# Community-based centralized solar mini-grid management for rural electrification: Evidence from remote villages

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**Abstract.** Centralized solar mini-grid Program (PLTS Terpusat) is a policy issued by the Indonesian government to assist rural electrification in remote villages. Muara Enggelam, Labuangkallo and Balikukup villages are remote villages that have received centralized solar mini-grid grants from the Central and Provincial Governments. This study aims to capture community-based centralized solar mini-grid management for rural electrification in remote villages based on a logic model perspective. Data collection was carried out qualitatively by conducting interviews with local authority, community leaders, business actors, community, and solar mini-grid managers unit. The results of the study show that solar off-grid managed by the community includes: (1) Inputs: community involvement, technical and managerial competence, and sustainable budget; (2) Processes: integrated with business local, community contribution, community commitment, and monev; (3) Outputs: rural electrification, and socioeconomic benefit. However, there are several obstacles in the management of the Solar off-grid in Labuangkallo and Balikukup Village, namely the community's commitment to providing monthly contributions and the weak leadership of the village government in managing the Solar off-grid.

## 1 Introduction

The state has an important role in providing public goods such as electricity to meet people's needs [1]. Government is trying to overcome the problem of the basic electricity needs of remote communities, one of which is through public policy [2]. One of the largest energy sources in Indonesia is solar. Research found that Indonesia has the potential for solar energy about 208 GW out of 443 GW [3]. This means that the solar energy development policy is a

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potential and appropriate policy for the government to implement for increasing electrification and the welfare of rural communities. The Government of the Republic of Indonesia issued a policy for rural electrification in rural areas through Law Number 30 of 2007 concerning Energy. Article 20 paragraph 1 of the Law states that the central government or regional governments can utilize and manage renewable energy (RE) for 3T areas (remote, under-developed and outermost). Centralized solar mini-grid is an alternative energy source in reaching energy needs in developing countries, especially remote and underdeveloped areas such as the outermost islands to increase the electrification ratio [4–6]. Centralized solar mini-grid is a power plant that converts solar energy into electricity using photovoltaic modules, and the energy produced is then distributed to users through the electric power network [7].

The Province of East Kalimantan through the ESDM Agency has granted 28 units of centralized solar mini-grid from 2014-2018 for remote villages that unelectrified. Scholars found that village communities have benefited from centralized solar mini-grid such as: lighting, changes in social activities, increased household productivity, and the emergence of informal businesses [8–12]. This has in fact had an impact on opening jobs, new income, and household expenses [13]. Conceptually it was also found that the use of RE had an impact on the socio-economic conditions of beneficiary communities such as increased income, business productivity, new jobs, and community capacity [14–16]. However, after three years of operation, solar mini-grid management found various problems such as power theft, payment delays, damaged components and even reduced electrical power performance. There are indications that community-based centralized solar mini-grid management was not working properly. On the one hand, it is found that solar mini-grid management was sustainable and provides socio-economic impacts and independent financing for its operations. This means that there are still differences in community-based centralized solar mini-grid management.

Several previous studies have looked at the feasibility, potentials analysis, and technical aspects of Centralized PV mini-grid [3,17], impact of solar PV mini- grid [15,18–20], and renewable energy policy [21–24]. How to manage community-based centralized PLTS and what factors influence it is still rarely explored, especially in remote villages in Indonesia. The Centralized PLTS business model known so far includes maintenance, utilization and financing managed by BUMDes or community groups [25]. Palit and Kumar describe the most significant factors in managing Centralized PLTS in India as Political, Economic and Financial factors [26]. Then Streimikiene analyzed what aspects are important in managing renewable energy, namely Economic, Financial, Political, Regulatory and Socio-Cultural [27]. This study is important, several previous studies have never analyzed how to manage ideal and sustainable community-based centralized PLTS.

This research aims to capture how community-based centralized PLTS is managed in remote villages and what factors influence it based on a logic model perspective (input, process, and output) [28]. The significance of this research is that it is hoped that it can contribute to the development of an ideal centralized solar mini-grid community-based management model in remote villages in Indonesia.

## 2 Research methods

### 2.1 Types of data and research models

This research is qualitative research by conducting in-depth interviews with various informants. Informants were selected based on their sufficient knowledge and experience in managing Centralized PLTS. The research was conducted in Labuangkallo Village which received a Special Allocation Fund (DAK) in the form of Centralized PLTS, Muara Enggelam and Balikukup Village which received a Centralized PLTS grant from the Ministry of Energy and Mineral Resources. Interviews were conducted with village government, community leaders, business actors, the community, and Centralized PLTS managers. The research locus was chosen based on the duration of management which was carried out > 5 years and having remote geographical conditions far from electricity. To make data analysis easier and more practical, every meaning obtained from the interview transcripts will be coded by the author using the ATLAS.ti tool. ATLAS.ti software will make it easier for researchers to process coding and data analysis between variables [29].

## 2.2 Unit analysis

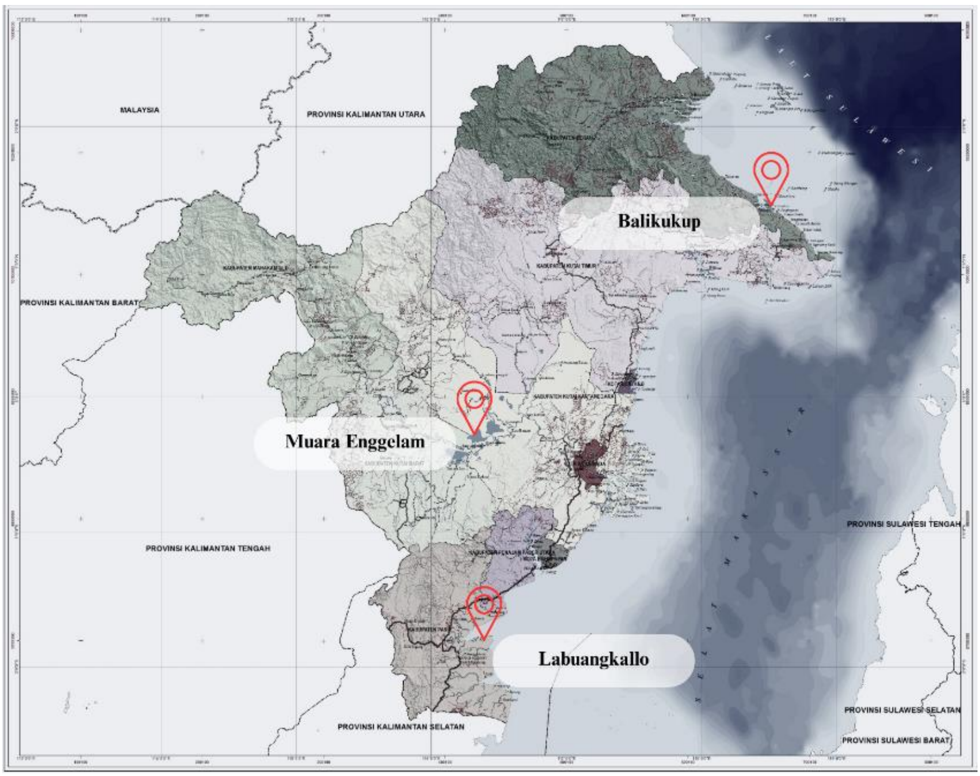


**Fig. 1.** Location of Muara Enggelam, Labuangkallo and Balikukup Villages.

Labuangkallo Village (see figure 1) is one of the remote villages that received a Centralized PLTS grant with a capacity of 67.2 kWp with power for each house of 200 watts per day. This villages located in the eastern part of Paser Regency which has limited access to basic services, especially electricity. This village has been given a Centralized PLTS since 2017 through DAK. The management of Centralized PLTS in Labuangkallo Village has gone through various obstacles and currently, the revitalization of the batteries and solar panels of Centralized PLTS has been carried out. Muara Enggelam and Balikukup Village is two of the villages that received a Centralized PLTS grant from the Directorate General of EBTKE of the Ministry of Energy and Mineral Resources with a capacity of 100 kWp with power for each house of 350 – 400 watts per day. Muara Enggelam located in remote villages near Melintang Lake in Muara Wis District, Kutai Kartanegara Regency. Balikukup Village is one of the villages that received a Centralized PLTS grant from the Directorate General of

EBTKE of the Ministry of Energy and Mineral Resources with a capacity of 100 kWp with power for each house of 400 watts per day. This village located in the island area of Batu Putih District, Berau Regency and has minimal access to basic services, especially electricity.

# 3 Result and discussion

We captured that the management of Centralized PLTS in Muara Enggelam, Labuangkallo and Balikukup Villages is completely managed by the community formed by the village government. The management of the Centralized PLTS below has been analyzed through input, process, and output aspects (see figure 2).

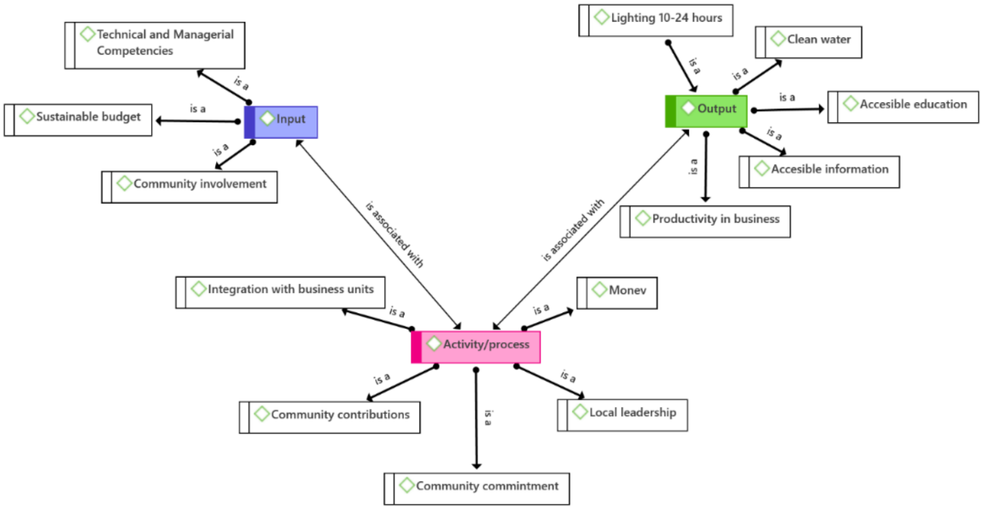


**Fig. 2.** Centralized PLTS management model in remote villages.

## 3.1 Resources/Inputs

Budget, community-based, knowledge and skills are important aspects in managing Centralized PLTS. The budget is a sustainable instrument in encouraging the management of Centralized Solar PV, not only construction but also maintenance. In general, the battery and solar cell components in Centralized PLTS are 5 years old [30], after that it is necessary to replace the components because their quality begins to decline. Cases of failure in the management of Centralized PLTS are caused by a lack of funding sources [31–33]. The case in Labuangkallo village also shows that the revitalization budget provided by the Provincial Government has an important role in encouraging the sustainability of Centralized PLTS. This budget has replaced the battery and increased the capacity of the solar panels so that the Centralized PLTS can return to work optimally maintenance of components.

The existence of community involvement and the transfer of knowledge regarding technical procedures is a prerequisite for Centralized PLTS to run [34]. This is because governance, such as grants made by the Central or Provincial Governments, aims to ensure that the management of Centralized PLTS is managed directly by the community. In this case, the role of the Ministry of Energy and Mineral Resources and the Provincial ESDM Office is more to foster and provide technical knowledge to the community managing the Centralized PLTS [13]. We found that this knowledge transfer process has been carried out in 2 ways, namely: (1) Guidance during construction and post-construction of Centralized PLTS; and (2) the Regional Government proposes technicians and operators from the community to attend education and training at the PPSDM KEBTKE.

Institutionally, the Centralized PLTS management unit can be formalized into a legal entity so that it is managed professionally by community groups. In Muara Enggelam Village, Centralized PLTS is managed by BUMDes [35], Kubu Karangasem Village [36], remote villages in India [37], Tibet [38], and Africa [39,40]. However, the management of Centralized PLTS in Labuangkallo and Balikukup Villages is not through BUMDes, because they experience difficulties in forming legal entity managers such as BUMDes.

### 3.2 Activities/Processes

Centralized PLTS management activities can be in the form of collecting electricity fees, enforcing regulations on violations of theft and arrears of electricity contributions, monitoring and evaluation carried out by local governments. This is important to ascertain whether the Centralized PLTS management activities experience problems or not. In general, Centralized PLTS which are managed by the community are not disciplined in electricity fees and enforcement of regulations through village regulations [13]. In addition, weak monitoring and evaluation has the potential for uncontrolled use of Centralized PLTS and results in decreased battery quality. Cases in several villages that have successfully managed PV mini-grid have committed to supervise joint management and receive supervision and evaluation from the local government [27,41]. Strong local leadership is also a part of determining the running of a sustainable Centralized PLTS [26]. Local leadership does not only come from the village government but can also come from individuals in the community [42].

The management of Centralized PLTS in this aspect of the process experiences quite a lot of obstacles. First, regarding contributions, people tend to demand it for free and are reluctant to pay because this electricity is a conversion from solar energy which does not require costs. In fact, the conversion process requires maintenance of solar panels, inverters, batteries, and other components so that it can be managed in the long term. Second, there is the practice of power theft and uncontrolled loss of electricity, due to the lack of strong supervision and regulation in the management of Centralized PLTS.

### 3.3 Outputs

Resources are deployed efficiently, activities carried out appropriately produce electricity that is supplied to the homes of the people of Underdeveloped Villages. The community can use electricity directly to support the activities in figure 3.

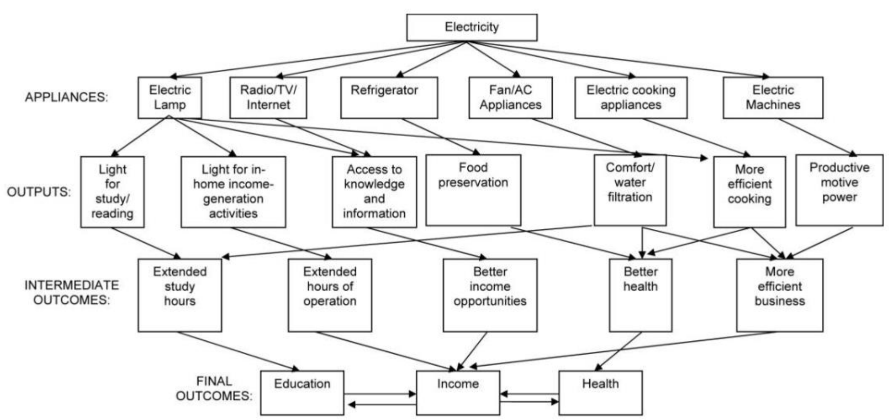


**Fig. 3.** Electrification to support human activities [8].

The existence of electrification in underdeveloped villages has provided benefits such as lighting for learning, increasing productivity, seeking information and knowledge, and clean water [8]. If the electrification of a village is carried out consistently, it will have a long-term impact on the community. The picture above is sufficient to explain the impact if centralized PLTS management can be managed sustainably. Another aspect that is no less important in this output is the revenue from contributions obtained from the community. These contributions are used for operational and management costs of Centralized PLTS. However, in practice this fee often experiences problems, because awareness among some people is still low and they think that electricity from Centralized PLTS comes from the sun and should be provided free of charge to the community.

### 3.4 Barrier factors

From interviews with managers of Centralized PLTS in remote villages, several obstacles were found that hamper sustainable management. First, commitment and awareness of the community in providing monthly dues. The monthly fee from the use of Centralized PLTS is the result of an agreement between the village government, BPD, community leaders and the community. however, in practice the fees start to stall in the third year of management. Second, the integrity of the community is still low where the practice of power theft and loss of electric current is found. This results in a decrease in the quality of the battery that is used continuously. Third, weak local leadership in managing Centralized PLTS. Traffic jam fees, power theft, and loss of electricity have not been overcome by the village government in the last five years. This had an impact on the performance of the Centralized PLTS which had declined so that each house was only able to be given lighting for two hours starting at 18:00 - 20:00. Some of the obstacles above were also found in previous research such as sociocultural and financial factors from the community which greatly affect the sustainability of the Centralized PV mini-grid management [26,27,43].

## 4 Conclusion

Community-based centralized PLTS management in remote villages consist of competence of managers, budgeting, community involvement, integrated with local business, community and contribution of community, and the socioeconomic benefit. But the implementation is still not running well. Management is still hampered by low community awareness and integrity in utilizing Centralized PLTS, and weak local leadership. There needs to be an ideal Centralized PLTS management model such as being managed by legal business units such as BUMDes or cooperatives, regulations regarding fees, management, supervision, and violations in the utilization of Centralized PLTS, and strong local leadership.

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