Gedhe Klaten. Furthermore, rooftop solar PV are used as a form of environmental commitment, contributing to carbon emission reductions reaching 3,340 tons of CO_2 per year at PT Tirta Investama and 934 tons of CO_2 per year at PT Sarihusada Generasi Mahardika.

The industrial sector is also driven by global demands for environmentally friendly energy to maintain relationships with consumers and business partners. Image enhancement is also a consideration, as reflected in the case of PT Uni-Charm Indonesia Tbk., whose adoption of rooftop solar PV contributed to improved corporate image alongside greater energy independence, operational cost efficiency, reduced carbon emissions, and increased employee awareness of environmental issues (Rahardjo et al., 2025).

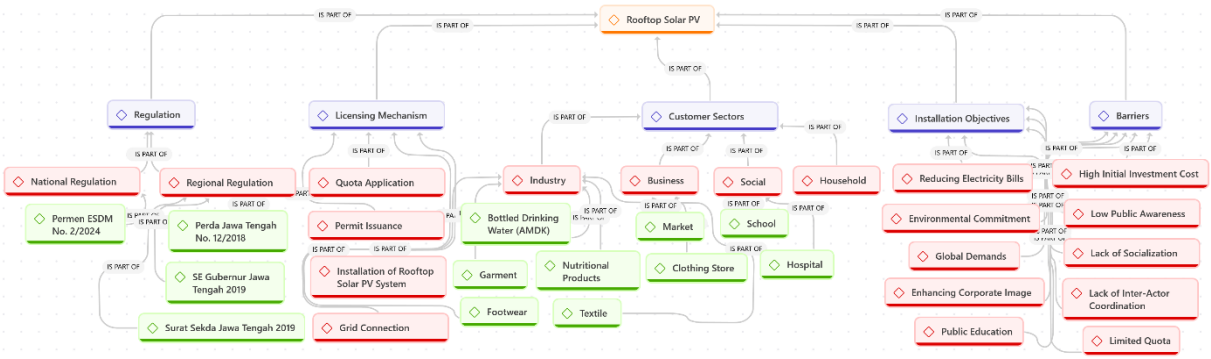
A similar motivation is evident in Amigo Group, which uses it as a marketing

strategy, and Pasar Gedhe Klaten, which has become an iconic traditional market based on renewable energy and a national model. Furthermore, the presence of rooftop solar PV serves as a means of educating the public about the use of solar energy through public facilities and campaigns on social media.

The implementation of rooftop solar PV in Klaten Regency still faces several major obstacles. High initial investment costs have resulted in low adoption of rooftop solar PV in the household sector, reflected in the household sector's installed capacity, which only reaches 0.4% of the total rooftop solar PV capacity in Klaten Regency.

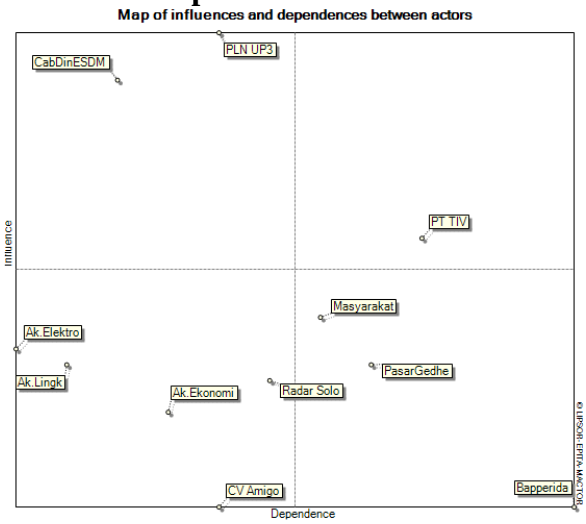
Other obstacles include low public awareness and minimal outreach regarding the benefits and mechanisms of rooftop solar PV. Furthermore, coordination between stakeholders is suboptimal due to the centralized authority of the energy sector.

The limited quotas set by the central government also pose a challenge, amidst increasing demand for rooftop solar installations, particularly from the industrial sector. This constraint aligns with the findings of Dzulkifli et al. (2024), who identified the limited quota system as a major weakness of the current rooftop solar regulation in Indonesia, despite the regulation's strengths in providing government support, legal certainty, and eliminating installation capacity restrictions.



Picture 1. Map of the Implementation of Rooftop Solar PV in Klaten Regency

2. Relationship Between Stakeholders



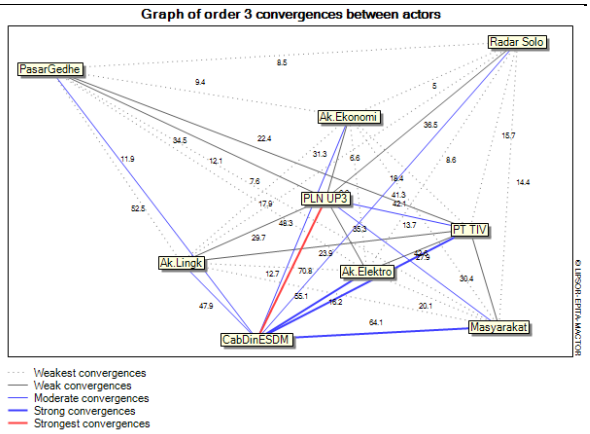
Picture 2. Map of Influence and Dependen Between Actors

The influence and interdependence between these factors are shown in the map above, creating four quadrants. Quadrant I (Influential Stakeholders) is occupied by PLN UP3 Klaten and the Merapi Region ESDM Branch, which have high influence and low dependency. PLN UP3 Klaten acts as the party that approves rooftop solar power plant quotas and grid interconnections, while Cabang Dinas ESDM Wilayah Merapi is authorized to receive reports and oversee electricity supply for its own purposes.

Quadrant II (Relay Stakeholders) is occupied by PT Tirta Investama, which has equally high levels of influence and dependency. This company pioneered the implementation of rooftop solar PV in the industrial sector and serves as a role model for other industries. However, its implementation remains dependent on approval and supervision from PLN UP3 Klaten and Cabang Dinas ESDM Wilayah Merapi.

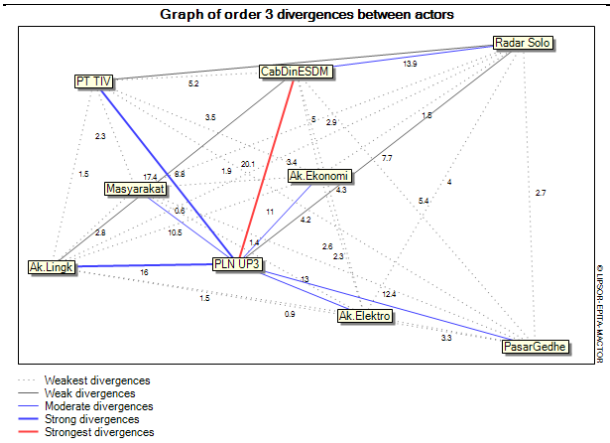
Quadrant III (Dependent Stakeholders) consists of the community, Pasar Gedhe Klaten, and Bapperida, which have low influence and high dependency. The community and Pasar Gedhe are highly dependent on interconnection approval from PLN UP3 Klaten to install rooftop solar PV. Meanwhile, Bapperida has limited involvement because the district/city does not have authority in the energy sector, so it only acts as a recipient of information from outreach activities organized by Cabang Dinas ESDM Wilayah Merapi.

Quadrant IV (Autonomous Stakeholders) includes Economics Academics, Environmental Academics, Electrical Engineering Academics, Amigo Group, and Radar Solo, which have low influence and dependency. Academic involvement at the district level is still limited because collaboration is mostly carried out at the provincial and national levels. Amigo Group has low dependency because the installation of rooftop solar PV at its store was carried out before the mandatory reporting requirement to the Merapi Regional ESDM Branch, so the licensing process only refers to PLN UP3 Klaten. Meanwhile, Radar Solo only plays a role as a publication media without being involved in the decision-making process.



Picture 3. Mapping Chart of Convergences Between Actors

Convergence between actors indicates the extent to which each actor shares common interests. This common interest allows for the formation of interactions and alliances between actors. The strongest convergence occurred between PLN UP3 Klaten and Cabang Dinas ESDM Wilayah Merapi, as both are key actors in the licensing of rooftop solar PV in Klaten Regency. Of the nine objectives analyzed, both actors shared a common view in supporting six of them: reducing electricity bills, creating jobs in the renewable energy sector, increasing human resource capacity, enhancing the agency's image, optimizing solar energy utilization, and reducing greenhouse gas emissions. Furthermore, both agreed that increasing public awareness of environmentally friendly energy has yet to be achieved, given the low level of public understanding and interest in rooftop solar PV.



Picture 4. Mapping Chart of Divergences Between Actors

Divergence between actors shows the many differing interests held by each actor. These differing interests can lead to conflict between actors. The strongest divergence is connected by the red line. The conflict between PLN UP3 Klaten and Cabang Dinas ESDM Wilayah Merapi arose from differing views on two goals: reducing dependence on fossil fuels and empowering regional energy independence and resilience.

Cabang Dinas ESDM Wilayah Merapi supports both goals because it believes the growing use of rooftop solar PV in Klaten Regency is clear evidence of reduced dependence on fossil fuels and strengthened regional energy independence, as mandated by the RUED-P of Central Java. However, PLN UP3 Klaten opposes this, believing that Klaten Regency's electricity system is still dependent on PLN's electricity supply.

The relationship between PLN UP3 Klaten and Cabang Dinas ESDM Wilayah Merapi shows a unique pattern, where both are simultaneously a pair of actors with the strongest convergence and divergence. The strong convergence is based on the shared mandate of both actors in supporting the energy transition and increasing the renewable energy mix in accordance with national policies and the RUED-P of Central Java. This is reflected in PLN's role in facilitating rooftop solar PV quota applications through PLN Mobile, as well as the Department of Energy and Mineral Resources or Dinas ESDM's role in overseeing and serving permits for electricity supply for its own purposes through the SIGANTENG system.

However, on the other hand, the two actors also have strong divergences due to differences in roles and interests, where PLN focuses on the reliability and stability of the electricity system, which is the basis for implementing the quota system for rooftop solar PV installations, while Dinas ESDM is more focused on accelerating the expansion of rooftop solar PV use to support the achievement of regional renewable energy mix targets.

Thus, although both have aligned interests in supporting the energy transition in general, the differences in functional orientation between them have the potential to create tensions in the implementation of rooftop solar PV in the field. Thus, although both have aligned interests in supporting the energy transition in general, there are also differences of opinion due to the different focus of roles and interests in the implementation of rooftop solar PV.

3. The Role of Stakeholders

The implementation of rooftop solar PV in Klaten Regency involves various stakeholders with different roles according to their respective authorities, indicating that this process is collaborative and requires synergy between actors.

In this study, no actor acts as a regulator, because the authority in the energy sector is at the provincial level through Dinas ESDM Provinsi Jawa Tengah (Central Java Provincial Energy and Mineral Resources Office) and Cabang Dinas ESDM Wilayah Merapi, while the quota for on-grid rooftop solar PV is fully determined by the central government (Ministry of ESDM and PT PLN) without additional authority for PLN UP3 to change it.

Based on these conditions, the research actors are divided into three roles. As the executor, PLN UP3 Klaten manages licensing, from accepting on-grid quota

applications to replacing meters with advanced meters. Meanwhile, Cabang Dinas ESDM Wilayah Merapi manages Wajib Lapor permits and IUPTLS inspections as a form of regional oversight in providing electricity for its own needs.

As a supporting institution, Bapperida supports regional development planning, the media plays a role in disseminating information to the public, while academics in economics, the environment, and electrical engineering provide research support and academic insights into the development of rooftop solar PV. As end users, PT Tirta Investama, CV Amigo Mangesti Utomo, Pasar Gedhe Klaten, and the general public are the primary beneficiaries, with adoption rates heavily influenced by regulations related to quotas, permits, and government policies.

CONCLUSION

This study concludes three things. First, the mapping of rooftop solar PV implementation in Klaten Regency yields five categories: regulations, licensing mechanisms, customer sectors, installation objectives, and barriers. Second, PLN UP3 Klaten and Cabang Dinas ESDM Wilayah Merapi are the most influential actors, while Bapperida and PT Tirta Investama have the highest dependency. The strongest convergence and divergence occur between PLN UP3 Klaten and Cabang Dinas ESDM Wilayah Merapi.

Third, the role analysis identifies the Ministry of ESDM, PT PLN, and Dinas ESDM Provinsi Jawa Tengah as regulators; PLN UP3 Klaten and Cabang Dinas ESDM Wilayah Merapi as executors; Bapperida, Radar Solo, and academics as supporting institutions; and PT Tirta Investama, CV Amigo Mangesti Utomo, Pasar Gedhe Klaten, and the community as end users.

RECOMMENDATION

Cabang Dinas ESDM Wilayah Merapi and PLN UP3 Klaten need to increase outreach and education regarding the benefits and licensing mechanisms for rooftop solar PV more extensively, by involving local governments, academics, the media, and business actors to expand the implementation of rooftop solar PV and support the achievement of energy mix targets and greenhouse gas emission reductions. In addition, the government needs to provide incentives and subsidies to make the use of rooftop solar PV more affordable for all groups, and consider increasing quotas and application periods to accommodate the increasing trend of demand from the industrial sector that is starting to shift to renewable energy.

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