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INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)

Article DOI: 10.21474/IJAR01/22477

DOI URL: <http://dx.doi.org/10.21474/IJAR01/22477>



RESEARCH ARTICLE

PERFORMANCE EVALUATION OF THE SOUAPITI HYDROELECTRIC POWER PLANT (APRIL–JUNE 2025) IN THE REPUBLIC OF GUINEA

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Manuscript Info

Manuscript History

Received: 14 October 2025

Final Accepted: 16 November 2025

Published: December 2025

Key words:-

Souapiti, hydraulic energy, performance, modelling, flow rates, PPA, dam.

Abstract

This study models the operational performance of the Souapiti hydroelectric power plant (Guinea) over a three-month period, from April to June 2025. The data analyzed include annual energy delivered to the grid, average daily power output, reservoir level, effective head, inflow and turbine flow rates, and monthly and annual performance rates compared to the contractual forecasts of the Power Purchase Agreement (PPA) [2], [6]. In April, the plant delivered 575,893.70 MWh with an average output of 242.31 MW, achieving 30.33% of its annual target. In May, production increased (762,610.50 MWh, 274.64 MW), despite a decrease in inflow (61.27 m³/s), suggesting intensive use of the water reservoir, which led to a reduction in the remaining effective head [3], [8]. In June, although the inflow rate increased (178.28 m³/s), the average power output dropped to 179.57 MW, due to a reduced water level of only 4.19 m, limiting production capacity. This variability reflects the direct influence of hydrological conditions on the plant's performance [9], [10], as well as the importance of optimized reservoir management [12], [14]. The analysis highlights the strategic use of available water to maximize power output at specific times, while emphasizing the need for a balance between resource exploitation and conservation [1], [4], [5]. This monitoring thus makes it possible to identify levers for optimization in medium-term management, particularly through better forecasting of inflows and dynamic modeling of energy production under climate variability [13], [15].

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Introduction:-

The Souapiti hydroelectric power plant, commissioned in 2020, is one of the cornerstones of Guinea's energy system. With an installed capacity of 450 MW, it plays a strategic role in the country's electricity supply, particularly in supporting industrialization, increasing urbanization, and rural electrification. Located on the Konkoure River, upstream from the Kaleta power plant, it benefits from a large reservoir that allows for some seasonal regulation. However, in a context of climate variability and a strong reliance on hydroelectric power, analyzing its operational performance, especially during the transition season (April to June), is crucial to ensuring the stability of the national

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grid. The transition season, which precedes the main rainy season in Guinea, is marked by a natural reduction in the flow into the dams. This period tests the capacity for optimized management of hydroelectric facilities, both in terms of production and resource conservation. Poor forecasting can lead to underperformance, or even risks of loadshedding or damage to infrastructure. The objective of this study is to model and evaluate the operational behavior of Souapiti dam from April to June 2025, using actual operating data collected monthly. This modeling relies on key indicators such as energy delivered to the grid, averaged daily power output, usable water levels, flow rates (inflow and turbine output), and achievement rates relative to the contractual objectives defined in the Power Purchase Agreement (PPA). By analyzing these variables together, the study aims to identify production dynamics within an evolving hydrological context, diagnose potential inefficiencies in dam management, and propose optimization strategies. This work also serves as a decision-making tool for energy authorities and sector operators, providing them with a more detailed understanding of Souapiti's actual capacity according to the seasons. The approach adopted here is based on comparative monthly modeling, making it possible to identify trends, tipping points or warning signs, and operational flexibility. Beyond its technical value, this approach contributes to strengthening the resilience of Guinea's energy mix, particularly in the context of energy transition, where the rational planning of water resources becomes a key lever for energy sovereignty.

Methodology:-

This study is based on a quantitative and comparative approach to the monthly performance of the Souapiti hydroelectric power plant over a three-month period (April, May, and June 2025). The data used were extracted from the daily operating reports produced by the site operator. These reports contain key indicators such as the cumulative annual energy delivered to the grid, the averaged daily power output, the reservoir level at midnight, the inflow and turbine flow rates, the remaining usable water head, daily rainfall, and the combined power output of the Souapiti–Kaleta complex (S+K). To ensure a consistent and readable analysis, the data were aggregated monthly and then modeled as time series. This modeling allows us to represent the progressive evolution of the power plant's performance and to detect any correlations between the parameters. Monthly and annual completion rates against the Power Purchase Agreement (PPA) were also included in the analysis to assess production compliance with contractual commitments.

The methodology adopted is based on three main components :

- 1) Descriptive analysis of technical variables for each month, allowing for the identification of specific characteristics of operational performance ;
- 2) Intermontly comparison of indicators to highlight seasonal variations or trend breaks (e.g., a decrease in inflow in May, but an increase in power output);
- 3) Cross-correlation between hydrological parameters (flow, water level, effective head) and energy production, with the aim of identifying levers for optimizing water management.

The approach is complemented by graphical representations (not included here) to visualize trends. The ultimate goal is to establish a robust operational diagnosis that will serve as a basis for adjusting the dam's management strategy, particularly during periods of hydrological transition when the trade-off between storage, turbine operation, and resource conservation becomes crucial.

Results:-

The monthly analysis of operating data from the Souapiti hydroelectric power plant, covering the period from April to June 2025, highlights operational dynamics marked by seasonal hydrological variability and water storage management. Three distinct periods can be identified, each characterized by a specific balance between available resources and electricity production.

a) For the month of April 2025:

As of April 11, 2025, the annual energy delivered to the grid reached 575,893.70 MWh, with an averaged daily power output of 242.31 MW. The dam's water level was 198.90 m, indicating a favorable water situation at the end of the dry season. The inflow was 170.76 m³/s, while the turbine flow was 305.96 m³/s, reflecting a significant draw on existing water storage to support production. Rainfall, moderate at 5.77 mm, confirmed a gradual return of precipitation. This situation allowed for a good level of production, while maintaining a comfortable usable water depth (13.90 m over 25 m).

b) For May 2025:

This month marked the peak of production with 762,610.50 MWh delivered and an average daily output of 274.64 MW. However, the inflow rate dropped sharply to 61.27 m³/s, reflecting either a temporary drought or a delayed rainy season. The plant's high performance can therefore be explained by the use of the reserve built up in April: the usable water depth was still 9.48 m, which made it possible to maintain sufficient pressure on the turbines. The turbine flow rate, on the other hand, increased significantly (378.80 m³/s), confirming substantial demand on the reservoir. Rainfall remained low (2.25 mm), which limited the natural recharge of the dam.

c) For June 2025:

In June, a notable slowdown in performance was observed: the energy delivered amounted to 933,043.40 MWh cumulatively for the year, but the average daily power output fell to 179.57 MW. The dam's water level dropped to 189.19 m, a loss of nearly 10 meters compared to April. The remaining usable height was only 4.19 m, making turbine operation less efficient. Paradoxically, the inflow rate increased to 178.28 m³/s, indicating the gradual return of rainfall (7.75 mm). However, the effect of this recovery is not yet fully visible on the reservoir level, as the turbine flow rate remains relatively high (261.52 m³/s), suggesting a desire to maintain a certain level of production despite low reserves. In short, these results illustrate a constant tension between electricity demand, natural water inflows, and reserve management. Intensive operation in May resulted in exceptional output, but at the cost of a significant reduction in available water resources in June, posing a risk for the following months if rainfall is insufficient to replenish the reservoir.

Discussion:-

The analysis of the monthly performance of the Souapiti hydroelectric power plant between April and June 2025 highlights the complexity of water resource management in a context of high climate variability. This quarter corresponds to a transition period between the dry and rainy seasons in Guinea. The observed results reveal the direct impact of this seasonality on electricity production and underscore the importance of a dynamic, adaptive, and predictive operating strategy. The month of April benefited from a high water level (198.90 m), a direct consequence of the reservoirs built up during the dry season. The inflow (170.76 m³/s) stabilized the water level while supporting an average daily production of 242.31 MW. At this stage, management was relatively balanced between turbine operation (305.96 m³/s) and resource conservation. This allowed for maintaining a usable head of nearly 14 m, a crucial factor in ensuring sufficient pressure at the turbine inlet. In May, despite a sharp drop in the inflow (61.27 m³/s) and low rainfall (2.25 mm), the power plant produced more energy than in April (762,610 MWh compared to 575,893 MWh). This performance was due to a high turbine flow rate (378.80 m³/s), allowing full utilization of the remaining usable head (9.48 m). However, this strategy, geared towards maximizing immediate production, led to a rapid depletion of the water storage capacity, putting pressure on the dam's reserves. This choice can be explained by national energy demand imperatives, but it also demonstrates a vulnerability of the system in the face of water scarcity.

In June, the situation reversed: although rainfall increased significantly (7.75 mm) and the inflow rose to 178.28 m³/s, production fell to an average daily output of 179.57 MW. The dam level dropped sharply to 189.19 m, leaving only 4.19 m of usable height. This paradox is explained by the fact that natural recharge, although improving, was still insufficient to compensate for the intense operation of the preceding months. Furthermore, the turbine flow remained high (261.52 m³/s), which continued to draw on the reservoir at the very time when it would have been opportune to begin replenishing it. These observations highlight an urgent need for seasonal turbine modeling, incorporating hydrological, meteorological, and energy forecasts. A more conservative strategy in May, such as a moderate reduction in turbine flow, would have allowed for a higher usable head in June, thus ensuring stable production over the medium term. The optimal management of a power plant like Souapiti cannot therefore rely solely on immediate water conditions or grid demand. It must be based on a balance between production and resource sustainability, through a smart flow management policy supported by decision-making tools based on predictive modeling. Finally, better coordination with other cascade dams (notably Kaleta) could also enable synergistic management of the Konkoure watershed, maximizing the resilience of the national electricity system.

Conclusion:-

Analysis of operating data from the Souapiti hydroelectric power plant for the period from April to June 2025 highlights the crucial importance of proactive and balanced hydrological management. This pivotal period, situated at the juncture between the dry season and the beginning of the rainy season, illustrates the vulnerabilities of an energy system heavily dependent on water availability. In April, the power plant benefited from a good water

retention level and a relatively favorable inflow to support energy production while maintaining a significant head. However, starting in May, the emphasis on immediately optimizing production, despite low water inputs, led to a heavy reliance on the water reservoir. This approach, while effective in the short term, compromised performance stability in June, a month in which a significant drop in the head resulted in a decrease in average daily power output, despite increased rainfall and a higher inflow. These findings underscore the need for a proactive management strategy, based not only on the immediate demand of the grid, but also on anticipating future climatic and hydrological conditions. It is imperative to develop and implement integrated forecasting models capable of guiding turbine operation decisions according to realistic seasonal scenarios. Furthermore, coordination between the hydroelectric power plants in the Konkoure basin—particularly between Souapiti and Kaleta—must be strengthened. Joint management of reservoirs would optimize resource sharing, ensure continuous production, and secure the country's energy supply throughout the year. Modeling the performance observed during these three months also demonstrates the value of regular analytical monitoring of technical indicators such as water levels, inflow and outflow rates, and performance rates relative to the Power Performance Agreement (PPA). This data forms an essential basis for energy planning, preventive infrastructure maintenance, and strategic decision-making. In conclusion, the long-term performance of the Souapiti dam will depend not only on its installed capacity and equipment, but above all on the quality of its hydrological management and its ability to anticipate natural cycles. Implementing a smart operating policy, coupled with modeling tools and collaborative basin governance, is essential to ensuring the resilience and performance of Guinea's energy system.

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