# Performance Evaluation of the Souapiti Hydroelectric Power Plant (April–June 2025) in the Republic of Guinea


## 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 $m^3/s$), 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 $m^3/s$), 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].



**Keywords:** Souapiti, hydraulic energy, performance, modelling, flow rates, PPA, dam.

## 1. Introduction

The Souapiti hydroelectric power plant, commissionedin 2020, is one of the cornerstones of Guinea'senergy system. With an installedcapacity of 450 MW, itplays a strategicrole in the country'selectricitysupply, particularly in supportingindustrialization, increasingurbanization, and rural electrification. Located on the Konkouré River, upstreamfrom the Kaléta power plant, itbenefitsfrom a large reservoirthatallows for someseasonalregulation. However, in a context of climatevariability and a strongreliance on hydroelectric power, analyzingitsoperational performance, especiallyduring the transition season (April to June), is crucial to ensuring the stability of the national grid.

The transition season, whichprecedes the main rainyseason in Guinea, ismarked by a naturalreduction in the flow into the dams. This period tests the capacity for optimized management of hydroelectricfacilities, both in terms of production and resource conservation. Poor forecasting can lead to underperformance, or evenrisks of loadshedding or damage to infrastructure.

The objective of thisstudyis to model and evaluate the operationalbehavior of Souapiti dam from April to June 2025, usingactual operating data collectedmonthly. This modeling relies on key indicatorssuch as energydelivered to the grid, averagedaily 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 analyzingthese variables together, the studyaims to identify production dynamicswithin an evolvinghydrologicalcontext, diagnose potentialinefficiencies in dam management, and propose optimizationstrategies. This workalso serves as a decision-makingtool for energyauthorities and sectoroperators, providingthemwith a more detailedunderstanding of Souapiti'sactualcapacityaccording to the seasons. The approachadoptedhereisbased on comparative monthly modeling, makingit possible to identify trends, tipping points or warning signs, and operationalflexibility. Beyond itstechnical value, thisapproachcontributes to strengthening the resilience of Guinea'senergy mix, particularly in the context of energy transition, where the rational planning of water resourcesbecomesa key lever for energysovereignty.

## 2. Methodology

This studyisbased on a quantitative and comparative approach to the monthly performance of the Souapiti hydroelectric power plant over a threemonthperiod (April, May, and June 2025). The data usedwereextractedfrom the daily operating reports produced by the site operator. These reports contain key indicatorssuch as the cumulative annualenergydelivered to the grid, the averagedaily power output, the reservoirlevel at midnight, the inflow and turbine flow rates, the remaining usable water head, dailyrainfall, and the combined power output of the Souapiti–Kaléta complex (S+K).

To ensure a consistent and readableanalysis, the data wereaggregatedmonthly and thenmodeled as time series. This modeling allows us to represent the progressive evolution of the power plant's performance and to detectanycorrelationsbetween the parameters. Monthly and annualcompletion rates against the Power Purchase Agreement (PPA) werealsoincluded in the analysis to assess production compliance withcontractualcommitments.

The methodologyadoptedisbased on three main components :

1) Descriptive analysis of technical variables for eachmonth, allowing for the identification of specificcharacteristics of operational performance ;
2) Intermonthly 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-correlationbetweenhydrologicalparameters (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.

## 3. Results

The monthlyanalysis of operating data from the Souapiti hydroelectric power plant, covering the periodfrom April to June 2025, highlights operationaldynamicsmarked by seasonalhydrologicalvariability and water storage management. Three distinct periods can beidentified, eachcharacterized by a specific balance betweenavailableresources and electricity production.

**a) For the month of April 2025:**

As of April 11, 2025, the annualenergydelivered to the gridreached 575,893.70 MWh, with an averagedaily power output of 242.31 MW. The dam's water levelwas 198.90 m, indicating a favorable water situation at the end of the dry season. The inflowwas 170.76 m³/s, while the turbine flow was 305.96 m³/s, reflecting a significantdraw 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, whilemaintaining 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, increasedsignificantly (378.80 m³/s), confirmingsubstantialdemand on the reservoir. Rainfallremainedlow (2.25 mm), whichlimited 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 leveldropped to 189.19 m, a loss of nearly 10 meterscompared to April. The remaining usable heightwasonly 4.19 m, making turbine operationless efficient. Paradoxically, the inflow rate increased to 178.28 m³/s, indicating the gradual return of rainfall (7.75 mm). However, the effect of thisrecoveryis not yetfully visible on the reservoirlevel, as the turbine flow rate remainsrelatively high (261.52 m³/s), suggesting a desire to maintain a certain level of production despitelowreserves. In short, theseresultsillustrate a constant tension betweenelectricitydemand, natural water inflows, and reserve management. Intensive operation in May resulted in exceptional output, but at the cost of a significantreduction in available water resources in June, posing a risk for the followingmonths if rainfallisinsufficient to replenish the reservoir.

## 4. 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 climatevariability. This quarter corresponds to a transition periodbetween the dry and rainyseasons in Guinea. The observedresultsreveal the direct impact of thisseasonality on electricity production and underscore the importance of a dynamic, adaptive, and predictive operating strategy.

The month of April benefitedfrom a high water level (198.90 m), a direct consequence of the reservoirsbuilt up during the dry season. The inflow (170.76 m³/s) stabilized the water levelwhilesupporting an averagedaily production of 242.31 MW. At this stage, management wasrelativelybalancedbetween turbine operation (305.96 m³/s) and resource conservation. This allowed for maintaining a usable head of nearly 14 m, a crucial factor in ensuringsufficient pressure at the turbine inlet.

In May, despite a sharp drop in the inflow (61.27 m³/s) and lowrainfall (2.25 mm), the power plant produced more energythan 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, thisstrategy, gearedtowardsmaximizingimmediate production, led to a rapiddepletion of the water storagecapacity, putting pressure on the dam'sreserves. This choice can beexplained by national energydemandimperatives, but italsodemonstrates 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 leveldroppedsharply to 189.19 m, leavingonly 4.19 m of usable height. This paradox is explained by the factthatnatural recharge, althoughimproving, wasstillinsufficient to compensate for the intense operation of the precedingmonths. Furthermore, the turbine flow remained high (261.52 m³/s), whichcontinued to draw on the reservoir at the very time whenitwould have been opportune to beginreplenishingit.

These observations highlight an urgent need for seasonal turbine modeling, incorporatinghydrological, meteorological, and energyforecasts. A more conservative strategy in May, such as a moderatereduction in turbine flow, wouldhave allowed for a higher usable head in June, thusensuring stable production over the medium term.

The optimal management of a power plant like Souapiti cannotthereforerelysolely on immediate water conditions or griddemand. It must bebased on a balancebetween production and resourcesustainability, through a smart flow management policysupported by decision-makingtoolsbased on predictive modeling. Finally, better coordination withother cascade dams (notably Kaléta) couldalso enable synergistic management of the Konkouré watershed, maximizing the resilience of the national electricity system.

## Conclusion

Analysis of operating data from the Souapiti hydroelectric power plant for the periodfrom April to June 2025 highlights the crucial importance of proactive and balancedhydrological management. This pivotal period, situated at the juncturebetween the dry season and the beginning of the rainyseason, illustrates the vulnerabilities of an energy system heavilydependent on water availability.

In April, the power plant benefitedfrom a good water retentionlevel and a relatively favorable inflow to support energy production whilemaintaining a significanthead. However, starting in May, the emphasis on immediatelyoptimizing production, despitelow water inputs, led to a heavyreliance 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 headresulted in a decrease in averagedaily power output, despiteincreasedrainfall and a higherinflow.

Thesefindingsunderscore the need for a proactive management strategy, based not only on the immediatedemand of the grid, but also on anticipating future climatic and hydrological conditions. It isimperative to develop and implementintegratedforecastingmodels capable of guiding turbine operationdecisionsaccording to realisticseasonal scenarios.

Furthermore, coordination between the hydroelectric power plants in the Konkouré basin—particularlybetween Souapiti and Kaléta—must bestrengthened. Joint management of reservoirswouldoptimizeresource sharing, ensurecontinuous production, and secure the country'senergysupplythroughout the year.

Modeling the performance observedduringthesethreemonthsalsodemonstrates the value of regularanalytical monitoring of technicalindicatorssuch 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 strategicdecision-making.

In conclusion, the long-term performance of the Souapiti dam willdepend not only on itsinstalledcapacity and equipment, but above all on the quality of itshydrological management and itsability to anticipatenatural cycles. Implementing a smart operating policy, coupledwith modeling tools and collaborative basin governance, is essential to ensuring the resilience and performance of Guinea'senergy system.

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