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Cost Analysis of Hybrid and Conventional Energy Systems In Telecommunication Shelter

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Abstract
The use of energy in the telecommunications system currently has several alternatives to support the power requirements of each site. There are three outlines used here, the first is a system using PLN as the main source of power supply, using a diesel-generator and battery backup energy, the second using a hybrid system which uses two energy supplies for solar power plants and PLN as its power source, with using diesel-generator and battery energy reserves and the latter only relying on solar power and diesel-generators as the main power supply or better known as off-grid system. The difference is based on the difference in access to the electricity network which is not evenly distributed in each region. This research will produce the most effective cost analysis of the system.

1. Introduction

The era of digital society in Indonesia is shown by the rapid development of Information and Communication Technology, especially the telecommunications industry over the last few years. There has been a shift from the use of fixed wire line telephones to the use of cellular telephones, especially the rapidly growing use of the internet via cellular telephones. In addition, due to the increasing development of telecommunications in Indonesia, the term "Digital Economy" is now known which has penetrated in urban and rural areas in Indonesia. Telecommunication has removed distance boundaries and reduced the differences between people in urban and rural areas (Liu et al., 2021). Differences in time, distance of location, and heterogeneity of population characteristics are no longer obstacles to the speed of information dissemination. The growth of the network of telecommunications companies in Indonesia is one of the largest in the world, as evidenced by internet users reaching 204.7 million as of January 2022. This figure is up by 1.03% from 2021, which is 202.6 million. And that number will continue to grow, accompanied by the government's efforts to provide telecommunications networks to remote parts of the country (Morrison-Smith & Ruiz, 2020).

This has become a challenge in supplying shelter power, which functions as the main means of providing telecommunications network infrastructure. There are three scenarios that are applied to be the foundation, namely the first conventional system with the application of the Charge Discharge System

(CDC) where PLN is the main supplier, relying on diesel-generators and batteries for backup, the second with a hybrid system with PLN and Solar Panels as the main suppliers and using a diesel-generator as a backup supply, the latter scenario uses solar panels and a diesel-generator but without relying on PLN or more familiar with the off-grid system (Agarwal et al., 2021). In this study, a cost analysis will be discussed in each of these scenarios to answer the effectiveness of appropriate infrastructure development which in addition to paying attention to regional potential factors with operational costs that will be incurred (Chowdhury et al., 2020).

2. Materials and Methods

Solar Power Plant

Solar Power Plant is a power generation system that converts solar photon radiation into electrical energy using photovoltaic (PV). PLTS work rate is influenced by several factors such as environmental factors, temperature of the photovoltaic module used, weather and environmental conditions, and the intensity of sunlight obtained by it self (Koppel et al., 2019).

a. Battery

The battery functions as a storage area for excess electrical energy produced by solar modules during the day or a diesel generator in the form of chemical energy which will be used as a backup for the existing system power supply at night or when no other power source is available (García et al., 2020). Batteries have various specifications, capacities and sizes according to implementation needs

b. Diesel Generator

Diesel Generator is a generator device electricity where as the main mover (prime mover) is a diesel engine and is connected (coupled) with electric generator in one base frame sturdy and well installed so that it can operates to produce electrical energy in accordance with capacity.

Solar Power Plant System

a. On-Grid

This type of system is designed by connecting the PV mini-grid system directly with the existing electricity utility system. The pattern of operation with the load served can be sourced from the PV or the utility and work in parallel (Zainol Abidin et al., 2021).

b. Off-grid

This system does not connect the PLTS with the existing utility network, the load is only supplied by the energy source supplied by the PLTS only. The development of this type of PLTS is the addition of batteries as a storage medium for electrical energy which can then be used when the PLTS does not produce electricity at all

c. Identify Problem

Parameters needed for research this was obtained from the related literature and carried out verification with actual conditions in the field. Besides parameters that have been obtained from the literature, this study will also use actual data taken from sample site before and after implementation hybrid energy system, some data needed including the following.

- Load profiles of 10 sample sites that have been implementing a hybrid energy system,group them into three types of load profiles;
- Diesel generator capacity, solar panels and capacity sample site battery;
- Total average fuel usage for activate the diesel generator on each sample sites;
- Design of a hybrid energy system that has been implemented;
- Investment value to implement hybrid energy system at the sample site and operational costs;

Hybrid Energy System Investment Analysis Method

a. *Cost of Electricity per Site*

The cost of electricity or commonly referred to as the cost of electricity (lcoe) is the nominal amount of the price that must be paid by the customer for each unit of energy used (kWh).

$$\text{Cost of Electricity} = \frac{Cn}{Total\ Produced\ Energy\ (n\ year)} \quad (1)$$

$$\text{Cost of Electricity (CoE)} = \frac{ICo(1-\gamma)+FCn+VCn-Yn}{Total\ Energy\ Produced\ (n\ year)} \quad (2)$$

Where:
Cn = Energy Production Cost (n year)
ICo = First Investment / Installation Cost (Initial Cost)
γ = Subsidy Value from the government (%)
FCn = Fixed Cost
VCn = Variable Cost
Yn = Residual Value of Investment
TEP = Total Energy Produced per year x n (kWh)

3. Results and Discussions

Load Profile

The process of designing a hybrid energy system using solar panels at telecommunications sites in rural areas must begin with a survey process to determine the load profile at each site. Knowing the load profile of each site is important so that the hybrid energy system design that is made does not exceed or less than the requirement.

Table 1. Profile Load

No	Site	Load	
		Ampere	Watt
1	Pian Pasir	40	2,160
2	Alor	22	1,188
3	Sape	17	918
4	Ende	18	972
5	Bajawa	32	1,728
6	Kisol	28	1,512
7	Tangge	35	1,890
8	Ruteng	38	2,052
9	Puncak Selasih	29	1,566
10	Radja	24	1,296

Hybrid Energy System Design Calculation

As previously mentioned, that in this study the hybrid energy system design will be calculated using manual calculations. Here's the calculation result.

Table 2. Hybrid Energy System Design Calculation

No	Site	Solar Panel Moduls	Area
			m2
1	Pian Pasir	66	98.6
2	Alor	36	54.2
3	Sape	28	41.9
4	Ende	30	44.4
5	Bajawa	53	78.9
6	Kisol	46	69.0
7	Tangge	58	86.3
8	Ruteng	62	93.7
9	Puncak Selasih	48	71.5
10	Radja	39	59.2

Table 3. Designed I Hybrid System

No	Site	Battery			MPPT
		Ah	Bank	Cell	Modul
1	Pian Pasir	1,588.2	2	38	4
2	Alor	873.5	1	21	2
3	Sape	675.0	1	16	2
4	Ende	714.7	1	17	2
5	Bajawa	1,270.6	1	30	3
6	Kisol	1,111.8	1	27	3
7	Tangge	1,389.7	1	33	4
8	Ruteng	1,508.8	2	36	4
9	Puncak Selasih	1,151.5	1	28	3
10	Radja	952.9	1	23	3

In this analysis, the author will compare the economic value between the electrification system of telecommunications sites in rural areas traditionally with those using a hybrid energy system. The traditional system referred to here is an electrification system that still uses a diesel generator and battery as the main components (CDC system), compared to a hybrid electrification system that uses additional renewable energy components.

Hybrid Energy System Investment

The addition of renewable energy components such as solar panels to the CDC system for electrification of telecommunication sites does require a higher investment cost. In addition to solar panels, the addition of other devices such as MPPT, other electrical components on the hybrid panel, and additional monitoring systems to optimize the design of the hybrid energy system.

Table 4. Hybrid Energy System Investment

No	Site	Convensional	Hybrid	Deviasi
1	Pian Pasir	IDR 724,371,000	IDR 831,440,028	13%
2	Alor	IDR 724,795,000	IDR 839,080,028	14%
3	Sape	IDR 721,886,000	IDR 839,654,928	14%
4	Ende	IDR 722,244,000	IDR 834,440,028	13%
5	Bajawa	IDR 722,930,000	IDR 836,880,028	14%
6	Kisol	IDR 722,345,000	IDR 839,654,928	14%
7	Tangge	IDR 723,350,000	IDR 834,440,028	13%
8	Ruteng	IDR 724,050,000	IDR 839,080,028	14%
9	Puncak Selasih	IDR 722,244,000	IDR 841,854,928	14%
10	Radja	IDR 722,930,000	IDR 836,880,028	14%

Comparison of cost of electricity (COE)

The next comparison is the comparison of the cost of electricity (COE) between the conventional CDC system and the hybrid energy system (Li et al., 2019). In accordance with the calculation formula for the 10 sites that were used as research samples.

Table 5 Comparison of cost of electricity (COE)

No	Site	COE Conventional	COE Hybrid	Deviasi
1	Pian Pasir	IDR 13,083	IDR 4,873	63%
2	Alor	IDR 24,223	IDR 8,691	64%
3	Sape	IDR 31,069	IDR 11,448	63%
4	Ende	IDR 30,997	IDR 10,850	65%
5	Bajawa	IDR 18,053	IDR 5,959	67%
6	Kisol	IDR 19,300	IDR 6,806	65%
7	Tangge	IDR 15,442	IDR 5,527	64%
8	Ruteng	IDR 14,288	IDR 4,991	65%
9	Puncak Selasih	IDR 19,027	IDR 6,673	65%
10	Radja	IDR 22,845	IDR 8,057	65%

The COE of the hybrid energy system is lower than the COE with using the CDC system. This is caused, among others, by the fixed maintenance costs and variable maintenance costs of the CDC system which is much more expensive than the hybrid energy system.

4. Conclusion

Based on the results of the analysis that has been carried out in this thesis, the following conclusions are obtained. a. The deviation of investment costs for the CDC system with HES is 14%, although hybrid is more expensive, but the COE value is cheaper up to 67%. CDC at a price of Rp. 4,431 per KWh and hybrid at a price of Rp. 1,463 per KWh. b. Hybrid Energy System is very suitable to be applied as an alternative to electrification of telecommunication sites in rural areas. Although the initial investment costs are greater than the CDC system, HES will provide reduced operational costs and better maintenance cost efficiency.

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