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Integration Virtual Power Plant Analysis Approach for Reliable Security Assessment in Electrical Operation System

Tijjani B. Ngajia, Babagana D. Maikale, Mohammad Goni Mustapha, Muhammad Yusuf
Department of Electrical and Electronics Engineering, Ramat Polytechnic Maiduguri, Borno State

Abstract: *Power system security and assessment are important tasks in modern energy management systems. The present trend towards deregulation and the need for new transmission expansion due to load growth or generation expansion has forced modern electric utilities to operate their systems under stressed operating conditions closer to their security limits. The purpose of security assessment is to provide information to the system operators about the secure and insecure nature of the operating states in the event of any contingency, so that proper control/corrective action can be initiated within the safe time limit. Power system security must be concerning all the time to ensure that the system always operate in a good condition. To make sure that the system operates in a good condition, security assessment must be done on the current system. Thus, this project performed power system security and assessment on 14 buses, the work is done to identify faulty buses and lines in order to take prompt action to sure that there is no problem occurs at the transmission line such as power overload and no voltage violation occurs at bus when one or two of the transmission lines are eliminated. The system was tested 4 different conditions, these include normal conditions, 5% Overloaded, 10% overloaded, 15% overloaded, 20% overloaded. The project was successfully done with all contingencies analysed. Hence, this project has conducted security assessment on 14 bus power system and will provide reliable data for future power system assessment and operation.*

Keywords: *Integration, power Security Assessment Reliability, Electrical Operation System.*

Introduction

The power system security is assessed to determine whether a network is reasonably safe against possible contingencies happening during its operation, today, everything depends on electrical source to do daily work. These can be seen at all places in the world such as house, supermarket, factory, universities and many more [1]. Therefore, continuous supply of electrical energy to the consumer is a must to make sure consumer's daily activities will be smooth [2]. This phenomena also has made the demand of electrical supply increase [3]. Power system security is very important[4]. In power system, security is when the system is free from any risk and can provide continuous supply of the electricity to the consumer without any problem [5. 6]. The definition of risk in ISO 31000 is the effect of the uncertainty upon objectives where on effect is a deviation from the expected either positive or negative [7,8]. Lack of power system security knowledge will make the power system become more risky and can become very dangerous. Continuous electricity is also important to the consumer especially factory [9, 10]. This is because, factory can lose a lot money just from a short time breakdown. That is why in almost all big factory, they have a backup power in case of breakdown of power system[11]. Security assessment is an analysis that can be done to check whether the system is safe from any problem that can affected its operation [12, 13]]. Therefore, many data from the test system is required to perform security assessment. In power system operations, the security of a system has always been an important issue, which is related to the ability to continue normal operation in post-contingency conditions[14]. Power system security assessment is an effective tool for checking the security of power systems, which aims to determine whether, and to what extent, a power system is reasonably safe from serious interference to its operation [15]

Results and Discussions

The proposed power flow analysis conducted have shown, the risk and uncertainty involved with system. Thus, this section provides the details analysis of the introducing virtual power plant (VPP) to the system[1]. The introduction of the VPP to the system is necessary since the system have 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[2]. Hence, power voltaic 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[3]. 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[4]. 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[5].

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 figure to figure 4.

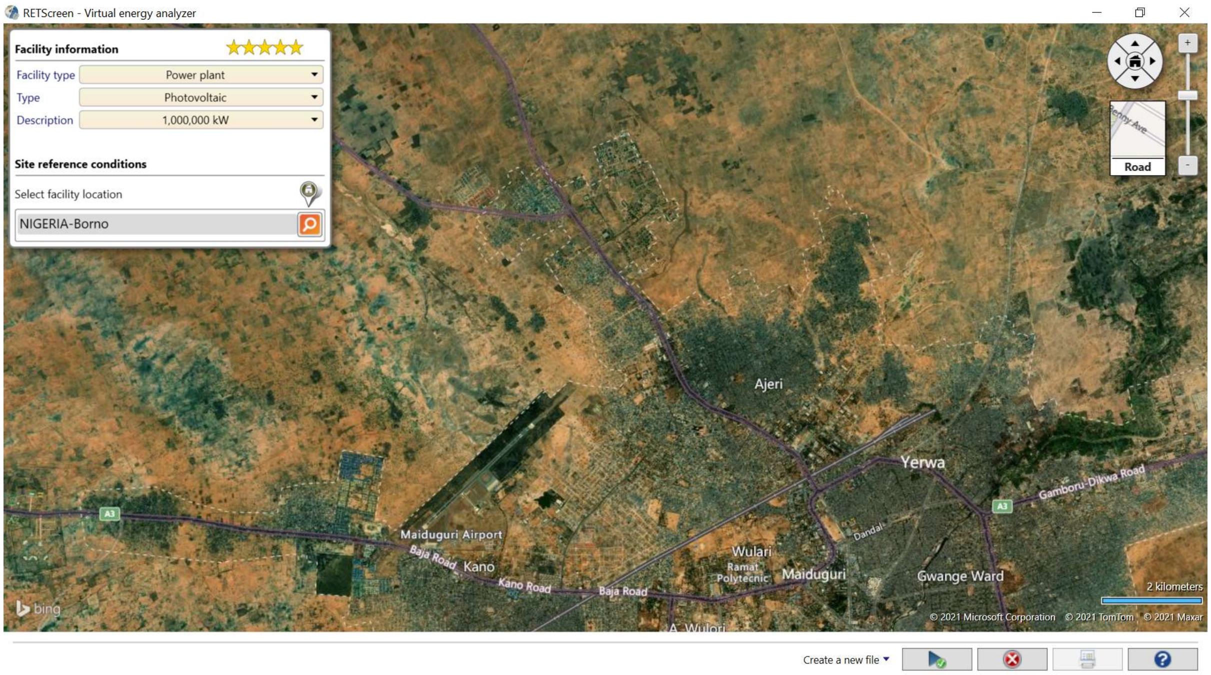


Figure : 1 The location of the project for the introduction of VPP

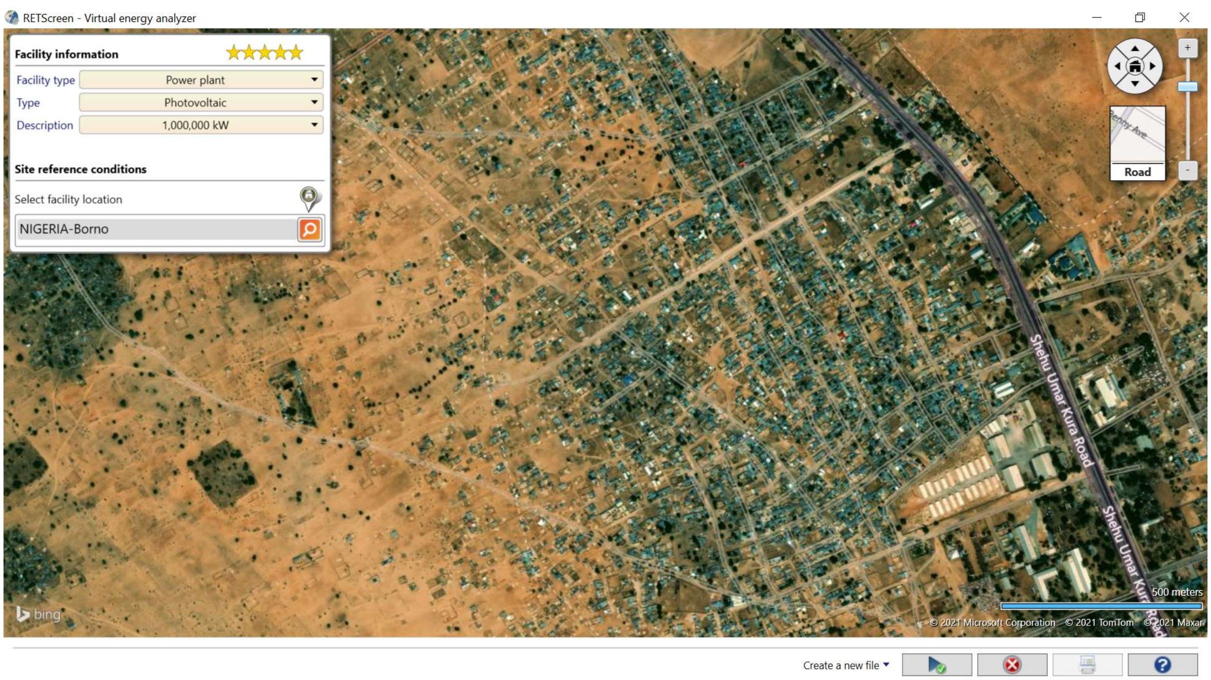
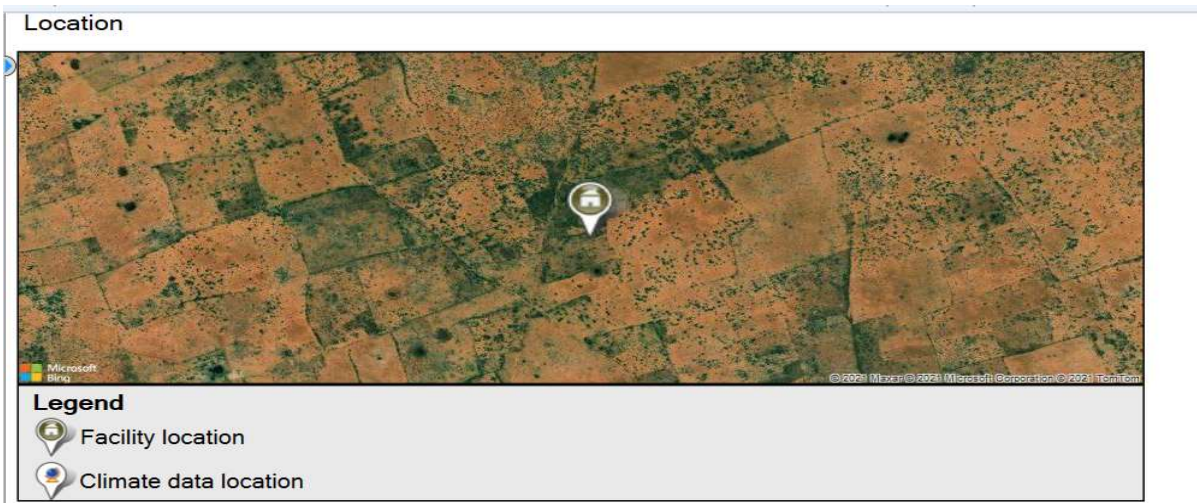


Figure 2: Facility and PV setting



	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 2: Solar resources available in the selected site

The figure 4 show the VPP architecture, it 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. 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.

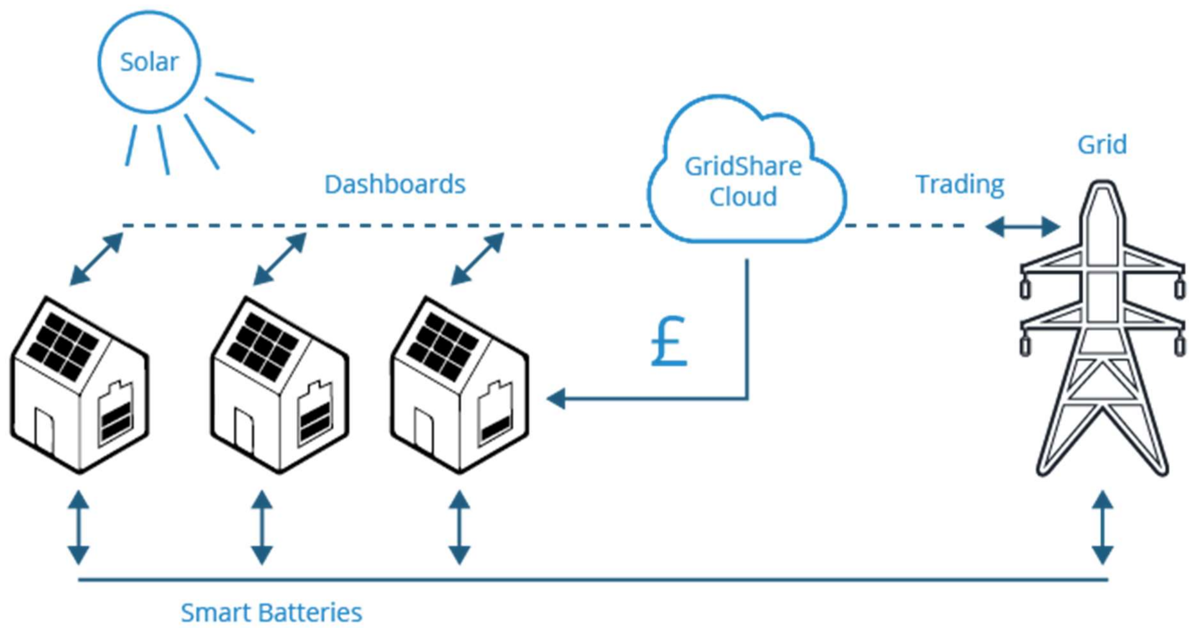


Figure 4: The VPP architecture

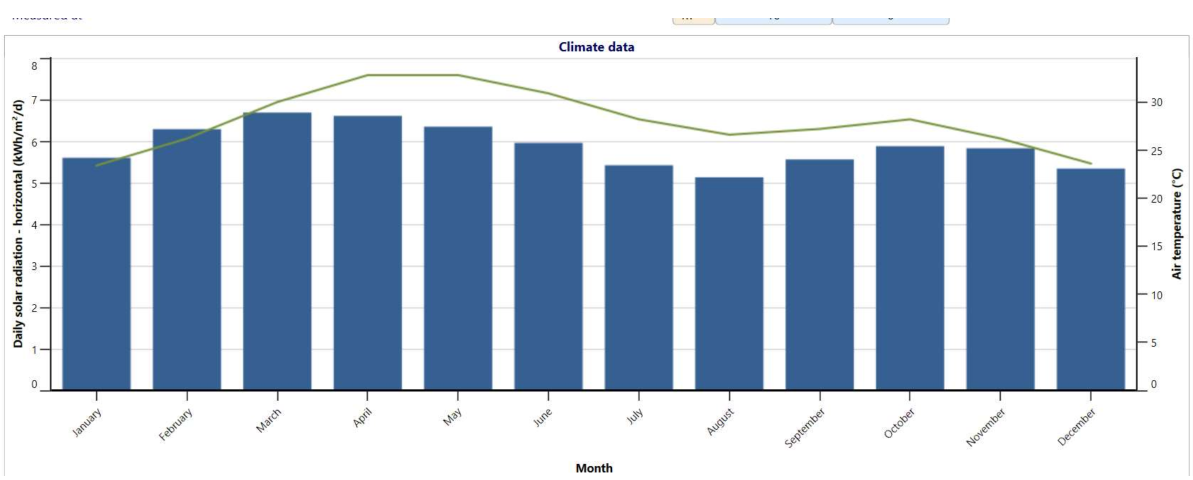


Figure 5: The climate data obtained the RET Screen software

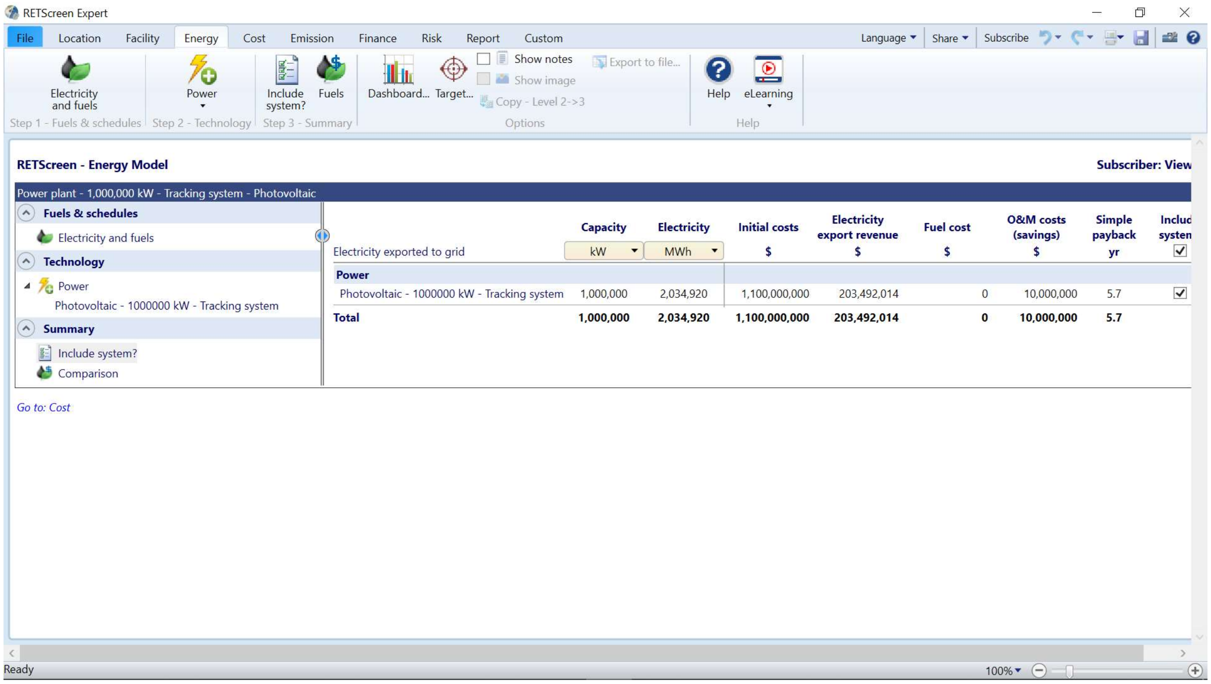


Figure 6: RET Screen window with virtual plant power rating

The figure 6 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.

Sensitivity and Analysis

A sensitivity analysis was carried out to assess the robustness of the VPP. In this scenario, the estimated generated exceeds the demand and injected into the gird, confirming the financial viability of the project with 2,034,920 MW and total revenue of $ 203,492,014. Moreover, the financial net incremental benefit of the project is highly sensitive to revenue variation, mainly because the determined tariff allows only for cost recovery and a minimal profit margin. The analysis shows the project may can recover costs within the first year as confirmed by the figure 7. in assumed revenues, making it vital to secure a cost-recovery tariff to ensure the project's financial sustainability. In the other hand, the financial analysis assessed the financial viability of the proposed VPP, the analysis was conducted using RET Screen. The site location was taken, Nigeria and Nigeria suffer from continuing power shortages and relies heavily on expensive imported oil for power generation. The gap between the supply and demand for electricity reached about 1000megawatts (MW) in 2020. The cause of the power deficit is the unsustainable power generation mix, with 34% of power generated using imported oil, which results in high generation costs. Acute load shedding has directly impacted the national economy, constraining annual gross domestic product (GDP) growth by at least 2%. Thus, VPP proposed will solve this major problem.

RETScreen - Sensitivity & Risk Analysis **Subscriber: Viewer**

Sensitivity analysis

Perform analysis on	Net Present Value (NPV)	
Sensitivity range	25%	
Threshold	0	$

- Remove analysis

Electricity export rate		Initial costs $				
		825,000,000	962,500,000	1,100,000,000	1,237,500,000	1,375,000,000
$/MWh		-25.0%	-12.5%	0.0%	12.5%	25.0%
75.00	-25.0%	768,561,714	642,128,514	515,695,313	389,262,113	262,828,913
87.50	-12.5%	1,040,935,159	914,501,959	788,068,759	661,635,559	535,202,359
100.00	0.0%	1,313,308,605	1,186,875,404	**1,060,442,204**	934,009,004	807,575,804
112.50	12.5%	1,585,682,050	1,459,248,850	1,332,815,650	1,206,382,450	1,079,949,249
125.00	25.0%	1,858,055,495	1,731,622,295	1,605,189,095	1,478,755,895	1,352,322,695

Figure 8: Sensitivity and risk analysis

The 1000-MW VPP consist of PV and grid to generate power. The new VPP will be more efficient and have a lower generation cost and is expected to increase the amount of reliable power supplied to the national grid, and alleviate the financial burden as shown in the sensitivity/risk analysis and financial viability in figure 4.8 and figure.9 respectively.

The project costs and benefits were computed and compared as shown in figure 9.

Financial viability

Financial parameters

General		
Inflation rate	%	2%
Discount rate	%	9%
Reinvestment rate	%	9%
Project life	yr	20
Finance		
Debt ratio	%	70%
Debt	$	770,000,000
Equity	$	330,000,000
Debt interest rate	%	7%
Debt term	yr	15
Debt payments	$/yr	84,541,861

Annual revenue

Electricity export revenue		
Electricity exported to grid	MWh	2,034,920
Electricity export rate	$/kWh	0.10
Electricity export revenue	$	203,492,014
Electricity export escalation rate	%	2%

Figure 9: The financial viability

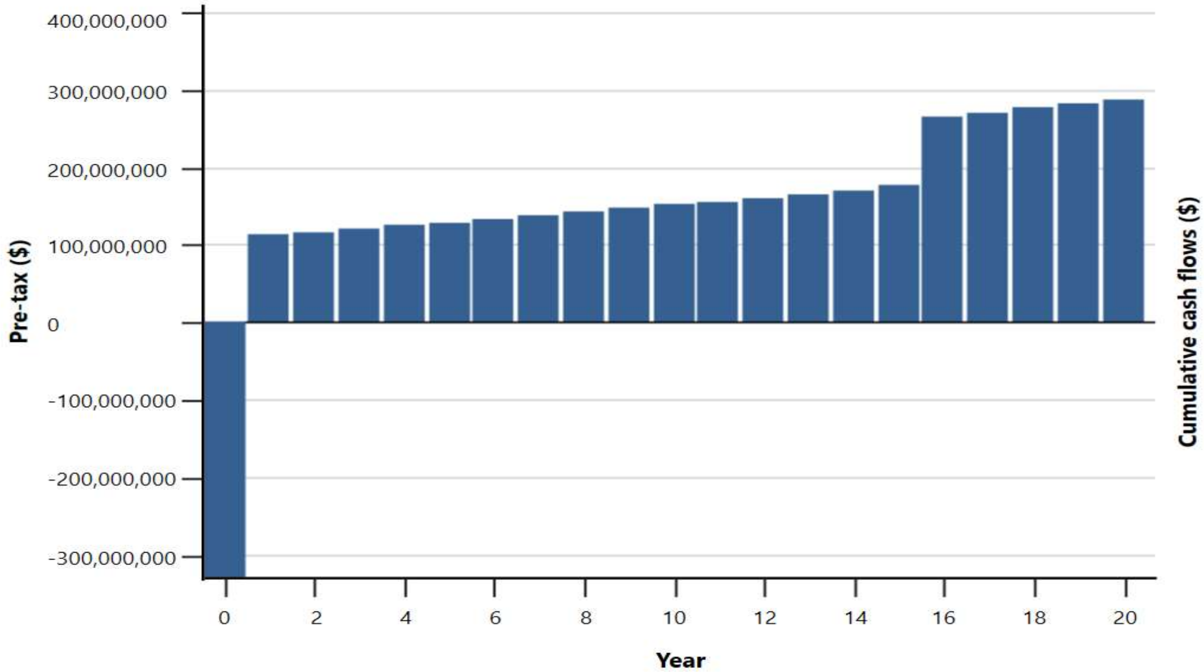


Figure 10 Cash flow

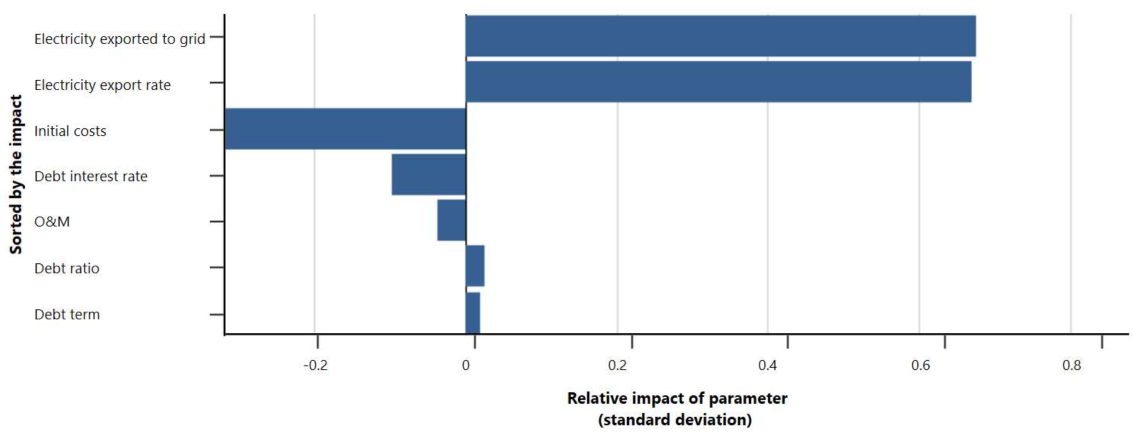


Figure 11 : Risk analysis

Table 11: Summary of the VPP

Summary

	Electricity exported to grid MWh	Electricity export revenue $	GHG emission reduction tCO_2
Proposed case	2,034,920	203,492,014	880,275

Conclusion

The reported presented analysis of 1000MW PV-grid connected Virtual power plant The system was analysis meteorological parameters with long-term average annual and monthly global solar radiation, the long-term average daily and monthly sunshine hours, the long-term monthly averaged relative humidity, and the long-term monthly averaged air temperature at 10 m above the surface of the earth. To aid the investors and decision makers and to show the feasibility of project through risk assessment VPP PV/grid power plants project viability analysis is performed, by using RET Screen software through electric energy production analysis, financial analysis, and GHG emission analysis. The results of energy production analysis show that the excess electricity is generated of 2,034, 920MWh with Revenue of $203,492,014 and 880,275 GHG emission reduction. Thus, the results of the financial analysis based on cash and risk analysis ensure a good profitability of VPP power plant.

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