Full Costing Analysis of Power Generation Supply Costs: Differences Across Power Plant Types in 2023

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ABSTRACT

Electricity production costs in power plants are closely linked to electricity tariffs (selling prices). To fund power generation, both direct and indirect costs, including basic and overhead costs, are calculated as components of the Power Generation Supply Cost (BPP). Changes in BPP components impact overall costs, affecting total BPP. This study aims to compare and analyze cost differences among PLN power plants and identify which types of power plants show significant cost variations. Conducted at PT PLN (Persero) in 2023, the research uses an exploratory descriptive method with quantitative data from financial reports and time-series data. The study examines four BPP subcategories across 38 power plants, grouped into six categories. Multivariate analysis is applied using SPSS. Results show that power plant groups significantly influence inefficiencies in BPP. Specifically, BPP A has inconsistent cost variations, with high deviations in fixed asset depreciation, leased asset depreciation, and loan expenses. Certain power plants show inefficiencies affecting BPP. PLTGU and PLTD contribute the highest costs in BPP A and BPP D, respectively. Overall, PLTU is the most efficient group, significantly impacting BPP elasticity.

INTRODUCTION

The energy sector plays a crucial role in national economic development, serving as the backbone of various industries and societal functions. Electricity, as one of the primary energy sources, is indispensable for economic growth, industrial productivity, and social well-being. Consequently, electricity providers, particularly state-owned enterprises, must operate efficiently while maintaining financial transparency and sustainability. Indonesia's state electricity company, Perusahaan Listrik Negara (PLN), has a strategic role in ensuring the provision of electricity across the archipelago. However, challenges persist in maintaining financial stability, regulatory compliance, and environmental sustainability. One of the major challenges faced by PLN is its financial sustainability, which is impacted by operational inefficiencies, government subsidies, and fluctuating global energy prices (Ministry of Energy and Mineral Resources. As a state-owned enterprise, PLN relies significantly on government subsidies to maintain affordable electricity tariffs for the public. However, this dependency raises concerns regarding long-term financial viability and the ability to invest in infrastructure improvements and renewable energy initiatives. Moreover, the rising demand for electricity necessitates a balance between supply reliability and financial sustainability.

Another critical issue in the electricity sector is environmental sustainability, particularly regarding carbon emissions and the transition to renewable energy sources (United Nations Framework Convention on Climate Change. As Indonesia commits to reducing greenhouse gas emissions under the Paris Agreement, the energy sector must shift towards sustainable practices, including the adoption of renewable energy and energy-efficient technologies. PLN, as the primary electricity provider, plays a central role in this transition, requiring comprehensive strategies for integrating sustainability into its financial and operational frameworks.

To address these challenges, production cost theory provides a framework for understanding the financial aspects of electricity generation, encompassing costs from feasibility studies to commercial operations (OECD, 2020). Cost components, including direct and allocated expenses, capital expenditures (CAPEX), and the weighted average cost of capital (WACC), influence investment feasibility and electricity pricing (Steffen, 2020; Bierer & Götze, 2012). Additionally, the Levelized Cost of Electricity (LCOE) serves as a standardized metric for comparing generation costs across different power plants, incorporating investment costs, operational expenditures, and discount rates (Jeremiah et al., 2023; Pagnini et al., 2024). Cost budgeting and cost control mechanisms play a crucial role in ensuring financial efficiency and accountability within PLN. Effective budgeting allocates financial resources to organizational activities, while rigorous cost control ensures alignment with budgetary constraints (GreatNusa). Decentralized cost management enables responsive decision-making, particularly within cost centers tracking capital expenditures, operational costs, and fuel expenses (Atkinson et al., 1995; Jeremiah et al., 2023).

Furthermore, sustainability accounting standards have emerged as a key strategy for enhancing transparency, accountability, and decision-making processes in the energy sector. Sustainability accounting encompasses environmental, social, and governance (ESG) factors, enabling companies to assess long-term impacts beyond financial performance. The adoption of sustainability reporting frameworks, such as the International Financial Reporting Standards (IFRS) for sustainability and the GRI standards, has gained traction among energy companies worldwide, including PLN. These frameworks provide a structured approach to reporting sustainability metrics, fostering greater investor confidence and regulatory compliance. Despite the recognized benefits of sustainability accounting, the integration of these standards within PLN faces several challenges. The complexity of data collection, measurement inconsistencies, and regulatory alignment pose significant hurdles in ensuring comprehensive and reliable sustainability reports (OECD, 2022). Additionally, the lack of internal expertise and technological infrastructure further impedes the effective implementation of sustainability accounting practices. Overcoming these barriers requires strategic investments in capacity building, digital transformation, and stakeholder engagement.

This study aims to examine the implementation of sustainability accounting standards in PLN, focusing on its impact on financial performance, regulatory compliance, and environmental sustainability. By analyzing PLN's financial disclosures, sustainability reports, and regulatory frameworks, this research seeks to provide insights into the effectiveness of sustainability accounting in enhancing transparency and corporate accountability. Furthermore, this study will contribute to the broader discourse on sustainability reporting in the energy sector, offering recommendations for policy improvements and best practices. Through this research, the study seeks to bridge the gap between sustainability accounting practices and financial performance in state-owned electricity enterprises. By understanding the interplay between sustainability reporting and corporate decision-making, this paper aims to support policymakers, industry stakeholders, and academics in advancing sustainable energy governance in Indonesia and beyond.

RESEARCH METHOD

This research focuses on analyzing the discrimination of the Cost of Electricity Supply (BPP) in power generation at electric power centers. A comparative analysis technique is utilized, incorporating financial and technical data available from power generation units as cost objects. PT PLN (Persero) operates various types of power generation plants, which serve as the basis for understanding the cost structure of electricity generation (Ministry of Energy and Mineral Resources, 2022/2023). The study applies cost accounting and management accounting theories, integrating cost concepts commonly used in the electricity sector, including the Levelized Cost of Electricity (LCOE). The research examines the BPP of electricity generation by comparing costs across different types of power plants. Additionally, it considers the implications of climate change, highlighting the necessity for transitioning to cleaner energy sources, which directly affects cost structures (International Renewable Energy Agency [IRENA]. The LCOE framework is employed to analyze initial investment, operational expenditures, and other factors, facilitating comparisons between different energy sources in power generation (Jeremiah et al., 2023; Pagnini et al., 2024).

The data for this study were obtained from both primary and secondary sources. Secondary data were collected from publicly available websites of various national and international electricity sector entities, including PT PLN (Persero), the Ministry of Energy and Mineral Resources of Indonesia (https://www.esdm.go.id/), the Central Bureau of Statistics (https://www.bps.go.id/id), and PT PLN subsidiaries such as PLN Batam and PLN Nusantara Power. Additionally, international organizations such as the International Energy Agency (IEA) (https://www.iea.org/), the International Renewable Energy Agency (IRENA) (https://www.irena.org/), and the United Nations Climate Change (https://unfccc.int/) provided global data relevant to electricity generation and climate change issues. These sources offer valuable insights into both national and international energy trends, particularly in the context of electricity generation and sustainability.

A phenomenological approach was employed for data collection, utilizing various methods, including literature review, observation, and documentation. The literature review involved gathering information from scientific texts, articles, and reports available both online and offline, with academic journals accessed through credible platforms. Observational data were obtained through passive observation, in which virtual observations of electricity sector entities were conducted by analyzing publicly available information on their official websites. This approach allowed for an assessment of the consistency between online information and official documentation. Direct observation was also conducted at PT PLN (Persero) Headquarters to collect primary data on the actual conditions of electricity generation and financial reporting. Additionally, documentation involved collecting official records and administrative data, ensuring reliability and validity by using authenticated documents from relevant entities (OECD, 2022).

The population of this study comprises various types of electricity generation plants operated by PT PLN (Persero), totaling eleven distinct categories: Hydroelectric Power Plants (PLTA), Micro Hydroelectric Power Plants (PLTM), Micro Hydro Power Plants (PLTMH), Coal-fired Steam Power Plants (PLTU), Gas Power Plants (PLTG), Combined Cycle Gas/Steam Power Plants (PLTGU), Geothermal Power Plants (PLTP), Diesel Power Plants (PLTD), Gas Turbine Power Plants (PLTMG), Solar Power Plants (PLTS), and Wind Power Plants (PLTB). A sample of six types of plants—PLTU, PLTGU, PLTP, PLTA, PLTG, and PLTD—was selected, comprising 38 electricity generation units (Ministry of Energy and Mineral Resources, 2022/2023). The selection was based on their significance in cost analysis, their impact on the overall cost structure of electricity generation, and their role in Indonesia's energy mix. PLTU and PLTG/PLTGU were chosen due to their high production costs and significant contribution to electricity pricing. PLTG/PLTGU plants were selected due to their role as load-following plants, which adjust their power output based on electricity demand. Renewable energy plants, including PLTP and PLTA, were included to represent the contribution of new and renewable energy sources. PLTD plants were selected due to their high operational costs, which directly influence electricity tariffs and subsidies (OECD, 2020).

The operational definition of variables in this study focuses on several critical factors. Electricity generation, which constitutes a substantial portion of PT PLN's production costs, is the primary variable, influencing both electricity pricing and government subsidies. The cost drivers of electricity generation include factors such as the Levelized Cost of Electricity (LCOE), fuel and lubricant usage technology, capital expenditure (CapEx), operational expenditure (OpEx), maintenance costs, and efficiency improvements (Steffen, 2020; Bierer & Götze, 2012). The components and scale of electricity generation costs (BPP) are also analyzed to determine the economic feasibility of different power plants, with operational effectiveness and financial performance serving as key indicators. The LCOE framework classifies BPP costs into four categories: BPP A, which includes investment costs; BPP B, which covers operational and maintenance costs; BPP C, which accounts for fuel generation costs; and BPP D, which includes the costs of supporting power plant operations. These costs are reported in the statement of profit or loss for power generation plants.

This study employs both descriptive and non-descriptive analysis techniques. Descriptive analysis is used to interpret the data, assess its reliability, and provide insights into financial and non-financial aspects of electricity generation. The power plants under study are categorized into six groups based on fuel type. These six categories were selected from 38 sampled plants using purposive sampling. Given PLN's widespread geographical distribution and the difficulty of physically accessing all plants, purposive sampling was used to target participants from the Accounting and Tax Division of PT PLN (Persero) for the year 2023 (Asian Development Bank [ADB], 2021). The six power plant categories—PLTA, PLTD, PLTG, PLTGU, PLTP, and PLTU—were selected to highlight cost differences between these plant types. These categories serve as independent variables, while BPP cost components derived from financial data act as outcome variables.

The collected data, primarily qualitative, are widely distributed and vary significantly. Due to the study's focus on BPP determinacy in power generation, statistical tests such as the t-test and multivariate analysis of variance (MANOVA) are applied to compare means and assess relationships between groups. These tests evaluate significant differences across cost categories in electricity generation plants. The analysis follows a structured process, beginning with data reduction, where data are organized and prioritized before being grouped into relevant themes. This ensures that key insights are extracted and presented using tables, charts, and matrices to enhance clarity and facilitate understanding for the reader.

RESULTS AND DISCUSSION

Overview of Research Object

The electricity generation sector in Indonesia operates through a national electrical system aimed at meeting the country's electricity demands. PT Perusahaan Listrik Negara (PLN) plays a critical role in managing electricity generation by positioning power plants strategically across the nation. This responsibility is divided between two sub-holding generation companies: PT PLN Indonesia Power (Genco 1) and PT PLN Nusantara Power (Genco 2). Electricity generation, as a part of an integrated electrical system, spans across various regions to supply power to multiple provinces. In total, there are 20 PLN electrical systems in Indonesia, each catering to specific provinces.

Electricity generation is an essential component of the electrical system, providing energy through a network of power plants. The electricity grid, which consists of generation plants, transmission lines, and distribution substations, must be effectively managed to ensure reliable electricity delivery to consumers. This study examines specific electrical systems and power plants, focusing on the contribution of each plant in supplying electricity across the integrated network. The electricity generated by these plants is critical for maintaining a stable power supply across regions.

Analysis of Full Costing in Power Generation

The assessment of costs in electricity generation employs the full costing method, based on the premise that each power plant serves as a cost center. This methodology enables financial statements for each power plant to be disaggregated into individual profit and loss reports. In essence, costs incurred in power generation are allocated proportionally, particularly those associated with long-term benefits extending throughout the plant's economic lifespan. A critical component of this analysis is the levelized cost, which represents the present value of total construction and operational expenses over the assumed economic lifespan of the plant, adjusted to constant real-dollar terms to eliminate the effects of inflation (EIA, 2010).

Structure of Power Generation Costs

Among various cost components, BPP A and BPP C constitute the largest proportion of overall generation costs. Variations in cost structure across different power plant types stem from three key determinants: operational efficiency (encompassing production capacity and sales), utilization hours, and technical and economic service life of assets. Analyzing the cost structure reveals that hydroelectric power plants (PLTA) exhibit the lowest proportion of BPP C, whereas BPP B is significantly higher compared to other power generation technologies.

Table 1. Determining the Proportion of BPP in the Generation Group in 2023

Sub_Total_BPP_Rp_k	PLTA (4 Unit)	PLTD (2 Unit)	PLTG (5 Unit)	PLTGU (6 Unit)	PLTP (3 Unit)	PLTU (18 Unit)
BPP_A_Rp_kWh	59.38	6.93%	15.81	59.94%	11.79	16.06%
BPP_B_Rp_kWh	35.83	22.82%	9.71%	22.99%	5.08%	21.14%
BPP_C_Rp_kWh	4.65%	68.86%	73.86	17.06%	82.48	62.46%
BPP_D_Rp_kWh	0.14%	1.39%	0.62%	0.02%	0.64%	0.34%
Total_BPP_Rp_kWh	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

A breakdown of the Total Cost of Power Generation (BPP) by Plant Type underscores the substantial contribution of gas and coal-fired power plants (PLTGU and PLTU), collectively accounting for over 73% of total generation costs. In contrast, hydro (PLTA) and geothermal (PLTP) plants contribute minimal proportions, highlighting their cost-efficiency in mitigating total BPP.

Components of Power Generation Costs

The structure of BPP in aggregate generation costs is dominated by fuel expenses (BPP C), which constitute 44.1%, followed by investment-related costs (BPP A) at 35.11%, with the remaining costs allocated to maintenance, personnel, and operational contingencies. The capital-intensive nature of power generation infrastructure necessitates significant upfront expenditures, particularly in asset acquisition and financing.

BPP A represents fixed costs associated with asset acquisition, depreciation, and financing expenses, where the magnitude of these costs is influenced by production volumes, plant lifespan, and financial leverage. BPP B encompasses personnel costs and operational maintenance, with older plants incurring higher maintenance expenses, thereby increasing this component's share. BPP C consists of fuel costs, which are subject to fluctuations in fuel prices, efficiency rates, and plant technology, making it a critical variable cost factor. Lastly, BPP D covers operational adjustments, including consumables, lubricants, and chemicals essential for maintaining plant performance and efficiency. Given the significant role of fuel expenditures in total BPP, optimizing power generation costs necessitates prioritizing renewable sources such as PLTA and PLTP, which offer long-term cost stability and sustainability.

Electricity Production and Sales

Several key factors influence the determination of electricity production and sales from a power generation system based on energy demand perspectives. These factors include: (1) the growth in aggregate demand, which directly impacts electricity consumption and power expansion, and (2) the increase in new customers (Assagaf, 2010). According to Adusah-Poku et al. (2022), the rising electricity demand is primarily driven by significant population growth, leading to urbanization, technological advancements, increased per capita income, structural economic shifts, government policies on electricity subsidies (such as in Ghana), and rural development initiatives (Adom, Bekoe, & Akoena, 2012; Adom & Bekoe, 2012; Dramani, Francis, & Tewari, 2012; Mensah, Marbuah, & Amoah, 2016; Adom, 2017). We have electricity production and sales figures from 38 power plants across the national electricity system in 2023. The data reveals that actual production remains below the installed capacity for each power plant, indicating potential inefficiencies or operational constraints.

Macroeconomic and demographic factors significantly influence electricity production and sales trends. Economic growth directly affects electricity consumption elasticity, with fluctuations observed between 2004 and 2017, and a decline in 2017 when consumption stagnated at 3.6%. Global financial crises and the COVID-19 pandemic further reduced elasticity levels below 1, though recovery is anticipated per the 2021–2030 RUPTL. Population growth projections from Bappenas are essential for estimating future electricity demand. Additionally, electrification ratio targets help determine new household electricity connections, with consumer growth eventually aligning with net household formation once full electrification is achieved.

Ranking of Power Generation Categories

Power plants are classified into six categories based on their operational characteristics and generation capacity. Table 4.7 illustrates the distribution of generation units by type, emphasizing the dominance of coal-fired power plants (PLTU), followed by gas and combined-cycle plants (PLTG and PLTGU). These classifications serve as independent variables for further analysis. To enhance efficiency, PLN has implemented three key strategies: (1) optimizing fuel consumption and operational parameters, (2) minimizing transmission losses, and (3) improving distribution efficiency (Haryanto, 2020). Based on production data, coal-fired power plants (PLTU) dominate electricity generation with 18 units producing 6,265.23 MWh, followed by combined-cycle power plants (PLTGU) with 6 units generating 1,812.42 MWh. Gas power plants (PLTG) contribute 622.57 MWh from 5 units, while hydropower plants (PLTA) generate 591.89 MWh from 4 units. Geothermal power plants (PLTP) produce 485.43 MWh from 3 units, and diesel power plants (PLTD) operate with 2 units. This ranking underscores the predominant role of coal-fired power plants in the national energy mix, with other power sources playing a supplementary role based on installed capacities.

Statistical Analysis of Sub BPP in Power Generation (2023)

The analysis of mean, median, mode, and percentiles provides insights into the cost distribution across different BPP categories. The lowest average cost (mean) is observed in BPP D at Rp8.19 per kWh, whereas BPP C records the highest mean value at Rp1,076.05 per kWh. The most significant discrepancy between the median and mean is found in BPP A, where the median is Rp199.51 per kWh, whereas the mean is Rp855.77 per kWh, suggesting the presence of extreme values influencing the overall mean. Conversely, the smallest gap between the median and mean occurs in BPP D (median Rp1.92 per kWh, mean Rp8.19 per kWh), indicating a more uniform distribution. These findings suggest that BPP C contributes the highest to the overall mean BPP across all categories, while BPP A is significantly affected by outliers.

Standard Deviation and Variance for BPP (2023)

Table 2. Standard Deviation and Variance for BPP in 2023

N		Minimum	Maximum	Std. Deviation	Variance
BPP_A (Rp/kWh)	38	62.82	23296.94	3742.03555	14002830.031
BPP_B (Rp/kWh)	38	20.24	8899.08	1434.20924	2056956.155
BPP_C (Rp/kWh)	38	5.68	4548.69	846.83215	717124.688
BPP_D (Rp/kWh)	38	.00	72.73	14.19017	201.361
Valid N (listwise)	38				

Source: Processed Data – SPSS Ver. 27

Variance analysis reveals the degree of dispersion within each BPP category. BPP A exhibits the highest variance at 14,002,830.03, whereas BPP D has the lowest at 201.36, reflecting a more stable cost structure. The significant variance BPP A is attributed to cost inconsistencies within its three cost components: BPP_A_Peny_AT_Rp_kWh, BPP_A_Peny_AT_Sewa_Rp_kWh, and BPP_A_Beban_Pinjaman_Rp_kWh. Conversely, BPP D demonstrates greater cost stability, with minor deviations among its cost components, particularly BPP_D_Cmpran_BB_Kimia_Pelumas_Rp_kWh.

A standard deviation analysis further reinforces these findings. BPP A exhibits the highest standard deviation (Rp3,742.04 per kWh), highlighting substantial variability in costs across power plants. The extreme cost variation is driven by a maximum depreciation charge (BPP_A_Peny_AT_Rp_kWh) at PLTGU Grati Block 3, reaching Rp23,296.94 per kWh. In contrast, BPP D records the lowest standard deviation (Rp14.19 per kWh), indicating the smallest cost dispersion, with a maximum component cost of Rp72.73 per kWh for BPP_D_Cmpran_BB_Kimia_Pelumas_Rp_kWh at PLTD UPDK Tello.

Efficiency Ranking of BPP and Power Generation Groups (2023)

Table 3. Efficiency Ranking of BPP and Power Generation Groups (2023)

Power Generation Group	Std. Deviation	N	BPP Efficiency Rank	Efficiency Rank within Each Group
BPP A				
PLTD	16.91	4	-	1
PLTP	38.54	2	-	2
PLTA	95.09	5	-	3
PLTU	176.22	6	-	4
PLTG	225.76	3	-	5
PLTGU	9417.52	18	-	6
Total	3742.04	38	4	-
BPP B				
PLTP	28.04	4	-	1
PLTA	72.75	2	-	2
PLTG	86.39	5	-	3
PLTU	353.84	6	-	5
PLTD	198.53	3	-	4
PLTGU	3594.58	18	-	6
Total	1434.21	38	3	-
BPP C				
PLTA	13.27	4	-	1
PLTU	440.17	2	-	4
PLTP	117.28	5	-	2
PLTGU	395.29	6	-	3
PLTG	1033.92	3	-	5
PLTD	2308.76	18	-	6
Total	846.83	38	2	-
BPP D				
PLTA	0.20	4	-	1
PLTGU	1.12	2	-	2
PLTU	6.60	5	-	4
PLTP	6.06	6	-	3
PLTG	8.09	3	-	5
PLTD	19.35	18	-	6
Total	14.19	38	1	-

Source: Processed Data – SPSS Ver. 27

This analysis confirms that PLTGU and PLTD have the highest contribution to BPP, with PLTGU leading in BPP A and PLTD in BPP D. However, from a cost variability perspective, PLTGU exhibits the widest range of cost dispersion, necessitating greater cost control measures, while PLTD demonstrates the least variation, implying a more predictable and controlled cost structure.

Multivariate Analysis on BPP Across Power Plant Groups in 2023

The results of the multivariate analysis for different power plant groups in 2023 are presented below. This analysis assesses whether the BPP (which includes BPP A, B, C, and D) exhibits varying effects across different power plant groups.

Table 4. Multivariate Tests on BPP Across Power Plant Groups in 2023

Effect	Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	0.800	28.983	4.000	0.000
	Wilks' Lambda	0.200	28.983	4.000	0.000
	Hotelling's Trace	3.998	28.983	4.000	0.000
	Roy's Largest Root	3.998	28.983	4.000	0.000
Kelompok Pembangkit	Pillai's Trace	1.439	3.597	20.000	0.000
	Wilks' Lambda	0.085	5.353	20.000	0.000
	Hotelling's Trace	5.662	7.786	20.000	0.000
	Roy's Largest Root	4.863	31.120	5.000	0.000

Source: Processed Data - SPSS Version 27

From the results above, the statistical output of the SPSS software indicates whether the sub-total BPP variables significantly differ across power plant groups. All four multivariate test statistics—Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root—yield p-values below the 0.05 threshold ($p = 0.000$). This confirms the statistical significance of the differences among power plant groups in terms of BPP. The MANOVA results provide sufficient evidence to reject the null hypothesis, implying significant variations in BPP across different power plant groups.

The results also suggest that production capacity and installed power play a significant role in these variations. Factors contributing to the differences include: (1) variation in production levels, with some plants operating at suboptimal levels while others run at full capacity, (2) fixed costs, such as depreciation and loan expenses, which remain constant regardless of production output, particularly affecting BPP Component A, and (3) fluctuations in unit production costs, particularly fuel costs, which tend to increase over time. Fuel cost components include MT for HSD/MFO, MTBU for gas, and MT for coal, while water-related costs remain limited to water usage taxes.

Levene's Test of Equality of Error Variances

Levene's test is employed to assess the assumption of homogeneity of variances across different groups. If the p-value exceeds 0.05, the null hypothesis is retained, indicating no sufficient evidence of variance differences. Conversely, if $p \leq 0.05$, the null hypothesis is rejected, suggesting at least one group exhibits significantly different variances.

Table 5. Levene's Test of Equality of Error Variances on BPP Across Power Plant Groups in 2023

Variable	Levene Statistic	df1	df2	Sig.
BPP_A_Rp_kWh	Based on Mean	6.488	5	32
	Based on Median	1.054	5	32
	Based on Trimmed Mean	4.372	5	32
BPP_B_Rp_kWh	Based on Mean	5.695	5	32
	Based on Median	0.937	5	32
BPP_C_Rp_kWh	Based on Mean	13.963	5	32
	Based on Median	4.973	5	32
BPP_D_Rp_kWh	Based on Mean	7.911	5	32
	Based on Median	2.644	5	32

Source: Processed Data – SPSS Version 27

Levene's test results confirm that, for most dependent variables, the assumption of equal variances is violated (Sig. < 0.05). This supports the robustness of the multivariate test statistics by ensuring that the statistical conclusions drawn remain valid.

Tests of Between-Subjects Effects

Between-subjects effects analysis investigates the impact of independent variables on each dependent variable separately. The Type III Sum of Squares for each BPP is assessed to determine statistical significance. The results from the Tests of Between-Subjects Effects indicate that BPP A and BPP B do not exhibit statistically significant differences among power plant groups, as their p-values exceed the 0.05 threshold ($p = 0.398$ and $p = 0.500$, respectively). Conversely, BPP C and BPP D demonstrate significant differences among power plant groups, with p-values below 0.05 ($p = 0.001$ and $p = 0.000$, respectively), suggesting that these cost components vary significantly across different power generation groups.

While MANOVA results suggest that BPP A, B, C, and D collectively influence cost efficiency in power plants, univariate analyses indicate that BPP A and B do not independently contribute to efficiency differences. This discrepancy arises because MANOVA considers the correlation among dependent variables, distinguishing power plant groups based on linear combinations of all sub-total BPPs rather than individual components. Therefore, the analysis of variance and multivariate statistical tests provide strong evidence of differences in cost structures across power plant groups. While MANOVA confirms significant overall effects, univariate analyses highlight variations in how individual BPP influence cost efficiency. These findings underscore the necessity of considering interdependencies among cost components rather than evaluating them in isolation.

CONCLUSION

The main objective of this research was to compare and assess the BPP (Cost of Electricity Supply) subtotals across different PLN power plants and identify which power plant types or groups exhibited significant cost disparities. Based on the analysis, the MANOVA results indicated that the groupings of power plants have a significant effect on the inefficiency of their respective BPP. Specifically, BPP A showed inconsistency in its cost components, particularly in depreciation and loan charges. The discriminant analysis further revealed that power plants like PLTGU and PLTD contributed significantly to specific BPP, such as BPP A and BPP D, respectively. In general, PLTU was identified as the most efficient group, exhibiting higher elasticity in its BPP. Furthermore, PLTGU demonstrated greater control over BPP compared to PLTD, which had a narrower cost range.

The study recognizes several limitations, notably the complexity involved in power plant operations and the vast distribution of electricity. Further investigation is needed to understand why PLTGU operates below its expected capacity factor and why PLTA's contribution to reducing BPP remains limited despite its low BPP. Additionally, there is a need to explore the classification of lease costs in BPP B, particularly whether they are fixed or variable. Regarding recommendations, selecting power plants should prioritize efficiency based on cost structures and operational optimization. A balanced approach in operating various plants is crucial for reducing BPP and ensuring that each power plant achieves its maximum capacity factor.

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