Modelling and Simulation of 330 KV, 600 MW Shiroro Substation in the DIgSILENT Environment for Integration of Hybrid Solar PV – Hydro System to Improve Power Supply in the Federal Capital Territory (FCT) of Abuja from Shiroro, Nigeria

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Abstract — This research paper focuses on modelling and simulation of 330 KV, 600 MW Shiroro Substation in the DIgSILENT Environment for the integration of Hybrid Solar PV – Hydro System to improve power supply in the Federal Capital Territory (FCT) of Abuja, Nigeria. A hybrid energy system is a system that combines multiple types of energy generations to satisfy the demand of the users effectively and efficiently. The Solar Photovoltaic (PV)/Hydro hybrid system consists of electrical energy generated from solar PV and hydro energy. Effect of environmental issues, reduction of fossil fuels in addition to its high cost have actively encouraged interest in great integration of renewable energy sources in power systems. This work capitalized on the possibilities of harnessing commercial solar energy and feeding it to the National grid through a nearby 330 KV substation at Shiroro Dam. The simulation is carried out in DIgSILENT (Power factory) environment. The Shiroro 16 kV, 330 kV, 600 MW Transmission Lines are modelled, and results of simulations of the five bus bars (Jebba, Shiroro, Gwagwalada, Katampe and Kaduna) voltages directly connected to Shiroro Network are: 331.8kV, 331.7 kV, 329.3 kV, 325.6 kV and 332.2 kV, respectively. All the values are within the Operational and Statutory Limits of the National Grid Code.

Index Terms — 330 KV 600 MW Transmission Grid, DIgSILENT (Power Factory) Software, Hybrid Energy System, National Grid Code.

I. INTRODUCTION

For any country to achieve tangible progress in technological advancement, proper and reliable power supply need to be made available, and in other to achieve this, other sources of energy have to be harnessed. The poor condition of power supply in Nigeria has adversely affected both the social, economic, and commercial activities. It is a known fact that economic growth of a nation depends on electrical power supply. While telecommunication market in Nigeria has recorded advancement and stability, the electricity market in Nigeria is still faced with myriads of problems [1]. The demand for electricity is much more than its supply. The

country is faced with acute electricity problems, which is hindering its development notwithstanding the availability of vast natural energy resources in the country ranging from abundant gas to renewable energy sources [2]. Nigeria as a country is blessed with plentiful sunshine annually and surplus vegetation. Nigeria should work alongside the global electricity market trend which is targeted on building a cleaner, and viable energy mix. Energy sector in Nigeria must accept and integrate Renewable Energy Sources (RESs) in its energy mix for the country to be energy sufficient. The main constraints in the rapid development and diffusion of technology for the exploitation and utilization of renewable energy resources in the country is the absence of appropriate policy, regulatory and institutional framework to stimulate demand and attract investors [3]. A hybrid Power system is a system that combines multiple renewable energy sources in order to provide greater efficiency in the system and reliable energy supply. Some of which includes solar photovoltaic, wind energy, diesel generator, hydro power, gas etc. Some of the advantages of a hybrid system are: Provision of overall reduction in both the system maintenance and in cost, less requirement of energy storage, Greater flexibility during system design and operation, ability to meet the load requirement, increased in efficiency of diesel engine etc. [4]. Recently, more attention is being drawn to solar energy because of its omnipresent, and the cost of Photovoltaic (PV) cell is fast reducing. Although, the intermittent nature of a PV system has made it impossible for it to be able to satisfy the power requirement alone throughout the year, it is therefore necessary to combine it with other forms of energy for reliable and constant power supply. Also, the grid integrated PV system with advancement is preferred to ensure the continuous power flow [5]. This research work capitalized on the possibilities of harnessing commercial solar energy and feeding it to the National grid through a nearby 330 kV substation at Shiroro dam of hydropower station. The choice of Shiroro dam was considered due to the importance of

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constant power supply to the Federal Capital Territory (FCT) as Shiroro Substation is connected to the existing Katampe and Gwagwalada 330 kV substations which are among the major sources of power supply to the FCT. The existing 330 kV Transmission Grid is modeled as the base case with major focus on the 330 kV Shiroro network while the study case is the modeled based case with the integration of PV solar plant. The network is modeled using DIgSILENT software power tool. In [6], analysis of grid interactive hydro (7.5 kW) and solar (10 kW) system was modelled using MATLAB Simulink and this hybrid-based power generation system was connected in parallel with a 132 kV, 2500 MVA utility grid. In the peak summer, solar energy is abundantly available [6], but in rainy days it is difficult to generate the electrical power using the solar energy and similarly, the power generation using the hydro energy gives better efficiency in rainy seasons [6]. The schematic diagram of the model is shown in Fig. 1. For connecting the solar and hydro system in parallel with the grid, it is essential that the voltage magnitude, frequency, and phase sequences of both the energy system and power grid must be same [6]-[9]. During summer, the grid connected solar system supplies the power to the load, and hydro system will be disconnected. In rainy days the grid connected hydro system supplies the power to the load, and solar system will be disconnected while in other seasons, grid connected solar and hydro systems are able to deliver the power to the consumer [6]. Hence, it is good option to adopt because according to results obtained by [10], the hybrid system was able to supply power to the consumer in all seasons. TCN, in collaboration with the Nigerian Energy Support Program (NESP) in [11], presented a study to analyze the feasibility of up to 2GW of PV generation in Nigeria. The studies consider two scenarios:

Scenario 1: Total installed PV capacity of 1GW.

Scenario 2: Total installed PV capacity of 2GW.

Fig. 1. Schematic Diagram of Grid-Integrated Hydro and Solar Based Hybrid System. [6].

This is to determine the technical and economic short-term impact of renewable energy capacity addition to the Nigerian power mix. According to [11], there are excellent PV resources in the north of Nigeria with average annual global horizontal solar irradiance of up to 2200 kWh/m² and therefore need to be harnessed. The simulation for the study was carried out using PSSE software. Despite existing problems with the Northern part of the grid, [11] showed that it is possible to integrate 1 GW of PV capacity in the north if modern PV inverters with advanced reactive power control capability are used.

Fig. 2. Connection of a PV Farm to the Secondary Side (132 kV-Side) of a 330 kV Substation [11].

In Fig. 2, a direct connection to the secondary side of a 330/132 kV substation was among the PV connection options considered and this posed a great limitation for the capacity of the PV farm that could have been connected to the grid. Although, the actual site of PV farm was not known, the most appropriate connection option recommended a direct connection to the primary side of a 330/132 kV substation especially, when large capacity integration of PV capacity is required. Vyonarc Development Limited referenced [12], in the interconnection study was carried out for the proposed connection of 50 MWp Mokwa Power Limited PV Solar Plant with a proposed point via a 24 km double circuit line from the the power plant to the existing 132 kV bus of Jebba 330/132/33 kV substation. Simulations of the power plant and its components are carried out by Solaris PV model, while the modelling and simulation of the TCN transmission network was done using Power System Simulation for Engineering (PSSE) version 33.4 software [12]. The plant is intended to be operational within 24 months of acquiring license from NERC, excluding downtime due to maintenance, failures, and grid blackouts report is considered to be 99% and according to the authors in [12], the Load flow analysis, short circuit analysis, contingency analysis, transient stability analysis and Yield assessment study were carried out. From the results obtained, the authors [12] concluded that; it is technically feasible to connect the 50 MW Mokwa power plant to the grid as all the voltages are within acceptable limits and no additional reinforcement are required to evacuate the 50 MW Mokwa power plant and also no upgrade of breaker is needed as all the short circuit fault currents did not exceed the existing breaker ratings. Lastly, the system regained synchronism when the Mokwa generator was lost [12]. The proposal is adopted as the addition of the PV Plant to the grid will be beneficial when the work is actually implemented. Nehrir M.H et al. [13] prepared by a special task force of the IEEE PES Renewable Technologies Subcommittee, is a review of hybrid renewable energy (RE) for power generation systems, important issues and challenges in their design. Critical challenges facing the widespread deployment of RE/AE power generation technologies as well as vision for future research were discussed [13]. The simulation was carried out in HOMER software.

Fig. 3. Case Study Diagram [12].

TABLE I: DIFFERENT RE/AE POWER GENERATION TECHNOLOGIES AND ENERGY STORAGE DEVICES [13]

Main RE/AE technologies	Energy storage types
Biomass	Battery
Geothermal	Compressed air
Hydro / microhydro	Flywheel
Ocean tidal / wave	Hydrogen
Solar PV/thermal	Pumped hydro
Wind	SMES
Fuel cell	Supercapacitor
Microturbine	Thermal

This research topic is adopted because of the intermittent nature of many RE resources (e.g., wind, solar, ocean wave), hybrid combinations of two or more of their relevant power generation technologies, along with storage and/or AE power generation, can improve system performance [13]. According to [13], despite their significant benefits to the environment and great long-term potential for sustainable energy development, hybrid RE/AE systems are currently in an economic disadvantage position because of their high installation costs compared with traditional electricity generation technologies. Incentives from federal, state, and local governments utilities are necessary to make a hybrid system economically viable [14], [15]. Emeka O. and Rebecca O. [16] discussed the analysis of the impact of integrated Hybrid Photovoltaic and Wind turbine System (HPWS) in a section of the Nigerian electricity grid (Benin Transmission Station) using Electrical Transient Analysis Program (ETAP) power tool. The HPWS proposed system will supply additional generated power of 40 MW at 16 kV to the aforementioned section of the grid network and the major focus was on the steady state stability of the electric grid network which was modelled with specified loads [16]. The Proposed hybrid system comprises of a Wind turbine and PV array. The PV array is connected to the hybrid system through an inverter as described Fig. 4 below.

Fig. 4. 330 kV Post Integration Network Diagram [16].

Different case scenarios were carried out in [16], at prehybridized integration (Unconnected), post-hybrid

integration (Connected) as well as at varying load increase of 20%, 60%, and 100%. [16] further stated, that when the results of the scenarios were compared based on voltage level, it was observed that integrating the hybrid system at 33kV close to the consumers at the distribution level will be more beneficial and significant reduction in line losses to the grid as compared to 330 kV and 132 kV transmission voltage levels [16]. However, the capacity of HPWS was limited to the maximum distribution voltage level. Connection to the primary side of 330 kV substation or lines is recommended for larger network and higher output voltage. [17] extensively analyses the performance of the DIgSILENT's PV model control aspects in terms of active power reduction and dynamic voltage support in a test network including the validation of static voltage support on modelled Malaysian distribution network according to the new German Grid Code. According to the authors in [17], the traditional methods that are in practice to control the voltage and reactive power is by controlling the transformer tap changer (OLTC). Use of capacitor banks and Volt-VAr control (VVC) activities by traditional methods are no longer appropriate due to intermittency solar irradiation caused by cloud transients [17]. The results show that involving the PV inverter in voltage control activities promise better future for penetration of renewable energy into distribution network for tropical country like Malaysia, which receives solar radiation throughout the year [17]. The model is okay since a DIgSILENT with Modern PV Inverter was adopted. Johnson D.O and Ogunseye A.A in [18] presented the design analyses of roof-mounted Grid-connected 148.5 kWp Photovoltaic System with Energy Storage for use in a Local Government secretariat in Nigeria. The design was simulated using PV*SOL software to evaluate the system's production performance and to know the amount of electric power generation for every day of the year and the system energy yield is much more than satisfactory [18].

From the results, the least daily energy production is 445.23 kWh which occurs in July and highest daily energy yield is 675.27 kWh in November as against maximum 131.51 kWh daily consumption [18]. The power generated far exceed demand, hence the need to export to the grid and the system could serve as good revenue source for the government by exporting more than 75% of the power generated to the grid in exchange for good cash from electricity utility; while at same time serving as motivation for home owners in the community as well as other governmental offices to generate some or all of their energy need [18]. The design system was adopted for encouragement of photovoltaic system integration. Author in [19] carried out a study for power generation and evacuation of 50 MWp Mokwa Power Plant on a transmission grid. The objective of this power evacuation study was to determine the impact the proposed 50 MWp Mokwa power plant will have on the transmission grid. The modelling and simulation of the TCN transmission network was done using Power System Simulation for Engineering (PSSE) version 33.4 software. The simulation results of the load flow, short-circuit and contingency analysis carried out on a Jebba 132 kV bus via a 24 km double circuit 132 kV conductor was found to be within operational limits and would be beneficial to the national grid if implemented. It was also recommended that

modern grid inverters capable of reactive power compensation should be installed for reactive power control. The study was adopted for a better utilization of mixed generation.

II. MATERIALS AND METHODS

A. Data Collection

The following methods are adopted in the preparation of the modelling of this system and for this paper:

a) Modelling data used for this analysis were collected from Transmission Company of Nigeria Corporate Headquarter and the network components collected include parameters of transmission Line, buses, transformers, load information and single line diagram.

b) Steady-state load-flow study on the 330 kV grid network is carried out, (pre-integration).

c) A Computer software program using Power Factory is used in modelling, simulations, and analysis of the results. For the purpose of this research, every discussions and analysis of results are focus only on Shiroro 330 kV network and other lines/substations that are directly connected to it, using the DIGSILENT (PowerFactory) power tool.

In modelling this network, the transmission lines data including the transformer loadings are collected from System Planning and Development Department (SP & D) of Transmission Company of Nigeria (TCN) whereas the generator and load data are collected from National Control Centre (NCC), Oshogbo. The daily operation of the national grid and updating of all the units of generating plants on the network at every hour interval per day are done by the National Control Centre Oshogbo. A spinning reserve of 3568.59 MW was recorded on the 29th May, 2019 when this data was collected, although generation supply has never been sufficient enough to meet the load demand of the entire nation. Because of the serious inadequacy in the Nigerian National Grid generation, it is hardly difficult presently, to maintain any reasonable amount of spinning reserve, hence the grid rarely keeps emergency generation reserve.

B. Network Description

The power flow study of Shiroro 330 kV network which is a section of the Nigerian power grid used for this research is relevant to ascertain the state performance of the existing network for scheduled loads to FCT and generation variance. Fig. 6 is a screenshot of the single line diagram of the existing Shiroro network in DIGSILENT environment. Shiroro Hydro Power Plant is located in Niger State of the Northern part of Nigeria. The existing network is made up of the following: 600 MW capacity of Hydro Power Generators comprising of four (4) units of 150 MW Hydro Power Generator, connected directly to a 16 kV bus, four (4) 200 MVA, 2-winding 3-phase Transformers, five (5) 330 kV buses, six (6) Branches, five (5) connected General loads, four (4) substations and all these are used for the assessment of the impact of integrating different various capacities of PV Solar and Hydro power to the grid network at a generated voltage of 16 kV and system frequency of 50 Hz. The choice of generated power is based on total load demand from the existing afore-mentioned network. The simulation and modelling are done to cross-check the network with respect to steady state stability.

Details of the single Line diagram at Pre-integration of existing Shiroro 330 kV transmission network as a section of the Nigerian electrical power transmission network as carried out consists of existing 100% (600 MW) Shiroro Hydro Power Plant with 0% PV Solar (0 MW).

Fig. 5. Single Line Diagram of the Existing 330 kV Shiroro Network.

C. Generator Model

For the modelling of generating plant in the network, it is a common knowledge that almost all the generators in the network do not generate at the installed capacity.

The various units of the generating plant do not always come up at the same time, hence in the modelled network, only the generating units that are connected on bar for each power plant are used. The various generating units in each power stations are lumped for the purpose of this studies. The dissertation uses the SYNCHRONOUS MACHINES and STATIC GENERATOR build-in-models in DIGSILENT environment to model the generation units. Both transformer loading techniques and Multi Year Tariff Order (MYTO) Standard stipulated by NERC are considered for this study. The Generator connection considered is Star Neutral (YN), for grounding, lighting protection and Station services.

Fig. 6. Load Flow Modelling of Shiroro Hydro Generator.

For the steady state behaviour of the network, the amount of active power generated by each of the generating units are entered into the DIGSILENT generator model for the simulation.

D. Dynamic Generator Modelling

The transient and sub-transient behaviours of a generator must be taken into consideration in order to accurately carry out its dynamic analysis.

The dynamics of the classical model is represented by swing (1) [20].

$$\frac{d^2\delta}{dt^2} = \frac{\omega_o}{2H} (P_m - P_e) - T_D \frac{d\delta}{dt} \quad (1)$$

where,

δ = the rotor angle with respect to a reference;

ω_o = the synchronous speed (pu);

H = the inertia constant in per unit (pu);

P_m = the mechanical power in pu;

P_e = the electrical power;

T_D = the damping coefficient.

The differential equations for the transient model are given by (2) and (3) [20].

$$\frac{de'_d}{dt} = \frac{1}{T'_{qo}} \left[\left(\frac{X_q - X'_q}{X'_q - X_l} \right) e_{ld} + \left(\frac{X'_q - X_l}{X'_q - X_l} \right) e^i_d \right] \quad (2)$$

and

$$\frac{de'_q}{dt} = \frac{1}{T'_{do}} \left[e_{fd} + \left(\frac{X_d - X'_d}{X'_d - X_l} \right) e_{lq} + \left(\frac{X'_d - X_l}{X'_d - X_l} \right) e^i_q \right] \quad (3)$$

where

e'_d and e'_q are the transient voltages in d- and q-axis; e_{ld} and e_{lq} are the voltages behind the d-and q-axis leakage reactance.

The transient and sub-transient models take into consideration the transient and sub-transient effects of direct (d) and quadrature (q) axis added to the swing equation [20]. The data required for the complete machine model (sub-transient generator model) are as follows:

R_a = stator (armature) resistance.

X_l = stator (armature) leakage reactance.

X_d, X_q = are synchronous reactance in d- and q-axis.

X'_d, X'_q = are transient reactance in d- and q-axis.

X''_d, X''_q = sub-transient reactance in d- and q-axis.

T'_{do}, T'_{qo} = open circuit time constant in d-and q-axis.

T''_{do}, T''_{qo} = sub-transient open circuit time in d-and q-axis.

S_m = apparent power (nominal complex power).

U_m = nominal voltage.

H and T_D = inertia constant and damping coefficient.

This data is entered into the Power Factory build-in models in the DIGSILENT software.

E. Transmission Line Model

Positive sequence impedance of the transmission lines is used to represent transmission lines and are modelled as π -equivalents. They are modelled into π -equivalent line model because in load flow studies, the static load-flow equations are written in terms of bus admittance matrix [20]. The equivalent representation of a transmission line is shown in Fig. 7.

Fig. 7. π -Model of a Medium Line [20].

The parameters required for the modelling of the transmission line are as follows:

R = Resistance of the line;

X = Reactance of the line;

B = Susceptance of the line (line charging admittance), where $Y = G + jB$;

l = Length of the transmission line (in km).

Some of the basic parameters used in modelling of the 330 kV transmission lines is shown in Fig. 8.

Fig. 8. Basic Data Requirement of 330 kV lines Modelling.

The resistance and reactance per length of the lines are 0.039 ohm/km and 0.331 ohm/km respectively at the nominal frequency of 50 Hz while the rated current of each of the 330 kV transmission is 1.36 KA.

F. Study Model

The existing 330 kV Nigerian Network is modelled, and the study is carried out using DIGSILENT Power Factory Simulation tool. A total generation of 5.944 GW is modelled as the base case generation. Transmission losses for the existing network are found to be 88.51 MW for the whole transmission network, thus a demand of 5855.60 MW is required for the dispatched generation. The load flow plot and the modelled load flow results of the relevant 330 kV network are shown in the appendices.

TABLE II: SUMMARY OF THE STEADY STATE ANALYSIS

	Active Power (MW)	Reactive Power (Mvar)	Apparent Power (MVA)
Generation	5497.33	800.86	5997.82
Grid losses	88.51	-2172.99	--
Line Charging	-	-3034.78	--
Installed Capacity	9841.5	--	--
Spinning Reserve	3568.59	--	--

The Study case is modelled and simulated as shown in Fig. 9. The four (4) units of the existing 150 MW of Shiroro Hydro Generation are connected to the national grid. The PV Solar Plant connection to the grid was switched off. Hence, only

the existing 100% (600 MW) generated by the Hydro Generating Plant are modelled using the Newton Raphson's load flow techniques and the network voltage profile to observe the steady state characteristic of the network and its convergence status. The load flow is done to ensure that there are no violations on the network in the form of overloaded lines and generators and to also checkmate the statutory limits of the 330 kV voltage as to whether it is maintained or not. The statutory limit of the 330 kV voltage in per unit ranges between 0.9 and 1.1 pu at a frequency of 50 Hz.

Fig. 9. Load flow diagram of the Base Case 100% Hydro.

G. Power Plant Grid Connection Point

The proposed connection point of the PV Solar power plant is via a 330 kV bus bar of the Shiroro 330/132/33 kV substation. This is because of the fact that, not only that it is the nearest transmission lines very close to the proposed PV site location (Shiroro Hydro dam), the expected maximum generation PV solar output of 300 MW is achievable.

Fig. 10. Model of the Hybrid PV Solar/Hydro System.

Output of both the PV Solar and the Hydro power are each connected to the 16 kV Bus bar. Step-up transformers raise the voltage to 330 kV which corresponds to the existing grid voltage.

III. RESULTS AND DISCUSSION

A. Voltage Stability

Voltage stability is the ability of any power system to remain within acceptable voltage limits as stipulated in the national grid code after disturbances. The voltage at the

330 kV bus bars should not fall out of those stipulated limits even after a circuit outage. The system should follow the generator voltage regulator or transformer tap changer action to restore the bus bar voltages to certain specified limits.

TABLE III: VOLTAGE LIMITS OF THE BUSES AS STIPULATED IN THE GRID CODE

Voltage Level	Nominal Voltage Level	
	Minimum Voltage kV (pu)	Maximum Voltage kV (pu)
330 Kv	280.5(0.85)	346.5 (1.05)
132 kV	112.2 (0.85)	145.2 (1.10)

To maintain system voltages within limits during light load conditions, shunt reactors are used, or it may be necessary to switch out unused circuits to maintain these voltage limits. More too, it may be required to switch on capacitor banks to improve voltage during heavy loads and to maintain voltages within acceptable limits as stipulated in the grid code and shown in Table III.

B. Study Results

This base case was established to represent the transmission system conditions expected without the integration of PV Solar connection. The Nigeria 330 kV network was modelled successfully, and the iterative solution was obtained using the Newton-Raphson iteration method. When simulated with this technique, the modelled network converged in five iterations as shown in Fig. 11.

```

DigSI/info - -----
DigSI/info - Start Newton-Raphson Algorithm...
DigSI/info - load flow iteration: 1
DigSI/info - load flow iteration: 2
DigSI/info - load flow iteration: 3
DigSI/info - load flow iteration: 4
DigSI/info - load flow iteration: 5
DigSI/info - Newton-Raphson converged with 5 iterations.
DigSI/info - Load flow calculation successful.
DigSI/info - -----

```

Fig. 11. Load flow iteration output.

It was observed from the simulated network that the voltage profile around the Shiroro network which is the area of consideration was found healthy as most of the voltages are within the normal operational limits and none of the transmission lines was overloaded as shown in Tables IV and V, respectively.

TABLE IV: VOLTAGE PROFILE: BASE CASE, 100% HYDRO, 0% PV SOLAR

S/N	Bus Bar	Voltage (kV)	Voltage (P.U)
1	Jebba	331.8	1.01
2	Shiroro	331.7	1.01
3	Gwagwalada	329.3	1.00
4	Katampe	325.6	0.99
5	Kaduna (Mando)	332.2	1.01

TABLE V: LINES LOADING: BASE CASE 100% HYDRO, 0% PV SOLAR

S/N	330 kV T/L	Loading (%)	Real Power (MW)	Reactive Power (Mvar)
1	Jebba-Shiroro	15.8	123	26.9
2	Shiroro-Gwagwalada	11.7	95	30.4
3	Shiroro-Katampe	18.1	146.6	43.1
4	Shiroro-Mando	23.1	199.7	16.5
5	Gwagwalada-Katampe	30.2	253.4	26.9

A graphical representation of the lines loading for the base case shown in Fig. 12 is exactly what is obtainable at the Shiroro network.

Fig. 12. Graphical representation of the base case lines loadings.

IV. CONCLUSION

The existing 330 kV, 600 MW Shiroro Hydro Power Plant was successfully modelled in DIgSILENT software environment and all the parameters of the system were found to be normal for the purpose of integration with Hybrid Solar PV System. The simulation results of the five bus bar (Jebba, Shiroro, Gwagwalada, Katampe and Kaduna) voltages are: 331.8, 331.7, 329.3, 325.6 and 332.2 KV, respectively. All the values obtained are within the Operational and Statutory Limits of the National Grid Code. Also, the bus voltages and thermal ratings of the lines obtained from the load flow analysis were seen to be within operational and statutory limits. Therefore, it is technically feasible to integrate PV Solar to the existing 330 kV Nigeria Grid via the existing 330 kV Shiroro Hydro power plant.

CONTRIBUTION TO KNOWLEDGE

Integration of the Hybrid System to the National Grid has eliminated the use of Battery as opposed the usual Standalone Network with Battery System for energy storage.

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