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Original Article

Capacity Analysis of Combined PLTD and Battery-Based PLTS in Supporting 24-Hour Electricity

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Abstract

Remote areas in Indonesia rely on diesel power plants with high costs, environmental impacts, and limited electricity access. Battery-based solar power offers a sustainable solution for 24-hour electricity while supporting digital economic growth. This study analyzes the combined capacity of PLTD and PLTS in providing continuous power in Sigapokna Village, Mentawai Islands. This study used comparative analysis methods, which compares conditions before and after PLTS operation. Results show that integration of 45 kW PLTD and 30 kWp PLTS increases customer operating hours from 7 hours to 10 hours per day, and planned PLTS expansion up to 170.8 kWp has potential to extend operating hours to 14 hours, even up to 24 hours with 319 kWp capacity. However, this capacity increase also impacts increased fuel oil consumption (BBM), demanding better energy efficiency strategies. These findings not only contribute to technical aspects of energy provision but also have significant implications for creative economy development and digital business in remote areas. Sustainable electricity access opens opportunities for Micro, Small, and Medium Enterprises (MSMEs) to utilize digital platforms, e-commerce, and digital financial services, while encouraging the birth of new digital-based energy business models (digital green business model) through Internet of Things (IoT) utilization, smart metering, and energy consumption data analysis. Thus, 24-hour electricity provision based on renewable energy not only improves community quality of life but also becomes a catalyst for digital economic transformation and social inclusion in Indonesia's 3T regions.

Keywords: Diesel Power Plant (PLTD), Solar Power Plant (PLTS), Renewable Energy, Digital Creative Economy, Energy Business Model.

1. Introduction

Electrical energy is one of the fundamental needs that can support economic, social, and daily life activities (Putri et al., 2023). It is the obligation of the government and PLN to provide electricity supply to areas not yet reached, including underdeveloped, frontier, and isolated (3T) areas according to Minister of Energy and Mineral Resources Regulation No. 48 of 2017 on Electricity Implementation, which includes electrical infrastructure development and use of environmentally friendly renewable energy technology to reach these areas.

For areas not yet reached by PLN's electricity network, they can only rely on off-grid technology for renewable energy use. In this case, minimum electricity operating hours depend on renewable generation capacity and energy storage. Usually, areas with solar panel systems can get 6 to 12 hours of operation per day, although the target is to increase capacity and provide longer access.

Yunus and Adi (2025) state that for several decades, Diesel-Based Power Plants (PLTD) have been the backbone of electricity supply in this region. Although PLTD operation faces various challenges, such as high fuel oil costs (BBM), dependence on external fuel supply causing BBM transportation costs, and environmental impacts such as noise, carbon emissions, and air pollution.

The construction of Battery Energy Storage System (BESS)-based Solar Power Plant (PLTS) in Mentawai is a solution to meet ideal customer operating hour needs for 24 hours. In their research, Manahara et al. (2023) explain that one of the main obstacles is the high initial investment cost for installation and required infrastructure. Although PLTS operational costs are relatively low because they don't require BBM, installation costs for solar panels, storage batteries, and other supporting infrastructure can be constraints due to the need for community involvement in operating and maintaining PLTS, which becomes an important factor to ensure PLTS operational sustainability.

The transition from PLTD to PLTS in Mentawai requires community adaptation to changes in energy consumption patterns, caused by operational changes from BBM use at any time and can be used anytime to PLTS use. In PLTS, energy availability depends on weather and sunlight and requires more planned energy use patterns (Harianto & Karjadi, 2022). Socialization is needed to educate the community in efficient electricity use and optimize utilization of energy produced during the day and reduce usage load at night when energy storage from batteries is limited.

Shabrina and Rahmadhanti (2024) state that the transition to new renewable energy like PLTS is also aligned with Indonesia's global commitment to reduce carbon emissions in addressing climate change. Indonesia is one of the countries with the largest tropical rainforests, which has a strategic role in reducing global warming by reducing dependence on fossil fuels (BBM) in increasing new renewable energy use.

Renewable energy development in Indonesia is not only a technical electricity issue but also closely related to digital business models, sustainability strategies, and regional economic transformation. Irfanto and Sudiarto (2023) emphasize the importance of Solar Power Plant (PLTS) implementation combined with Battery Energy Storage System (BESS) to maintain stability of isolated network systems. Similar studies by Istiqamah et al. (2023) highlight life cycle cost aspects and environmental impact of power plants, but haven't deeply touched on digitalization implications in energy management, especially in remote areas. Meanwhile, research by Kadang and Windarta (2021) discusses PLTS photovoltaic (PV) potential in 3T regions, and Bayu and Windarta (2021) review PLTS development policies in achieving 23% new renewable energy mix target by 2025.

However, there is still a research gap regarding the relationship between renewable energy management and energy business model digitalization. Not many studies have integrated PLTS-PLTD capacity analysis with digital monitoring systems, customer consumption data, fuel efficiency, and customer operating hours managed comprehensively to support sustainable 24-hour electricity provision in remote areas. Yet, the existence of sustainable electricity based on renewable energy managed through digital systems can encourage the birth of new business models, support MSME digitalization, and accelerate community digital inclusion in remote areas like Mentawai.

2. Methods

Research planning is systematic design in collecting, processing, and analyzing data to achieve objectives and answer problem formulations. Quantitative approach allows authors to measure and analyze the impact of PLTS construction on PLTD and PLTS operation patterns and customer operating hours. This method uses comparative analysis aiming to compare two different conditions before and after PLTS implementation. By comparing data from these two periods, authors can evaluate changes that occurred and identify effects caused by transition to renewable energy sources.

Operational definition of variables is clear and measurable description of research variables to facilitate measurement and analysis.

Table 1. Operational Definition of Variables

Variable	Conceptual Definition	Dimension	Measurement Scale
Number of Customers	Number of users/Power service capacity based on demographic data in 2023 and 2024	Number of Customers/Installed Power 2023 and 2024	Ratio (VA)
Customer Operating Hours	Number of Operating Hours enjoyed by customers in 2023 and 2024	Operating Hours (before and after PLTS operation)	Ratio (Operating Hours)
PLTS Expansion 140.8 kWp	Effect of adding 140.8 kWp PLTS capacity on customer operating hour changes	Operation Pattern of 45 kW PLTD and 170.8 kWp PLTS on customer operating hours	Production kWh (kWh)

Source: Own Data Processing

2.1. Population, Sample, and Sampling Technique

Population is all objects or individuals that become research focus (Firmansyah & Dede, 2022). The writing population consists of PT PLN (Persero) customers in Sigapoka Village, Labuan Bajau Hamlet who use electricity from PLTD before PLTS operation on customers connected to the electricity network that can be identified into two main groups:

a. Electricity consumers: Communities and business entities connected to the electricity network.
b. Energy generation facilities: PLTD and PLTS in Mentawai region.

Sample is part of the population selected to take data to represent the entire population. The sample used in this research consists of:

a. Customer Groups: number of electricity customers and contracted power in Sigapokna Village, Labuan Bajau Hamlet, Mentawai Islands in 2023 and 2024, to provide representation regarding electricity consumption before and after PLTS construction based on contracted VA amount.
b. Energy Generation Facilities: PLTS and PLTD facilities selected for evaluation in this writing. Focus on energy provision in Sigapokna Village, Labuan Bajau Hamlet, Mentawai Islands.

The sampling technique used is purposive sampling, which is sample determination technique based on certain criteria (Firmansyah & Dede, 2022). This technique was chosen because the writing focuses on customer groups and facilities relevant to research objectives, namely to analyze operational generation capacity combination in PLTD and PLTS in supporting sustainable 24-hour electrical energy provision in Sigapokna Village, Labuan Bajau Hamlet, Mentawai Islands during PLTS operation on customer operating hours. Several criteria used in purposive sampling are:

a. Customers with connected VA data that becomes the basis for kWh needs for 2023 and 2024 periods.
b. PLTD and PLTS Production kWh that have large contribution to energy provision for customer operating hours in that region.

This data will be analyzed to see differences in energy consumption before and after PLTS implementation.

2.2. Research Instruments

In this research, data will be collected using various instruments appropriate to the type of data to be analyzed. Instruments used include:

1) Document Analysis
a. BBM Usage Data and Customer Contracted Power: This data includes components of BBM usage amount on PLTD operation patterns and customer contracted power used in electrical energy fulfillment for customer operating hours.
b. Production kWh data and number of customers/contracted power in 2023 (before PLTS) and 2024 (after PLTS).
2) Production kWh Calculation for adding 140.8 kWp PLTS capacity and PLTS Capacity needed to fulfill 24 hours operation for customers in Sigapokna Village, Labuan Bajau Hamlet, Mentawai Islands.

2.3. Data Analysis Techniques

Data analysis techniques in this research are divided into several stages covering various types of analysis, such as comparative analysis and correlation analysis. Following is complete explanation of these techniques:

a. Comparative Analysis The purpose of this analysis is to compare contracted power and customer operating hours before and after PLTS implementation on PLTD operation patterns.
b. Correlation Analysis Aims to evaluate the relationship between PLTD and Expansion PLTS operation patterns in calculating customer operating hours.

3. Results and Discussion

3.1. Research Results

3.1.1. Analysis of PLTD and PLTS Operation Patterns for 10 Hours Operation

Operation of 45 kW PLTD and 30 kWp PLTS is conducted alternately with patterns where from morning to afternoon, electricity needs will be served by 45 kWp battery-based PLTS, while at night electricity needs will be served by PLTD which functions to charge PLTS batteries and distribute electrical power. PT PLN (Persero) is expected to increase customer operating hour service to 10 hours/day.

Table 2. PLTD and PLTS Operation Pattern 10 Hours Customer Operation 2024

No.	Month	Operating Hours	PLTS (kWp)	PLTD (kW)	BBM Usage (Liters)	Customer Operating Hours/Day
1	January	217.0	30	45	3,418	10
2	February	196.0	30	45	3,087	10
3	March	217.0	30	45	3,418	10
4	April	210.0	30	45	3,308	10
5	May	217.0	30	45	3,418	10
6	June	210.0	30	45	3,308	10
7	July	217.0	30	45	3,418	10
8	August	217.0	30	45	3,418	10
9	September	210.0	30	45	3,308	10
	Total	**1,911**			**30,098**	

Source: PT PLN (Persero) PUSHARLIS

Based on Table 2, with the operation of 45 kW PLTD and 30 kWp PLTS Generator with capacity 75 kW, services provided by PT PLN (Persero) are expected to meet electrical energy needs for contracted VA of 66,650 VA for 10 hours requiring electrical energy of 565.25 kWh.

Table 3. PLTD and PLTS Power Generation (kWh) Production for 10-Hour Customer Operation in 2024

Description	PLTD 45 kW	PLTS 30 kWp
Battery Capacity VA		15,000
Battery Capacity 80% kWh/day		648
Capacity	45	30
Operating hours (day)	7	5
Production kWh	267.75	142.50
Operating hours (year)	1,911	
BBM Usage (ltr/year)	30,098	
BBM Usage (IDR/year)	373,669,774	
Carbon Emission CO2 (eq kg/Year)	94,509	
Carbon Tax	2,835,255	

Source: Own Data Processing

In Table 3, it can be known that Customer 10-hour operation service improvement by PT PLN (Persero) is conducted by operating PLTS for 5 hours and PLTD operation for 7 hours to produce electrical energy needs of 410.25 kWh or 73% of total need 565.25 kWh for 10 hours, where this situation certainly makes customers have to be efficient in consuming electrical energy for the continuity of 10-hour operation.

3.1.2. Production kWh Needs Projection

Electrical energy needs projection at PLTS Sigapokna Village, Labuan Bajau Hamlet, Mentawai Islands is presented in kilowatt-hour (kWh) units based on historical data collected for nine months, from January to September 2024. This projection aims to provide an overview of expected Electrical Production (Production kWh) in the next six months.

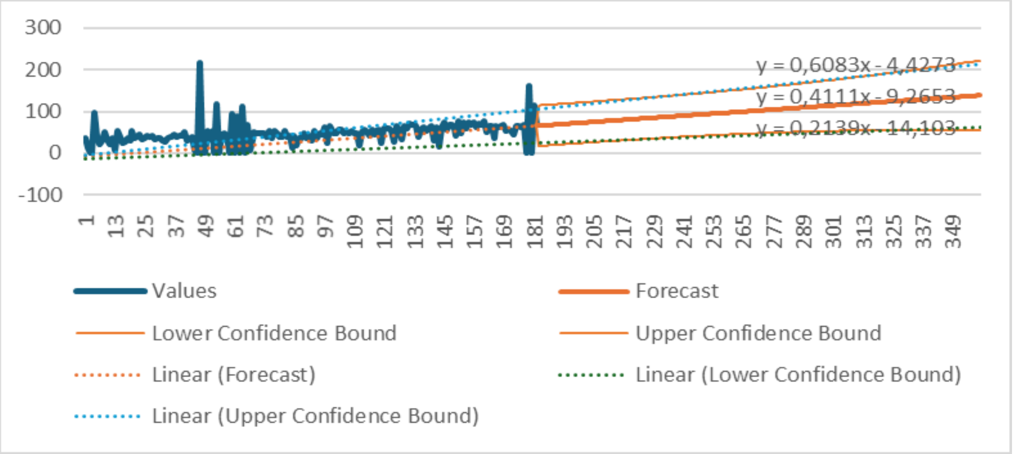

Figure 1. Production kWh Projection
Source Data: Own Data Processing

Based on Figure 1, the average PLTS kWh production with 30 kWp Capacity is 47.4 kWh or maximum 66.80 kWh every day for electrical energy needs for 10 hours operation/day through 30 kWp PLTS and 45 kW PLTD operation. On days 180-360, based on data it can be analyzed that average daily electrical energy needs increase by 102.14 kWh or highest 138.74 kWh, this shows positive electrical power sales growth trend and must be balanced with additional installed generation capacity.

3.1.3. BBM Usage 2024

Table 4. PLTD Labuna Bajau BBM Usage 2024

Month	Operating Hours	PLTS (kWp)	PLTD (kW)	BBM Usage (Liters)	Customer Operating Hours/Day	BBM Cost (monthly)	CO2 eq (kg/month)	Carbon Tax
January	217.0	30	45	3,418	10	42,431,366	10,732	321,952
February	196.0	30	45	3,087	10	38,325,105	9,693	290,795
March	217.0	30	45	3,418	10	42,431,366	10,732	321,952
April	210.0	30	45	3,308	10	41,062,613	10,386	311,567
May	217.0	30	45	3,418	10	42,431,366	10,732	321,952
June	210.0	30	45	3,308	10	41,062,613	10,386	311,567
July	217.0	30	45	3,418	10	42,431,366	10,732	321,952
August	217.0	30	45	3,418	10	42,431,366	10,732	321,952
September	210.0	30	45	3,308	10	41,062,613	10,386	311,567
Total	**1,911**			**30,098**		**373,669,774**	**94,509**	**2,835,255**

Source: PT PLN (Persero) PUSHARLIS

Installation of 30 kWp PLTS has impact on BBM usage and operating hours on PLTD. BBM Usage Cost increase by 105% in Rupiah and increases operating hours from 5 hours to 7 hours. This is done to improve service to PLN Customers to 10 Operating Hours per day.

3.1.4. PLTS Expansion 140.8 kWp

In efforts to meet electrical power distribution needs to customers in Sigapokna Village, Labuan Bajau Hamlet, Mentawai Islands for 24 hours using PLTS, PT PLN (Persero) conducts PLTS Expansion with capacity 140.8 kWp, adding capacity 140.8 kWp is expected to serve electrical power distribution to existing customers with contracted power 66,650 VA.

Table 5. PLTS Expansion Data 170.8 kWp

Description	PLTD 45 kW	PLTS 30 kWp	PLTS 140.8 kWp
Number of Customers		44	
Installed Power (VA)		66,500	
kWh/hour Calculation		56.5	
Customer Operating Hours		14.4	
Wh Needs		811	

Source: Own Data Processing

Based on Table 5, PT PLN (Persero) service improvement by adding battery-based PLTS capacity of 170.8 kWp with Battery capacity of 79.5% from 28,350 Ah, then electrical energy stored in battery is 811 kWh with battery charging efficiency of 90% from energy needs 811 kWh can increase customer operating hours to 14.4 per day.

Table 6. PLTS Operation Pattern 170.8 kWp

Description	PLTD 45 kW	PLTS 30 kWp	PLTS 140.8 kWp
Battery VA		15,000	13,350
Battery Capacity 80% kWh/day			1,021
Capacity	45		170.8
Operating hours (day)			5
Production kWh			811

Source: Own Data Processing

Electrical energy needs with contracted Power of 66,500 VA requiring electrical energy 56.65 kWh/hour, then customers can enjoy operating hours for 14.4 hours relying on 170.8 kWp PLTS and PLN doesn't need to operate 45 kW PLTD.

Table 7. PLTD and PLTS Operation Pattern 19 Hours Operation

Month	Operating Hours	PLTS (kWp)	PLTD (kW)	BBM Usage (Liters)	Customer Operating Hours/Day	BBM Cost (monthly)	CO2 eq (kg/month)	Carbon Tax
January	217.0	170.8	45	3,418	19	42,431,366	10,732	321,952
February	196.0	170.8	45	3,087	19	38,325,105	9,693	290,795
March	217.0	170.8	45	3,418	19	42,431,366	10,732	321,952
April	210.0	170.8	45	3,308	19	41,062,613	10,386	311,567
May	217.0	170.8	45	3,418	19	42,431,366	10,732	321,952
June	210.0	170.8	45	3,308	19	41,062,613	10,386	311,567
July	217.0	170.8	45	3,418	19	42,431,366	10,732	321,952
August	217.0	170.8	45	3,418	19	42,431,366	10,732	321,952
September	210.0	170.8	45	3,308	19	41,062,613	10,386	311,567
October	217.0	170.8	45	3,418	19	42,431,366	10,732	321,952
November	210.0	170.8	45	3,308	19	41,062,613	10,386	311,567
December	217.0	170.8	45	3,418	19	42,431,366	10,732	321,952
Total	**2,555**			**40,241**		**373,669,774**	**94,509**	**2,835,255**

Source: Own Data Processing

Based on Table 6, Operation of 45 kW PLTD and 170.8 kWp PLTS is conducted alternately with patterns where from morning to afternoon electricity needs will be served by 170.8 kWp battery-based PLTS, while at night electricity needs will be served by PLTD which functions to charge PLTS batteries and distribute electrical power. PT PLN (Persero) is expected to increase customer operating hour service to 19 hours/day.

3.1.5. PLTS Expansion 148.3 kWp

To determine additional PLTS and battery capacity needed to meet 24-hour electricity needs, we conduct staged analysis.

Table 8. PLTS Expansion Data 319 kWp

Description	PLTD 45 kW	PLTS 30 kWp	PLTS 140.8 kWp	PLTS 148.3 kWp
Number of Customers	44			
Installed Power (VA)	66,500			
kWh/hour Calculation	57			
Customer Operating Hours	24			
kWh Needs	1,357			

Source Data: Own Data Processing

Based on the table 8, it can be analyzed that with Battery capacity of 100% from 34,500 Ah, electrical energy stored is 1,242 kWh considering battery charging efficiency of 90% from energy needs 1,357 kWh.

Table 9. PLTS Operation Pattern 319 kWp

Description	PLTD 45 kW	PLTS 30 kWp	PLTS 140.8 kWp	PLTS 148.3 kWp
Battery VA		15,000	13,350	6,150
Battery Capacity 80% kWh/day				1,242
Capacity	45			319.1
Operating hours (day)	-			5
Production kWh	-			1,364
Operating hours (year)	-			
BBM Usage (ltr/year)	-			
BBM Usage (Rp/year)	-			
Carbon Emission CO2 (eq kg/Year)	-			
Carbon Tax	-			

Source Data: Own Data Processing

Electrical energy needs with contracted Power of 66,500 VA requiring electrical energy 56.65 kWh/hour, then customers can enjoy operating hours for 24 hours relying on 319 kWp PLTS and not operating 45 kW PLTD.

Table 9. Sigapokna Village Labuan Bajau Hamlet Customer Data 2023

Description	2023											
	January	February	March	April	May	June	July	August	September	October	November	December
450 VA	43	43	43	43	43	43	43	43	43	43	43	43
900 VA	-	-	-	-	-	-	-	-	-	-	-	-
2200 VA	1	1	1	1	1	1	1	1	1	1	1	1

Source: PT PLN (Persero) PUSHARLIS

In Table 9, there are 44 PT PLN (Persero) customers in West Siberut District, Sigapokna Village, Labuan Bajau Hamlet served by PLTD with cumulative contracted power of 21,550 VA. Referring to this condition, customers can only enjoy 7 hours operation per day by paying electricity tariff according to applicable Basic Electricity Tariff (TDL), this is due to limited kWh production generated by PLTD with 45 kW capacity.

Table 10. PLTD LABUAN BAJAU BBM Usage 2023

No.	Month	Operating Hours	PLTD (kW)	BBM Usage (Liters)	Customer Operating Hours/Day	BBM Cost (monthly)
1	January	155	45	2,441	7	30,308,119
2	February	140	45	2,205	7	27,375,075
3	March	155	45	2,441	7	30,308,119
4	April	150	45	2,363	7	29,330,438
5	May	155	45	2,441	7	30,308,119
6	June	150	45	2,363	7	29,330,438
7	July	155	45	2,441	7	30,308,119
8	August	155	45	2,441	7	30,308,119
9	September	150	45	2,363	7	29,330,438
10	October	155	45	2,441	7	30,308,119
11	November	150	45	2,363	7	29,330,438
12	December	155	45	2,441	7	30,308,119
Total		**1,825**		**28,744**		**356,853,656**

Source: PT PLN (Persero) PUSHARLIS

In Table 10, PLTD operation in 2023 with average operating hours for 5 hours uses BBM of 28,744 liters or Rp 356,853,656 to meet customer needs with operating hours for 7 hours.

3.2. Discussion

In 2023, there were 44 electricity customers with total contracted power of 21,550 VA, all from small household category (450 VA for 43 customers and 2,200 VA for 1 customer). This condition represents electricity market characteristics in remote villages that are relatively small, limited, and very homogeneous. With only 7 hours operation per day, energy access is still inadequate to support digital economic and creative activities of the community. This means potential energy utilization for productive economic activities based on technology (for example local e-commerce, MSME digital marketing, or creative content production) is still constrained by electricity supply limitations.

PLTD operational costs are very high, reaching Rp 356.85 million per year just to provide 7-hour electricity service per day. From business management perspective, this shows inefficient electricity cost of goods sold (COGS), due to high BBM consumption (28,744 liters) to serve relatively small customers. Compared to potential battery-based PLTS development, digital renewable energy business model becomes more attractive. Through monitoring digitalization (IoT, smart metering, and prepaid electricity payment applications), PLN can optimize energy distribution, reduce BBM costs, and open opportunities for customer energy consumption data monetization. Real-time data management meter technology enables real-time energy consumption analysis to improve distribution efficiency and usage transparency. Collected energy data can even be monetized into additional services such as energy efficiency consulting, digital energy service subscription, and community-based peer-to-peer energy trading. This concept aligns with studies on business models for digitalization-enabled energy efficiency that emphasize the importance of data-based value creation (Ma et al., 2023).

Integration of Diesel Power Plant (PLTD) and battery-based Solar Power Plant (PLTS) in Sigapokna Village, Mentawai, not only functions as technical solution for sustainable electricity provision, but also opens space for the birth of Digital Green Business Model, which is an energy business approach that combines renewable energy source use with digital technology utilization to improve efficiency, transparency, and value-added creation. In value proposition dimension, sustainable 24-hour electricity provision based on PLTS–BESS becomes key, which not only reduces carbon emissions but also enables local communities and MSMEs to enter digital economic ecosystem. From main activities side, hybrid PLTD–

PLTS system operation, digital monitoring implementation based on Internet of Things (IoT), and Artificial Intelligence (AI) and Machine Learning (ML) utilization in energy consumption prediction become important strategies to maintain system sustainability.

Sustainable energy access becomes important enabler for MSMEs and digital creative economy in 3T areas. With only 7-hour electricity supply, business actors are very limited in utilizing digital technology. Yet, with 24-hour electricity, MSMEs can expand market through e-commerce, use digital payments, and conduct social media-based promotion consistently. This aligns with findings that MSME digital transformation in Indonesia is greatly influenced by digital infrastructure availability, digital literacy, and access to fintech services (Andjarwati & Wulan, 2021). In rural context, research shows that renewable energy-based digitalization programs can increase digital inclusion and encourage new entrepreneurship, including rural women empowerment through digital platform-based business (Ahmad et al., 2024).

Further, the existence of digital-based renewable energy systems may be categorized as Digital Green Business Model, an energy business model that combines sustainability (green) with process and service digitalization. Value proposition offered is not just 24-hour electricity access, but also community participation opportunities in digital economic ecosystem. Thus, this paper adds to the literature that energy transition can become bridge for digital economic transformation and new business model formation in energy sector and MSMEs.

From cost structure perspective, high initial investment for PLTS, BESS, and digital system construction is the key issue, but can be balanced with long-term operational cost reduction and energy usage optimization. Meanwhile, revenue sources can come from sustainable electricity tariffs, subscription-based digital energy services, carbon credit trading from emission reduction, and energy consumption data monetization for efficiency consultation.

Table 10. Digital Green Business Model Canvas

Key Partners	**Key Activities**	**Key Resources**	**Value Proposition**	**Customer Relationships**
a. PLN, Government b. Green investors c. Local community d. IoT & AI providers	a. PLTS–PLTD–BESS operation b. Digital monitoring (IoT) c. AI/ML consumption prediction d. Community education e. Community energy marketplace	a. PLTS, PLTD, BESS b. IoT, AI, Cloud c. Local technicians & operators d. Social capital & regulatory support	a. Sustainable 24-hour electricity b. Environmentally friendly energy c. Real-time smart monitoring d. Energy data for digital services e. Community energy marketplace	a. Education & assistance b. Digital customer service (app) c. Energy-based community engagement
			Channels a. PLN–PLTS hybrid network b. Energy monitoring app c. Digital energy marketplace	**Customer Segments** a. Households b. Local MSMEs c. Government & PLN d. Green/CSR investors

Cost Structure	**Revenue Streams**
a. High initial investment (PLTS, BESS, IoT) b. Operation & maintenance c. Digitalization costs (AI/IoT) d. Community education	a. Sustainable electricity tariff b. Digital energy service subscription c. Carbon credit trading d. Energy consumption data monetization

Integration between Diesel Power Plant (PLTD) and Solar Power Plant (PLTS) in Sigapokna Village, Labuan Bajau Hamlet, Mentawai Islands, not only provides benefits in technical aspects of energy provision, but also potentially encourages birth of digital-based energy business models. Implementation of Internet of Things (IoT)-based digital monitoring systems, such as smart metering and data analytics, enables energy managers to monitor electricity consumption in real time, conduct load prediction, and optimize energy distribution. Research by Khowarizmi and Setiyono (2025) shows that real-time PLTS monitoring system based on Programmable Logic Controller (PLC) and IoT has high accuracy level with average deviation below 3%, making it feasible to implement for improving energy management efficiency in remote areas.

Aligned with this, smart system development based on IoT, Artificial Intelligence (AI), and Machine Learning (ML) proves capable of improving monitoring efficiency and PLTS performance optimization. Taneza and Firdaus (2024) report that smart system implementation can improve operational efficiency up to 95%, damage prediction capability up to 110.8%, and energy output up to 130% compared to conventional methods. This fact reinforces that energy digitalization can become catalyst in electrical sector transformation toward sustainability.

From digital economic perspective, existence of sustainable 24-hour electricity can become enabler for Mentawai community socio-economic transformation. Stable electricity access enables Micro, Small, and Medium Enterprise (MSME) actors to utilize digital platforms for economic activities, such as electronic commerce (e-commerce), digital payments, and platform-based business models. This condition also encourages digital inclusion acceleration, supports technology-based education implementation, and strengthens local creative economic ecosystem. This aligns with study (Sambodo et al., 2024) that affirms digitalization role of electricity networks (smart grid) in supporting energy transition and digital economic development in Southeast Asia.

Thus, PLTD and PLTS combination managed through digital systems can be positioned as part of digital green business model, which is energy business model that integrates sustainability principles with digital technology utilization. This model is not only oriented toward clean energy provision, but also creates added value through customer energy consumption data that can be monetized, for example in form of energy efficiency consulting services or community-based digital energy marketplace. Therefore, this research provides contribution not only to renewable energy technical literature, but also to development of energy sector digital transformation studies and its implications for digital economic development in Indonesia.

Limited 7-hour/day electricity limits local MSME actors from utilizing digital technology, such as online store management, digital payment use, or creative content-based tourism promotion. If operating hours increase to 24 hours through PLTS expansion, this condition can become enabler for local economic transformation. MSMEs can operate longer, access digital platforms sustainably, and expand market outside region through digital business ecosystem.

Existence of 24-hour electricity potentially encourages local MSME and creative economy development in Mentawai. Culinary business actors can increase production and expand market through e-commerce platforms, while local craftsmen can utilize digital media to market traditional weaving or regional specialty crafts. Tourism sector can also obtain significant benefits, because stable electricity enables homestay managers and tourism services to use online booking systems, digital content-based promotion, and electronic payments. Thus, sustainable electricity is not only technical infrastructure, but also foundation for digital-based creative economic ecosystem growth in remote areas.

Integration of PLTS–PLTD equipped with digital monitoring systems opens opportunities for creation of new energy business models. Implementation of digital electricity payment systems through prepaid applications or QRIS can facilitate customers while improving PLN revenue transparency. Energy consumption data collected from smart metering can be utilized for energy usage analysis services or even community-based energy marketplace development (peer-to-peer energy trading). Moreover, operating hours increase also accelerates community digital inclusion through access to online education, telemedicine services, and digital banking, thus supporting acceleration of village economic transformation toward digital economy.

Research novelty lies in integration of PLTD–PLTS technical capacity analysis with digital business and creative economy dimensions. If most previous research only emphasizes technical aspects (kWh capacity, BBM costs, or environmental efficiency), this study adds management and digital economic perspectives by proposing Digital Green Business Model that combines renewable energy, IoT, smart metering, and energy consumption data monetization. Moreover, this research explicitly relates sustainable 24-hour electricity with enabler for digital creative economic transformation in 3T regions, especially in encouraging local MSMEs to enter e-commerce ecosystem, digital payment, and digital tourism platforms. Thus, this research contribution is not only solving energy limitation problems, but also offering new conceptual framework about how energy transition can become catalyst for digital business model innovation and creative economic development in remote areas.

4. Conclusion

The examination illuminates that operation of 45 kW capacity PLTD and 30 kWp PLTS can increase number of customers served in West Siberut District, specifically Sigapokna Village, Labuan Bajau Hamlet, although still limited. PLTD contributes with operating hours of 7 hours per day, showing installed power efficiency, while planned PLTS capacity increase to 170.8 kWp is projected to significantly expand community energy access. PLTD and PLTS integration proves effective with customer operating hours increase from 7 hours to 10 hours per day, indicating that combination of these two energy sources can meet electricity needs more efficiently, although there is still dependence on PLTD in daily operations. On the other hand, PLTS use hasn't fully reduced BBM consumption; even PLTD fuel consumption increases up to 105%, from 21,449 liters to 30,098 liters due to increased operating hours, causing challenges in operational cost management. However, implementation of 140.8 kWp PLTS expansion is expected to extend operating hours up to 14 hours per day. With good management, this expansion potentially increases energy availability, reduces BBM dependence, and strengthens sustainable electricity provision sustainability in remote areas.

Besides these technical achievements, this research also has strategic implications for creative economy and digital business development. Existence of sustainable 24-hour electricity can become enabler for MSMEs to connect with digital ecosystem through e-commerce utilization, digital payment services, social media-based promotion, and online tourism platforms. This shows that energy access is not only technical infrastructure, but also foundation for digital creative economic acceleration in 3T regions. Furthermore, digital technology integration in energy management such as IoT, smart metering, and data analytics potentially creates new business models oriented toward efficiency, transparency, and energy data monetization, including subscription schemes, community-based digital energy marketplace, and carbon credit trading.

Integration of battery-based PLTD and PLTS is not only technically important, but also provides significant implications for creative economy and digital business development in remote areas. Sustainable electricity access enables Micro, Small, and Medium Enterprise (MSME) actors in Mentawai to adopt e-commerce platforms, digital payments, and technology-based services, thus expanding market and improving competitiveness. Stable energy availability also supports digital creative economic ecosystem growth such as content production, design services, and online platform-based business.

Moreover, implementation of IoT, smart metering, and data analytics-based digital monitoring systems in PLTS–PLTD management can create digital green business model, which is energy business model that integrates sustainability with energy consumption data monetization. This is not only oriented toward clean energy provision, but also opens opportunities for additional services such as energy efficiency consulting or community-based digital energy marketplace. Thus, renewable energy-based sustainable 24-hour electricity in 3T regions not only answers basic energy needs, but also becomes catalyst for digital economic transformation, social inclusion, and local community future work.

5. References

Ahmad, A., Hajriyanti, R., Wulandari, E. S., & Rizal, S. (2024). Digital Transformation in Rural Areas: A Case Study of Computer Training as Community Service. *Jurnal Pengabdian Bangsa*, *3*(2), 30–38.

Andjarwati, T., & Wulan, V. R. (2021). Technology Transformation: Promoting Sustainable Indonesia MSMEs and Cooperative by Digitalization. *JEJAK: Jurnal Ekonomi Dan Kebijakan*, *14*(2), 364–383.

Bayu, H., & Windarta, J. (2021). Tinjauan Kebijakan dan Regulasi Pengembangan PLTS di Indonesia. *Jurnal Energi Baru Dan Terbarukan*, *2*(3), 123–132. https://doi.org/10.14710/jebt.2021.10043

Firmansyah, D., & Dede. (2022). Teknik Pengambilan Sampel Umum dalam Metodologi Penelitian: Literature Review. *Jurnal Ilmiah Pendidikan Holistik (JIPH)*, *1*(2), 85–114. https://doi.org/10.55927/jiph.v1i2.937

Harianto, B., & Karjadi, M. (2022). Planning of Photovoltaic (PV) Type Solar Power Plant as An Alternative Energy of the Future in Indonesia. *ENDLESS Int. J. Futur. Stud*, *5*(2), 182–195.

Irfanto, I., & Sudiarto, B. (2023). Studi Pengaruh Implementasi PLTS dan BESS terhadap Kestabilan Sistem Jaringan Terisolasi di Indonesia. *JTEV (Jurnal Teknik Elektro Dan Vokasional)*, *9*(1), 84. https://doi.org/10.24036/jtev.v9i1.122721

Istiqamah, D. A., Sasongko, N. A., & Boedoyo, M. S. (2023). Analisis dampak lingkungan dan life cycle cost pembangkit listrik tenaga panas bumi. *E-Jurnal Ekonomi Sumberdaya Dan Lingkungan*, *12*(1), 39–48. https://doi.org/10.22437/jesl.v12i1.26631

Kadang, J. M., & Windarta, J. (2021). Optimasi Sosial-Ekonomi pada Pemanfaatan PLTS PV untuk Energi Berkelanjutan di Indonesia. *Jurnal Energi Baru Dan Terbarukan*, *2*(2), 74–83. https://doi.org/10.14710/jebt.2021.11113

Khowarizmi, M. H., & Setiyono, S. (2025). Real-Time Monitoring System for Solar Power Plants Using PLC and IoT-Based Architecture. *ELKOMIKA: Jurnal Teknik Energi Elektrik, Teknik Telekomunikasi, & Teknik Elektronika*, *13*(2), 215.

Ma, Z., Jørgensen, B. N., Levesque, M., Amazouz, M., & Ma, Z. (2023). Business models for digitalization enabled energy efficiency and flexibility in industry: a survey with nine case studies. *Energy Informatics Academy Conference*, 253–270.

Manahara, S., Putri, S. K., & W, I. S. K. (2023). Tantangan transisi energi terbarukan di Indonesia. *Journal of Innovation Materials, Energy, and Sustainable Engineering*, *1*(1). https://doi.org/10.61511/jimese.v1i1.2023.259

Putri, R. A., Rorong, I. P. F., & Tumangkeng, S. Y. L. (2023). Analisis Faktor-faktor yang Mempengaruhi Permintaan Daya Listrik Rumah Tangga di Kota Manado. *Jurnal Berkala Ilmiah Efisiensi*, *23*(1), 133–144.

Sambodo, M. T., Silalahi, M., & Firdaus, N. (2024). Investigating technology development in the energy sector and its implications for Indonesia. *Heliyon*, *10*(6).

Shabrina, & Rahmadhanti, F. (2024). Mendorong Program Pertumbuhan Ekonomi Hijau (Green Growth Economy) Melalui Transisi Energi Terbarukan Di Indonesia. *Inovasi Makro Ekonomi (IME)*, *6*(3).

Taneza, E., & Firdaus, F. (2024). Smart System Untuk Pemantauan Dan Optimasi Kinerja Pembangkit Listrik Tenaga Surya. *Transmisi: Jurnal Ilmiah Teknik Elektro*, *27*(1), 20–32.

Yunus, R. F., & Adi, T. W. (2025). Comparative simulation analysis of the economics of unit commitment to determine the cost of supplying electricity in simple generating systems in the Bengkulu region. *Jurnal Pendidikan Teknologi Kejuruan*, *8*(2), 127–140.