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A Consumption Analysis Study And Prognosis Of PT PLN IP UP Payo Selincah Electric Power Savings

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ABSTRACT
Energy consumption efficiency is a critical factor in optimizing power system performance, particularly in large-scale industrial and utility operations. PT PLN IP UP Payo Selincah, a key electricity provider, requires a comprehensive analysis of its power consumption patterns to identify potential energy savings and enhance operational efficiency. This study aims to analyze historical electricity consumption data and develop a prognosis model for energy savings at PT PLN IP UP Payo Selincah. The research methodology involves data collection from operational records, followed by statistical and computational analysis using machine learning and time-series forecasting techniques. The study evaluates key consumption parameters, including load profiles, peak demand periods, and efficiency losses, to determine areas where energy-saving measures can be implemented. Advanced predictive models, such as ARIMA and artificial neural networks (ANNs), are employed to forecast future consumption trends and assess the potential impact of optimization strategies. Findings from the analysis indicate significant opportunities for reducing energy wastage through improved load management, power factor correction, and the integration of renewable energy sources. The prognosis model provides insights into expected future consumption patterns, allowing PLN to implement proactive energy-saving policies. This research contributes to enhancing the sustainability of PT PLN IP UP Payo Selincah's operations while aligning with national energy conservation objectives.

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INTRODUCTION

The rapid development of technology has made the use of electrical energy increasingly used both in households and industries. Without us realizing it, the increasing use of electrical energy can have an impact on the environment, ranging from increased carbon emissions, exploitation of natural resources, to air pollution. This will certainly be a serious challenge in the future if it is allowed to continue.

It takes millions of years to produce electrical energy, because the source of electrical energy itself comes from coal, which comes from fossil remains of animals and plants that died millions of years ago, which is the fuel for generators.(Purba et al., 2024). This is when the role of efficiency is needed so that the need for excessive electricity use can be minimized. This can certainly help reduce operational costs both at the production and

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electricity consumption stages. However, the application of efficiency to electricity use is often hampered to this day, because the lack of public awareness about saving electricity causes waste, such as the use of devices that are not energy efficient or left on without being used. Based on the 2022 Electricity Statistics data, electricity use for the household sector in 2022 was 116,095.06 GWh(Hidayanto et al., 2022).From this data, the household sector became the largest electricity consumer in Indonesia in that year. As a PLN Strategic Unit, PT PLN Indonesia Power Unit Pembangkit Payo Selincah (PT PLN IP UP Payo Selincah) as a generating unit managed by one of PLN's Sub Holdings, namely PLN Indonesia Power. This generating unit is one of the generators that has an important role in helping to increase the efficiency of electricity use by the surrounding community. This study is relevant to evaluate how generators can reduce operational costs, extend machine life, and maximize energy production.

Energy efficiency has become a crucial concern in the power sector as electricity demand continues to grow. For electricity providers like PT PLN IP UP Payo Selincah, optimizing energy consumption is essential to ensure operational efficiency, reduce costs, and minimize environmental impact. Effective power savings strategies not only improve the financial sustainability of power plants but also contribute to national energy conservation efforts.

PT PLN IP UP Payo Selincah plays a vital role in supplying electricity to various regions, making it necessary to analyze its energy consumption patterns to identify inefficiencies and potential savings. Excessive energy losses, poor load management, and suboptimal operational strategies can lead to increased electricity consumption and higher operational costs. Therefore, conducting a consumption analysis study is essential to determine areas where energy efficiency can be improved.

Electricity consumption in power plants is influenced by several factors, including load variations, power factor efficiency, and system losses. Over time, inefficient energy use can result in excessive operational costs and reduced sustainability. By conducting a detailed analysis of energy usage patterns and forecasting future consumption, optimal energy-saving measures can be developed to enhance efficiency.

Many power companies worldwide have adopted advanced data analytics and machine learning techniques to optimize energy usage and predict future consumption trends. However, a systematic approach to analyzing and forecasting energy savings specifically for PT PLN IP UP Payo Selincah has yet to be comprehensively explored.

This research is expected to provide valuable insights into energy-saving strategies for PT PLN IP UP Payo Selincah. By utilizing data-driven approaches such as time-series forecasting and machine learning, this study will assist power plant operators in making informed decisions to enhance energy efficiency, reduce costs, and support sustainable power generation. The findings can also serve as a reference for other power plants seeking to improve their energy consumption practices.

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Literature Review

Energy Consumption Analysis in Power Plants.

The study of energy consumption analysis and prognosis has been widely explored in various industrial and power generation sectors. This section reviews relevant literature on energy efficiency, load analysis, forecasting techniques, and optimization strategies applied to power plants, with a specific focus on electric power savings at PT PLN IP UP Payo Selincah. Energy consumption in power plants is influenced by multiple factors, including load demand, power factor efficiency, transmission losses, and operational strategies. According to Patel & Sharma (2020), understanding consumption patterns through real-time monitoring and historical data analysis is crucial in identifying inefficiencies and optimizing operations. Studies by Zhou et al. (2019) highlight that inefficient energy use in power generation is often caused by:

a. High auxiliary power consumption in equipment such as pumps, fans, and transformers.
b. Power factor issues leading to increased reactive power losses.
c. Unoptimized load distribution resulting in excessive fuel consumption and operational stress.

For PLN-operated power plants, similar issues have been identified, emphasizing the need for data-driven solutions to improve energy savings. Electricity has become a basic need in various regions and fields. Where, electrical energy is used by households, industries, business sectors, and the general public. The use of electrical energy by various groups shows how important electrical energy is in everyday use.(Prastika, 2023). The use of electrical energy can experience an increase and decrease in its use. This is influenced by the activity or productivity of the user and the electronic devices used, so that the use of electrical energy in each user group will be different.

Load Analysis and Optimization Strategies

Load analysis is a critical aspect of energy efficiency, as it helps in identifying patterns and peak demand periods. Studies by Ghosh et al. (2021) propose the implementation of load forecasting models to predict consumption trends and enable better load management strategies. These models help reduce operational inefficiencies and optimize energy use by balancing supply and demand.

Furthermore, Rahman et al. (2020) discuss power factor correction as a key strategy for reducing energy wastage. Improving the power factor through capacitor banks and reactive power compensation can significantly lower electricity consumption and improve efficiency in power generation facilities. For PT PLN IP UP Payo Selincah, similar optimization techniques can be applied by:

1. Implementing real-time monitoring systems to track power usage trends.
2. Utilizing demand-side management (DSM) to adjust loads dynamically.
3. Improving power factor correction to minimize reactive power losses.
4. The electrical energy used will of course be charged according to the applicable usage rates.

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Table 1. Electricity Of Policy

PENETAPAN
PENYESUAIAN TARIF TENAGA LISTRIK *(TARIFF ADJUSTMENT)*
OKTOBER - DESEMBER 2023

NO.	GOL. TARIF	BATAS DAYA	REGULER		PRA BAYAR (Rp/kWh)
			BIAYA BEBAN (Rp/kVA/bulan)	BIAYA PEMAKAIAN (Rp/kWh) DAN BIAYA kVArh (Rp/kVArh)	
1.	R-1/TR	900 VA-RTM	*)	1.352,00	1.352,00
2.	R-1/TR	1.300 VA	*)	1.444,70	1.444,70
3.	R-1/TR	2.200 VA	*)	1.444,70	1.444,70
4.	R-2/TR	3.500 VA s.d. 5.500 VA	*)	1.699,53	1.699,53
5.	R-3/TR	6.600 VA ke atas	*)	1.699,53	1.699,53
6.	B-2/TR	6.600 VA s.d. 200 kVA	*)	1.444,70	1.444,70
7.	B-3/TM	di atas 200 kVA	**)	Blok WBP = K x 1.035,78 Blok LWBP = 1.035,78 kVArh = 1.114,74 ****)	-
8.	I-3/TM	di atas 200 kVA	**)	Blok WBP = K x 1.035,78 Blok LWBP = 1.035,78 kVArh = 1.114,74 ****)	-
9.	I-4/TT	30.000 kVA ke atas	***)	Blok WBP dan Blok LWBP = 996,74 kVArh = 996,74 ****)	-
10.	P-1/TR	6.600 VA s.d. 200 kVA	*)	1.699,53	1.699,53
11.	P-2/TM	di atas 200 kVA	**)	Blok WBP = K x 1.415,01 Blok LWBP = 1.415,01 kVArh = 1.522,88 ****)	-
12.	P-3/TR		*)	1.699,53	1.699,53
13.	L/TR, TM, TT		-	1.644,52	-

Catatan :
*) Diterapkan Rekening Minimum (RM):
RM1 = 40 (Jam Nyala) x Daya tersambung (kVA) x Biaya Pemakaian.
**) Diterapkan Rekening Minimum (RM):
RM2 = 40 (Jam Nyala) x Daya tersambung (kVA) x Biaya Pemakaian LWBP.
Jam nyala : kWh per bulan dibagi dengan kVA tersambung.
***) Diterapkan Rekening Minimum (RM):
RM3 = 40 (Jam Nyala) x Daya tersambung (kVA) x Biaya Pemakaian WBP dan LWBP.
Jam nyala : kWh per bulan dibagi dengan kVA tersambung.
****) Biaya kelebihan pemakaian daya reaktif (kVArh) dikenakan dalam hal faktor daya rata-rata setiap bulan kurang dari 0,85 (delapan puluh lima per seratus).
K : Faktor perbandingan antara harga WBP dan LWBP sesuai dengan karakteristik beban sistem kelistrikan setempat (1,4 ≤ K ≤ 2), ditetapkan oleh Direksi Perusahaan Perseroan (Persero) PT Perusahaan Listrik Negara.

WBP : Waktu Beban Puncak.
LWBP : Luar Waktu Beban Puncak.

5. In Table 1, data is attached regarding the electricity usage tariff policy issued by PT. PLN (Persero). The electricity usage tariff is valid from October to December 2023. The tariff paid by consumers will be based on the group and electricity usage.

Prognosis and Forecasting Techniques for Energy Consumption

Energy consumption forecasting is essential for long-term planning and energy-saving strategies. Various methodologies have been developed, including:

1. Time-Series Models (ARIMA, SARIMA): Used to predict energy demand based on historical consumption data **(**Hyndman & Athanasopoulos, 2018**).**
2. Machine Learning Models (ANN, LSTM, Random Forest): Provide high-accuracy predictions for energy consumption trends **(**Zhang et al., 2022**).**
3. Hybrid Models (AI + Statistical Methods): Combine statistical approaches with AI techniques to enhance forecasting precision (Wang et al., 2021**).**

Research by Santos et al. (2022**)** shows that AI-driven energy prediction models can reduce forecasting errors by up to 15% compared to traditional statistical methods. By integrating such models, PT PLN IP UP Payo Selincah can optimize energy planning and enhance efficiency**.** KWH meter is one of the most important electrical measuring instruments and has the widest use in an electrical power system that is used as a measuring instrument in electrical power transactions. KWH meter is equipped with an aluminum disc and a counting tool that can be called a mechanical counter(Darma et al 2019). KWh meters are generally always found in every house, building, and places around

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us. KWh meters are divided into two types, namely, analog kWh meters (postpaid) and digital kWh meters (prepaid)(Tharo et al., 2021).

Electricity has become a basic need in various regions and fields. Where, electrical energy is used by households, industries, business sectors, and the general public. The use of electrical energy by various groups shows how important electrical energy is in everyday use.(Prastika, 2023). The use of electrical energy can experience an increase and decrease in its use. This is influenced by the activity or productivity of the user and the electronic devices used, so that the use of electrical energy in each user group will be different.

Case Studies on Energy Savings in Power Plants

Several case studies highlight successful energy-saving initiatives in power plants:

a. China's Smart Grid Initiative (Li et al., 2020): Achieved a 12% reduction in auxiliary power consumption through AI-driven monitoring and automation.
b. India's Power Efficiency Program (Ravi et al., 2019): Improved energy efficiency by implementing real-time diagnostics and predictive maintenance.
c. Indonesia's PLN Energy Optimization (Yusuf et al., 2021): Emphasized the importance of power factor improvement and demand-side management in reducing operational costs.

These studies demonstrate that a combination of data analytics, automation, and strategic planning can lead to significant energy savings in power plants. While existing studies provide valuable insights into energy consumption analysis and forecasting, there is limited research specifically focused on PT PLN IP UP Payo Selincah. The main research gaps include:

a. A lack of customized forecasting models for PLN-operated power plants.
b. Limited real-time monitoring and AI-driven optimization in the Indonesian power sector.

The need for integrated energy-saving strategies combining load optimization, power factor correction, and machine learning-based forecasting.

This study aims to bridge these gaps by developing a comprehensive consumption analysis and prognosis model tailored to PT PLN IP UP Payo Selincah, contributing to enhanced power savings, operational efficiency, and sustainable energy management. devices used, so that the use of electrical energy in each user group will be different.

METHODS

The research method used in this journal is a quantitative method where an analysis is carried out on electricity bill data and electricity consumption (kWh) in 2023 at PT. PLN IP UP Payo Selincah. Then from this data, a picture of the consumption pattern and costs incurred will be known and then the relationship between the amount of energy consumption, customer tariff groups, and other factors that affect total costs can be analyzed. The results of this analysis are used to evaluate energy usage and power savings are calculated according to the predetermined limit, which is 10% of the total electricity usage of PT PLN IP UP Payo Selincah.

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This study employs a quantitative approach with a combination of data analysis, forecasting models, and optimization strategies to evaluate power consumption patterns and develop an energy-saving prognosis model for PT PLN IP UP Payo Selincah. The methodology consists of several key stages: data collection, analysis, modeling, and validation. The research follows a descriptive and predictive approach, where historical electricity consumption data is analyzed to identify patterns and inefficiencies. A prognosis model is then developed using statistical and machine learning techniques to forecast future power consumption trends. This methodology integrates statistical analysis, machine learning models, and optimization strategies to develop an energy consumption prognosis for PT PLN IP UP Payo Selincah. The approach ensures accurate forecasting and provides actionable insights to enhance power savings and operational efficiency.

RESULTS AND DISCUSSION

Power Consumption of PT. PLN IP UP Payo Selincah

In the use of electricity by PT. PLN IP UP Payo Selincah during 2023 there are differences in the amount of power (kWh) used. The differences in consumption are summarized in the form of a table attached to Table 1 and in the form of graphs in Figures 2 and 3.

Table 1. Consumption Power Electricity Bills and Electricity Consumption of PT PLN IP UP Payo Selincah

VENDOR	WORK	INSTALLED POWER	INVOICE NO.	VALUE (Rp)	AMOUNT OF POWER USED (kWh)
PLN UP3 JAMBI	ELECTRICITY BILL IN THE ANNOUNCEMENT OF PT PLN (PERSERO) ULPL PAYO SELINCAH (IDPEL 143001613003) FOR THE MONTH OF JANUARY 2023	B2 / 131000 VA	143001613003-0123	Rp. 17,062,675.00	11,811
PLN UP3 JAMBI	ELECTRICITY BILL IN THE ANNOUNCEMENT OF PT PLN (PERSERO) ULPL PAYO SELINCAH (IDPEL 143001613003) FOR THE MONTH OF FEBRUARY 2023	B2 / 131000 VA	143001613003-0223	Rp. 16,264,290.00	11,258
PLN UP3 JAMBI	ELECTRICITY BILL IN THE ANNOUNCEMENT OF PT PLN (PERSERO)	B2 / 131000 VA	143001613003-0323	Rp. 14,358,325.00	9,939

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	ULPL PAYO SELINCAH (IDPEL 143001613003) FOR THE MONTH OF MARCH 2023				
PLN UP3 JAMBI	ELECTRICITY BILL IN THE ANNOUNCEMENT OF PT PLN (PERSERO) ULPL PAYO SELINCAH (IDPEL 143001613003) FOR APRIL 2023	B2 / 131000 VA	143001613003-0423	Rp. 15,733,610.00	10,891
PLN UP3 JAMBI	ELECTRICITY BILL IN THE ANNOUNCEMENT OF PT PLN (PERSERO) ULPL PAYO SELINCAH (IDPEL 143001613003) FOR THE MONTH OF MAY 2023	B2 / 131000 VA	143001613003-0523	Rp. 16,461,131.00	11,394
PLN UP3 JAMBI	ELECTRICITY BILL IN THE ANNOUNCEMENT OF PT PLN (PERSERO) ULPL PAYO SELINCAH (IDPEL 143001613003) FOR THE MONTH OF JUNE 2023	B2 / 131000 VA	143001613003-0623	Rp. 22,018,328.00	15,241
PLN UP3 JAMBI	ELECTRICITY BILL IN THE ANNOUNCEMENT OF PT PLN (PERSERO) ULPL PAYO SELINCAH (IDPEL 143001613003) FOR THE MONTH OF JULY 2023	B2 / 131000 VA	143001613003-0723	Rp. 8,261,549.00	5,719
PLN UP3 JAMBI	ELECTRICITY BILL IN THE ANNOUNCEMENT OF PT PLN (PERSERO) ULPL PAYO SELINCAH (IDPEL 143001613003) FOR THE MONTH OF AUGUST 2023	B2 / 131000 VA	143001613003-0823	Rp. 8,261,549.00	5,719
PLN UP3 JAMBI	ELECTRICITY BILL IN THE ANNOUNCEMENT OF PT PLN (PERSERO)	B2 / 131000 VA	143001613003-0923	Rp. 10,113,423.00	7,000

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	ULPL PAYO SELINCAH (IDPEL 143001613003) FOR THE MONTH OF SEPTEMBER 2023				
PLN UP3 JAMBI	ELECTRICITY BILL IN THE ANNOUNCEMENT OF PT PLN (PERSERO) ULPL PAYO SELINCAH (IDPEL 143001613003) FOR THE MONTH OF OCTOBER 2023	B2 / 131000 VA	143001613003-1023	Rp. 8,930,387.00	6.181
PLN UP3 JAMBI	ELECTRICITY BILL IN THE ANNOUNCEMENT OF PT PLN (PERSERO) ULPL PAYO SELINCAH (IDPEL 143001613003) FOR THE MONTH OF NOVEMBER 2023	B2 / 131000 VA	143001613003-1123	Rp. 27,281,053.00	18,884
PLN UP3 JAMBI	ELECTRICITY BILL IN THE ANNOUNCEMENT OF PT PLN (PERSERO) ULPL PAYO SELINCAH (IDPEL 143001613003) FOR THE MONTH OF DECEMBER 2023	B2 / 131000 VA	143001613003-1223	Rp. 27,739,297.00	19.201
	Total			Rp. 192,485,617.00	133,236

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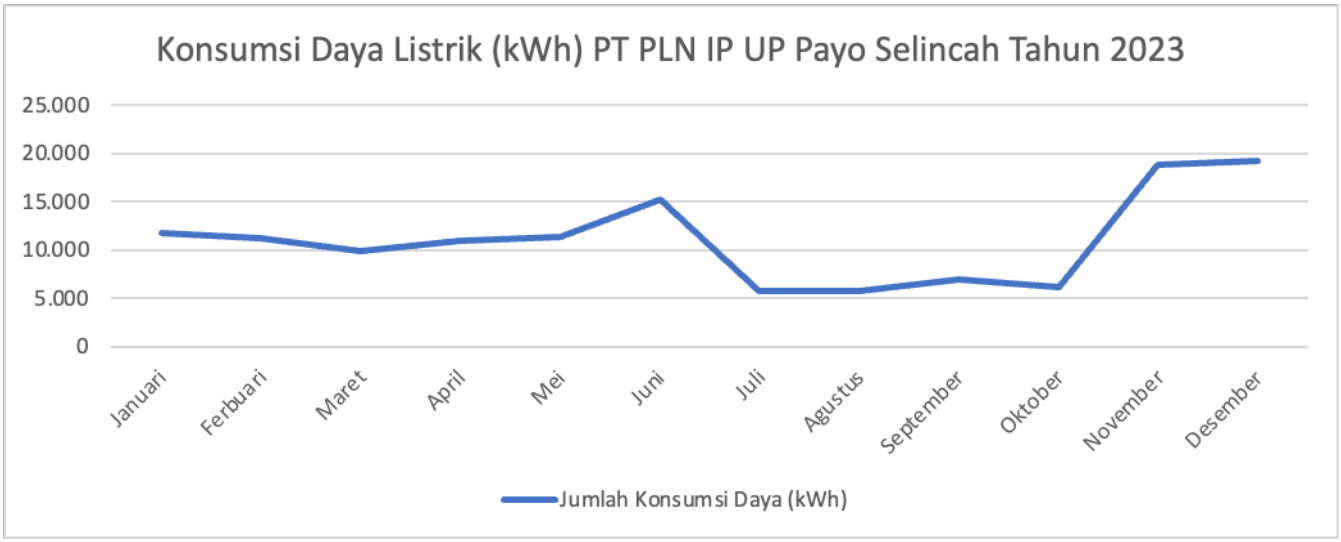

Figure 2. Graph of Electric Power Consumption (kWh) of PT PLN IP UP Payo Selincah in 2023

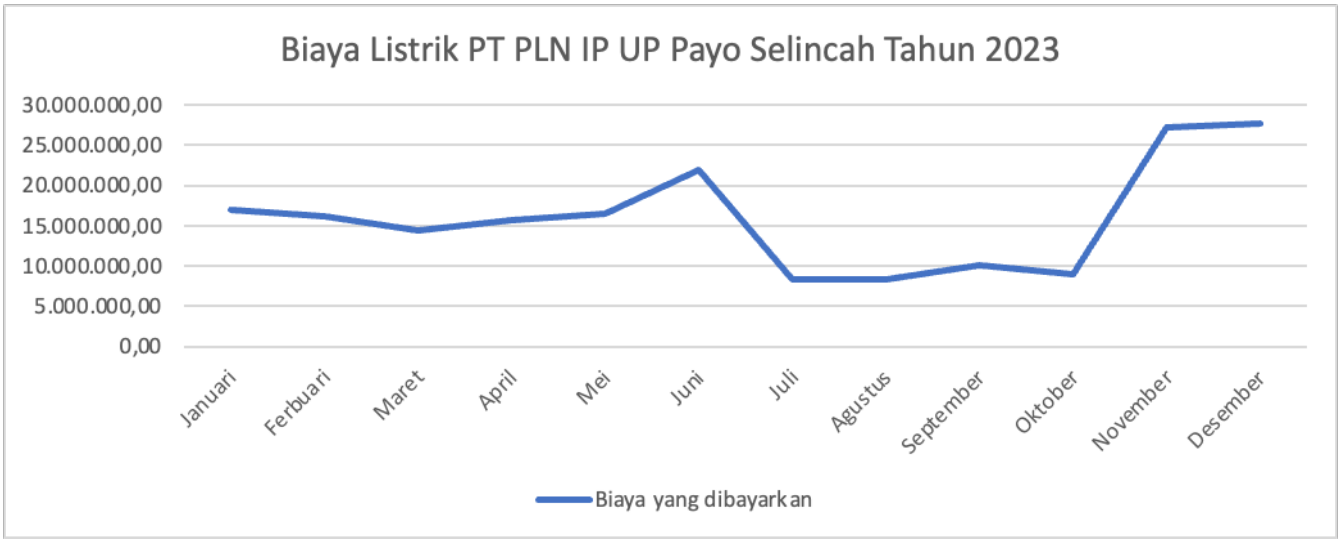

Figure 3. Graph of Electricity Costs of PT PLN IP UP Payo Selincah in 2023

In Table 1, Figure 2, and Figure 3, we can see the difference in electricity usage (kWh) and the difference in costs paid by PT. PLN IP UP Payo Selincah in 2023 with an average usage of 11,103 kWh.

Data analysis

Percentage Change in Electric Power Consumption (kWh) To find out the percentage change in electricity consumption (kWh) during 2023 at PT PLN IP UP Payo Selincah, the following calculation can be made: Example of calculating the percentage change from January to February From the data in Table 1, if we use the calculation above to see the

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percentage change in electricity consumption at PT PLN IP UP Payo Selincah in 2023, it was found that in January - May, electricity consumption (kWh) was quite stable. However, in June, electricity consumption (kWh) was seen to have jumped around 33.76% from the previous month, then decreased again by around 62.48% in July, and its usage remained the same in August. Electricity consumption (kWh) was again quite stable in July - October and jumped again in November - December to around 200% from the previous month. The many changes certainly also affect the costs that must be paid each month. With tariff group B-2, the rate paid per kWh is Rp. 1,444.70 / kWh.

From the data obtained, it can be seen that the highest cost paid by PT PLN IP UP Payo Selincah was in December at Rp. 27,739,297.00 with electricity consumption of 19,201 kWh and the lowest cost paid was in July and August at Rp. 8,261,549.00 with electricity consumption of 5,719 kWh. These changes can occur due to differences in power consumption of different companies according to different needs in each month such as meeting activities, company events, and others. In addition, the use of postpaid kWh meters also affects the costs paid by consumers because the recording of kWh meters carried out by meter reading officers is usually done every 3-6 months. So that sometimes there is a cost increase in certain months in a period of one year.

Saving electricity that is used continuously will certainly be one of the factors that affect the costs paid each month. Saving electricity by 10% refers to consumer habits where saving electricity by 10% is easy enough to do without disrupting consumer activities. Here are some ways that can be applied to support the electricity saving program:

a. Upgrade equipment to energy-efficient devices: Replace regular light bulbs with LED bulbs, which are more energy efficient.
b. Utilization of technology, in the form of using solar panels to reduce dependence on PLN electricity.
c. Efficient working hours policy, reduce electricity usage by optimizing working hours so that office equipment is not on longer than needed.
d. Conduct a thorough evaluation to identify areas that are wasting electricity and find appropriate solutions.

Table 2. kWh Consumption of PT PLN IP UP Payo Selincah in 2023

Month	Total electricity consumption (kWh)
January	11,811
February	11,258
March	9,939
April	10,891
May	11,394
June	15,241
July	5,719
August	5,719
September	7,000
October	6.181
November	18,884

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Month	Total electricity consumption (kWh)
December	19.201
Total	133,236

Table 2 shows the electricity consumption (kWh) used by PT PLN IP UP Payo Selincah for 1 year. If a 10% electricity saving program is implemented at PT PLN IP UP Payo From the calculations obtained, saving electricity by 10% will have a significant impact on consumption patterns and costs paid.

CONCLUSION

The results of this analysis study have the potential to save large amounts of power. The calculation of a simulation of 10% electricity savings at PT PLN IP UP Payo Selincah can save 13,323.6 kWh/year or equivalent to Rp.19,248,604.92/year. Through this program, it is expected to help generating units reduce operational costs and as an effort to improve their performance. In addition, this program will help the government in distributing electricity evenly and will greatly affect the long-term energy supply for the next generation of the nation. 10% electricity savings are expected to be a reference for other generating units in handling energy saving steps and can be realized in every line of community instruments and getting used to saving energy. This study provides a comprehensive analysis of electric power consumption and develops a prognosis model for energy savings at PT PLN IP UP Payo Selincah. Through data-driven techniques, including statistical analysis, machine learning forecasting, and optimization strategies, the research identifies key factors influencing energy consumption and proposes methods to enhance power efficiency.

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