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Power System Safety Evaluation

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Abstract: *This work explores the integration of power network safety evaluation results into the operation of a Virtual Power Plant (VPP). Network safety assessments are crucial for identifying potential vulnerabilities and ensuring grid stability. By incorporating these results, VPPs can optimize their decision-making processes to contribute to overall system security. The project proposes a methodology that utilizes safety evaluation data, such as overloaded lines or voltage violations, to inform VPP actions. This could involve adjusting power generation or consumption patterns within the VPP to mitigate identified risks and enhance system resilience. The proposed approach has the potential to improve VPP integration with the grid while contributing to a more secure and reliable power system.*

Keywords: *Power system safety evaluation, Virtual Power Plant (VPP), static security assessment (SSA), dynamic security assessment (DSA)*

BACKGROUND OF STUDY

Ensuring the safety and reliability of power networks is crucial in today's world. Electricity is the backbone of modern life, powering everything from homes and businesses to factories and hospitals [1]. Continuous and uninterrupted power supply is essential for smooth daily operations and economic activity. This ever-increasing demand for electricity necessitates a strong focus on power system network security. In the context of power systems, safety refers to the system's ability to provide a continuous and reliable flow of electricity to consumers without disruptions. Standardized definitions, such as ISO 31000, define risk as the potential for negative consequences arising from uncertainties [2]. A lack of understanding and proactive measures towards power system safety can lead to increased risks and potentially dangerous situations.

Uninterrupted electricity is particularly critical for industrial facilities. Even short power outages can result in significant financial losses due to production stoppages. This is why many large factories have backup power generation systems that kick in during outages. Security evaluations involve a systematic analysis of the power network to identify potential vulnerabilities and ensure its ability to withstand various challenges [3]. Various types of data from the power grid are essential for conducting these assessments. In the world of power system operations, safety has always been a top priority. It's about maintaining normal system operation even after unexpected events (contingencies). Security evaluations serve as a powerful tool for analyzing the power grid's ability to handle such contingencies and ensuring its overall reliability [4].

OBJECTIVE

The main objective of this research is

- To incorporate network safety evaluation results into a Virtual Power Plant (VPP).

SCOPE OF STUDY

- A 100MW renewable system was considered to be installed at Maiduguri, Nigeria to analysis the VPP.

REPORT ORGANIZATION

The project report is outlined as follows: Introduction where the background of the study is presented, Literature Review, Methodology provide the necessary steps to be taken, Results and discussion, Summary and proposed the future works that need to be done.

SAFETY EVALUATION

Power system safety evaluation includes static security assessment (SSA) and dynamic security assessment (DSA). A static security assessment is concerned with factors related to the insecurity situation, such as overload, overvoltage, and so on, via the load flow calculation of the power system in post-contingency conditions of Violation beyond or below (0.95 to 1.05) [5]. The security assessment is done to check whether, and to what extent, a power system is sensibly out of danger from any obstacle that can affect its operation. There are two types of security assessment. The first one is a static security assessment and secondly is dynamic security assessment. Both of these assessments are different and will be discussed. Several researchers have worked on power system analysis with different approaches and conditions where some look at over-voltage, these are the common conditions and criteria used in most of the studies [6].

RESEARCH METHODOLOGY

INTRODUCTION

This chapter outlines the methods and procedures adopted to implement the set objectives of the research.

VIRTUAL POWER INTEGRATION

This section describes the integration of proposed system with clean energy, since solar energy road map to attract solar energy investors to invest on clean energy technology from the underutilized and abundant solar energy in the Northeastern Nigeria to help reduce the effect of global warming caused by the burning of wood and also, enhance the sustainable technological development of the region that was hampered by so many security issues. To achieve this, RET Screen Expert software is used to validate the techno-economic and environmental sustainability of installing a grid-connected solar photovoltaic system in Maiduguri. Climatic data from the National Aeronautics and Space Administration (NASA) for the various locations were used for the assessment. Maiduguri is considered as the best site for photovoltaic technology due to its highest annual solar radiation of 5.96 kWh/m^2/d, and clear sunny days. Bus and Line parameters were examine before and after integration of Virtual power plant.

RESULTS AND DISCUSSION

VIRTUAL POWER PLANT ANALYSIS

The proposed power flow analysis conducted has shown, the risk and uncertainty involved with the system. Thus, this section provides a details analysis of the introduction virtual power plant (VPP) to the system. The introduction of the VPP to the system is necessary since the system has shown high vulnerability. The objective of a Virtual Power Plant is to relieve the load on the grid by smartly distributing the power generated by the individual units during periods of peak load. Additionally, the combined power generation and power consumption of the networked units in the Virtual Power Plant is traded on the energy exchange.

Hence, photovoltaic is introduced in order obtained clean energy system, all other system such diesel engine could be introduced but the fossil fuel is the major and the primary sources of energy used around the world but the production and use of these fossil fuels create serious environmental concerns. The energy is major element to ensure human survival, development and continues improvement, the world energy demand now entering new phase, to sustain the very environment human live, a clean and low-carbon energy is inevitably required. The energy based on the fossil fuel have been the major energy source, however, in the last 40 years strategic dream of energy independence has been envisioning. The effort toward the vision is now changing the pattern of global energy, exerting a profound impact on global economic development.

As such, PV is introduced and reference location was chosen to be Maiduguri, Nigeria due to abundant nature of solar resources in this area. Solar radiation being abundantly present

in Nigeria, especially in the northern regions, the northern region especially Maiduguri receives an average solar radiation of about 7.0kWh/m2-day (25.2MJ/m2-day). But unfortunately, with this abundant solar resource, reliable and pollution-free power, solar power makes up less than 0.1% of all power produced in Nigeria and Maiduguri. To harvest more of this free energy for Maiduguri, this project proposed development of hybrid power generation that will fully utilise available natural resources as shown in Figure 4.2 to 4.4.

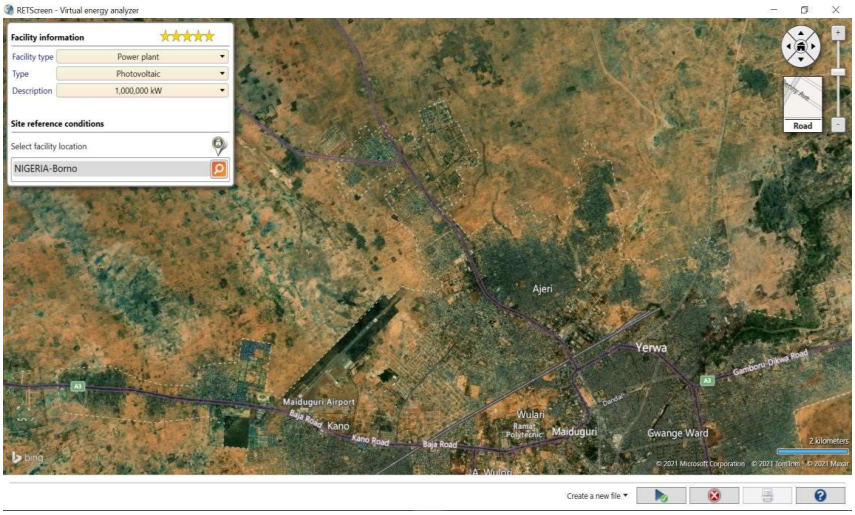

Figure 4.2 Site Location of The Project for The Introduction of VPP

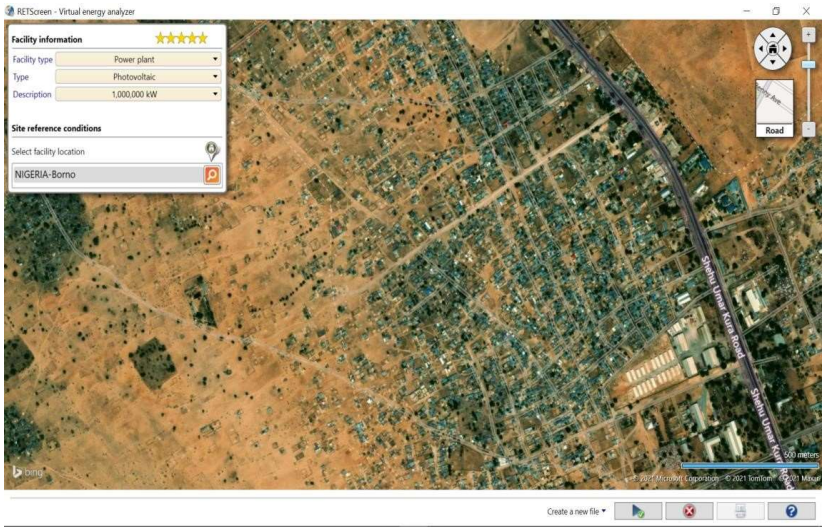

Figure 4.3 Facility and PV Setting

	Unit	Climate data location	Facility location
Name		Nigeria - Maiduguri	Nigéria - Borno - Mimitlu
Latitude	°N	11.9	11.9
Longitude	°E	13.2	13.0
Climate zone		0B - Extremely hot - Dry	0B - Extremely hot - Dry
Elevation	m	332	340

Figure 4.4: Solar Resources Available in The Selected Site

The Figure 4.5 show the VPP architecture, its PV system is one where the photovoltaic panels or array are connected to the utility grid through a power inverter unit allowing them to operate in parallel with the electric utility grid. In general, the grid-tie systems are without batteries are simple to design and are substantially cost effective, as they have relatively few components as shown in Figure 4.5. The main objective of a grid-tied system is to lower your energy bill and benefit from solar incentives. This system does not have battery or related battery equipment.

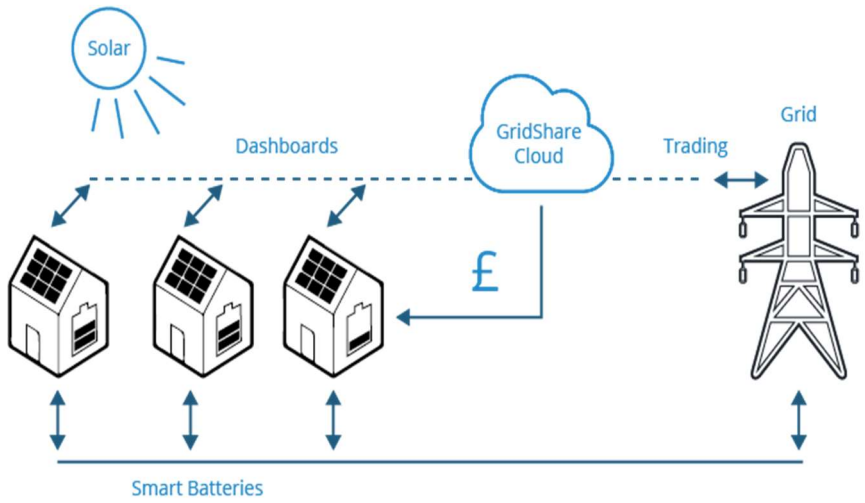

Figure 4.5: The VPP Architecture

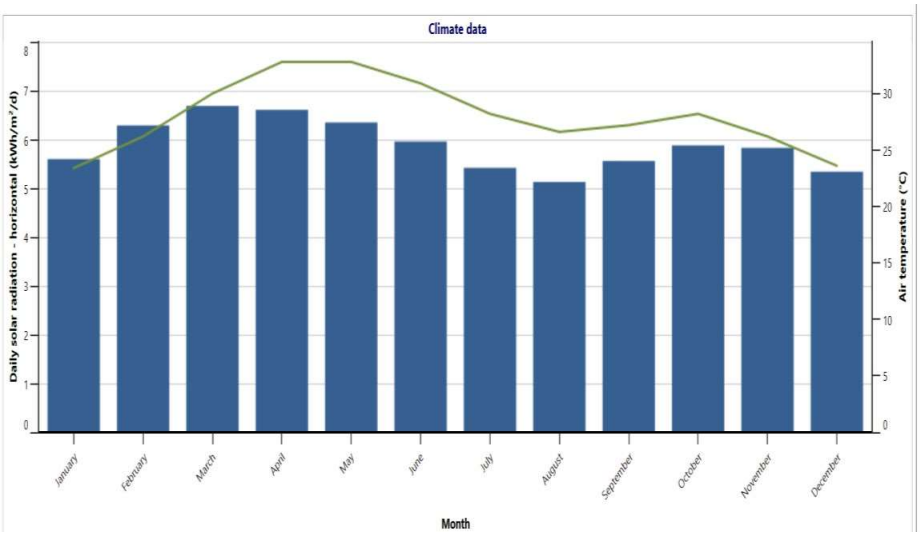

Figure 4.6 The Climate Data Obtained the RET Screen Software

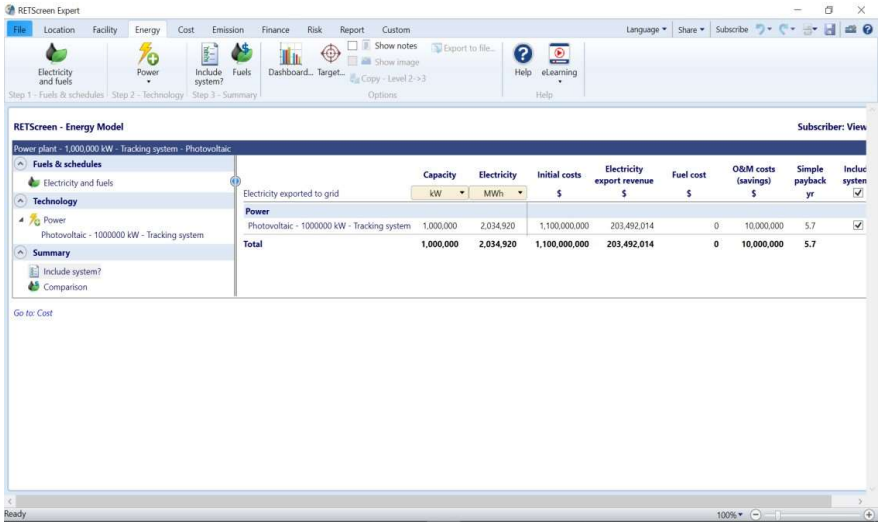

Figure 4.7 RET Screen Window with Virtual Plant Power Rating

The Figure 4.7 show the window of the software used where the VPP with capacity of 100,000kW which is equivalent to 100MW, the system is similar in rating to the one analysis for voltage and power flow.

CONCLUSION AND RECOMMENDATIONS

In order to complement the system problem, VPP was introduced and the results of energy production analysis show that the excess electricity is generated 2,034, 920 MWh with Revenue of $203,492,014 and 880,275 GHG emission reduction and an early payback period is recorded. Likewise, the system stability improved. More, from both the line and virtual power integration, the security level of the system when the overloaded to critical can be improved can

by adding another line in the system or the integration with power line. This line provides more path for the power to flow from generation to the load thus make the performance index of the line decrease and give surplus energy respective.
The integration of the VPP have drastically improved the system stability. Therefore, it is recommended to integrate more system component such as wind turbine in order to further increase the robustness of the system

REFERENCES

[1] Walid G. Morsia, M.E. El-Hawary. Power quality evaluation in smart grids considering modern distortion in electric power systems. Electric Power Systems Research;2011,81[5], p. 1117-1123

[2] Tadeusz Inglotp. Intermediate efficiency by shifting alternatives and evaluation of powerp. Journal of Statistical Planning and Inference;2010,140[11], 3263-3281

[3] Sarah Parkinson. Power and perceptions in participatory monitoring and evaluation, Evaluation and Program Planning; 2009,32[3], p. 229-237

[4] Hu Xiangp. The Application of Gray Incidence Assessment Method on Safety Assessment of Gridp. East China Electric Power, 2009,37[6], p. 1029-1032

[5] Fei Zhicongp. Research on Entropy Weight-Analytic Hierarchy Process and Grey-Analytic Hierarchy Processp. Tian Jin University;2009

[6] Refat Atef Ghunem, Muhammad Hamid, Shesha Jayaram. Transformer Insulation Risk Assessment Under Smart Grid Environment Due to Enhanced Aging Effects. 2011 Electrical Insulation Conference, p. 276-279

[7] Mohamed Shaaban, Md Shah Majid. Operational Security Criterion of a Smart Grid. 2010 IEEE International Conference on Power and Energy (PECon2010);2010

[8] Partha Datta Ray, Rajgopal Harnoor, Dr. Mariana Hentea. Smart Power Grid Security: A Unified Risk Management Approach. IEEEIndustrial Application Magazine, vol. 16, no. 5, pp. 14-19, September/October 2010 8 Xie Chuansheng,et al./ Systems Engineering Procedia00 (2011) 000–000

[9] Mahesh Sooriyabandara,Janake Ekanayake. Smart Grid -Technologies for its realisation. IEEE ICSET 2010