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Analysis of Optimized Solar and DG based Hybrid Power System for different loading condition

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ABSTRACT: Lack of quality electricity supply in the remote areas is one of the main hindering factors of global development. Many countries around the world are trying to utilize renewable energy sources for remote electrification including developing countries. This paper proposes a new method to determine the placement and sizing of diesel generators (DGs), photovoltaic solar panels (PV) and batteries for off-grid systems. In this work, our objective is to reduce the total system cost while fulfilling the load demand and maintaining the grid power quality, among other constraints. This study analyzes the techno-economic feasibility of the solar PV-diesel hybrid system with different load conditions. From the techno-economic evaluation, it is observed that the optimum time to run the agriculture load is during the daytime. In this case, the solar PV has the highest contribution to meet the energy demand with the slightly increased cost of electricity.

KEYWORDS: Diesel Generator, Solar Panel, Optimal loading, System balancing.

I.INTRODUCTION

Energy is the ultimate bloodline of civilization; every aspect of modern life is one way or another derived from any form of energy. Among all the forms of energy, the most commonly used and the most important in our modern life is the electricity. However, even today a significant portion of the world is not without electricity. Most of the remote and rural areas those are geographically or topographically isolated from the urban areas have a scarcity of energy services, leads to lack of modern facilities, which is considered as one of the major obstacles to global development. Therefore, a reliable and continuous supply of electricity is essential not only for the social and economic development of communities but also for vital services like health and education. However, it is not always that straightforward task to bring the remote areas under the regular electricity network. Electricity networks consist of complex entities[1-5]. It requires a high initial investment cost to expand the grid and regular maintenance cost. But it is not feasible to expand the network if the load density is not high enough. Therefore, the governments around the world are becoming reluctant to invest in expanding the grid to remote areas. Hence, small scale standalone diesel generator based power systems are being used in remote or rural locations. On the other hand, the concern of global warming and finite source of fossil fuels have raised a big question about the sustainability of typical fossil fuel generated electricity [6-9]. Therefore, the concept of renewable energy sources like solar energy, wind energy, and biomass energy has been emerging for a couple of decades. These renewable energies are recently used in the remote areas either in the local networks or as asingle unit. Remote networks consist of diesel generators, and renewable energy sources are reliable, sustainable and even cost effective compared to both grid connected system and only fossil fuel based system [10-14]. Several countries around the world, such as Australia, Bangladesh, India, South Africa, and Malaysia are involved in extensive research and development on renewable energy based rural electrification which includes standalone unit and microgrid system with distributed renewable energy sources. The addition of renewable energies, particularly solar and wind power into the generation mix can significantly contribute in global Greenhouse Gas (GHG) emission reduction initiative [15-20].

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Being a developing country, Bangladesh is struggling to provide electricity to a major portion of the country; most ofthem are very remote. Approximately 40% of the population has no access to electricity [25]. However, the government has been trying to utilize the renewable energy sources, particularly solar PV to address the electricity crisis of the remote areas [6]. Therefore, utilities operating in remote areas are now interested in integrating PV based electricity generation into their network due to its long-term sustainable performance and environment-friendly attributes. However, regardless of this success, there are certain limitations of thiselectrification option that includes-the poorest demographic

II.SYSTEM MODEL AND ASSUMPTIONS

The system design is presented in Figure 1. It comprises ofa main threephase AC grid and resistive loads. To avoid the community'sdiscomfort related to the emission of pollution and noise, theGenset are placed at the initial point, while the solar panelsand batteries can be installed on any side.DC/AC converters are used to optimize the power generationfrom the solar panels. They operate as maximum powerpoint tracking devices (MPPT) so that the solar panels cangenerate their maximum power. Nevertheless, if this powerlevel affects the grid quality, this converter canshift the operational point of the solar panels to reduce thegenerated power. To charge and discharge the batteries, abidirectional DC/DC converter is employed. The DC gridsformed by the solar panels and batteries are then connected tothe main AC grid by a DC/AC inverter.

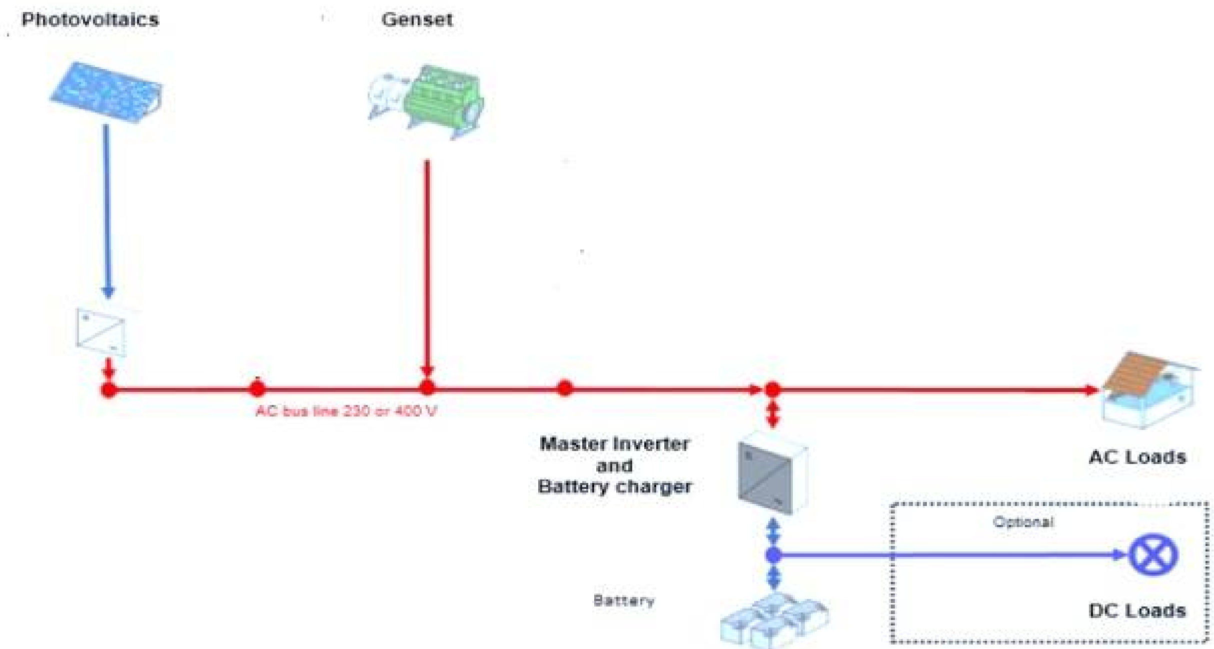

Figure 1 PV solar and Diesel generation connected on grid system

The electricity generation philosophy considered in this network is to maximise the PV penetration level. However, there are significant technical challenges as the PV penetration levels increase. These challenges include: power quality issues (i.e. voltage fluctuation, frequency fluctuation, harmonics, voltage flicker), switching of electrical equipment, system blackouts, islanding detection, electromagnetic interference etc.

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III. SIMULATION MODEL

The Simulink based model is presented in figure 2 having a utility grid of conventional sources integrated with a solar plant which is constituted of solar panel with MPPT. To make the system fully oriented with 24 hour supply a diesel generation plant is also implemented in the system as a backup supply source. Solar plant can supply the electricity to the overall system only in daytime. For obtaining the supply in night timing it is necessary to have a storage unit by virtue of which system can get supply from that storage device by means of converters.

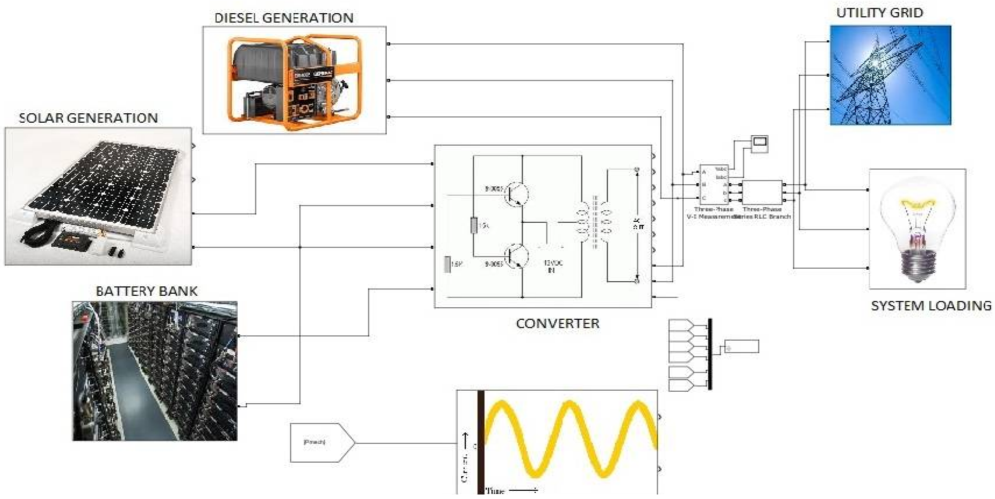

Figure 2 Simulink model of hybrid system integrated with solar and diesel plant

From the measuring unit we got some waveform at starting point of system in which we get power output of pv panel, power of dc unit and power we are getting from diesel generation. The simulation is very low here to just to identify the wave of complete system behaviour. One thing is to be notified that power from dc unit is zero is in case if solar is running and diesel is also running then no need to run battery power.

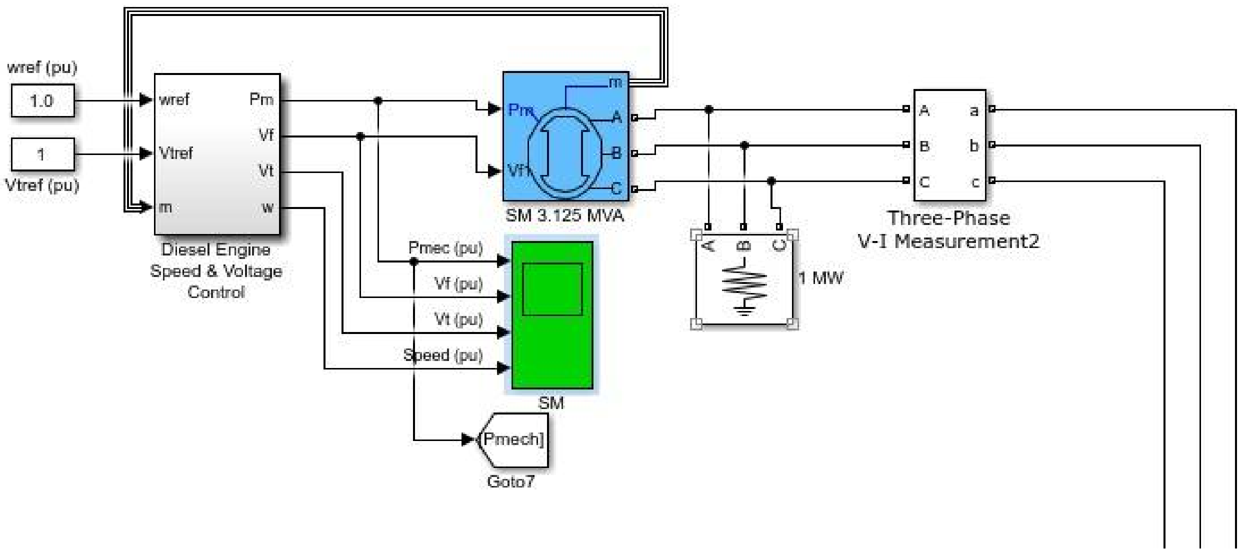

Figure 3 Simulink model of diesel generator

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The permissible minimum loading for diesel generators varies from manufacturer to manufacturer. It has also been considered in the PV-diesel network (without any storage) that the operating spinning reserve is equal to 100% of the PV output plus 10% of the average hourly load. PV output is unpredictable and thus operating with a spinning reserve strategy equal to the total PV capacity has been adopted for maintaining high system reliability. In the simplified PV steady-state power output model, the PV output is only related to solar radiation and ambient temperature.

$$P_{pv}(t) = f_{pv}P_{STC}\frac{G(t)}{G_{STC}}(1 + k(T(t)) - T_{STC}))(1)$$

$$T(t) = T_{air}(t) + 0.0123[1 + 0.031T_{air}(t)](1 - 0.042V_w)G(t) \quad (2)$$

$$T_{air}(t) = 0.5[(T_{max} + T_{min}) + (T_{max} - T_{min})\sin\left(\frac{2\pi(t-t_p)}{24}\right)] \quad (3)$$

Where $_{pv}f$ is the PV array derating factor, $_{STC}P$ is themaximum output power under standard test conditions(STC)(the sunlight intensity is $1000W / m_2$ and theambient temperature is 25_), $G(t)$ is the actual sunlightintensity, $_{STC}G$ is the sunlight intensity under the STC,the value of K is 0.45%/ ◦C, K is power temperaturecoefficient, $T(t)$ is the surface temperature of the PVarray at time t, $T(t)_{air}$ is the ambient temperature, $_{STC}T$is the surface temperature of the PV array under STC,value of $_{STC}T$ is 25, $T_{max}$is the maximum temperature of the day, $T_{min}$is the minimum temperature of the day, t is the moment of average temperature, $V_m$is the current wind speed. the The possibility of power quality issues, due to increasing levels of PV penetration, might occur but this is beyond of the scope of this study. Nonetheless, optimization has been performed with constraints that should ensure acceptable power quality.

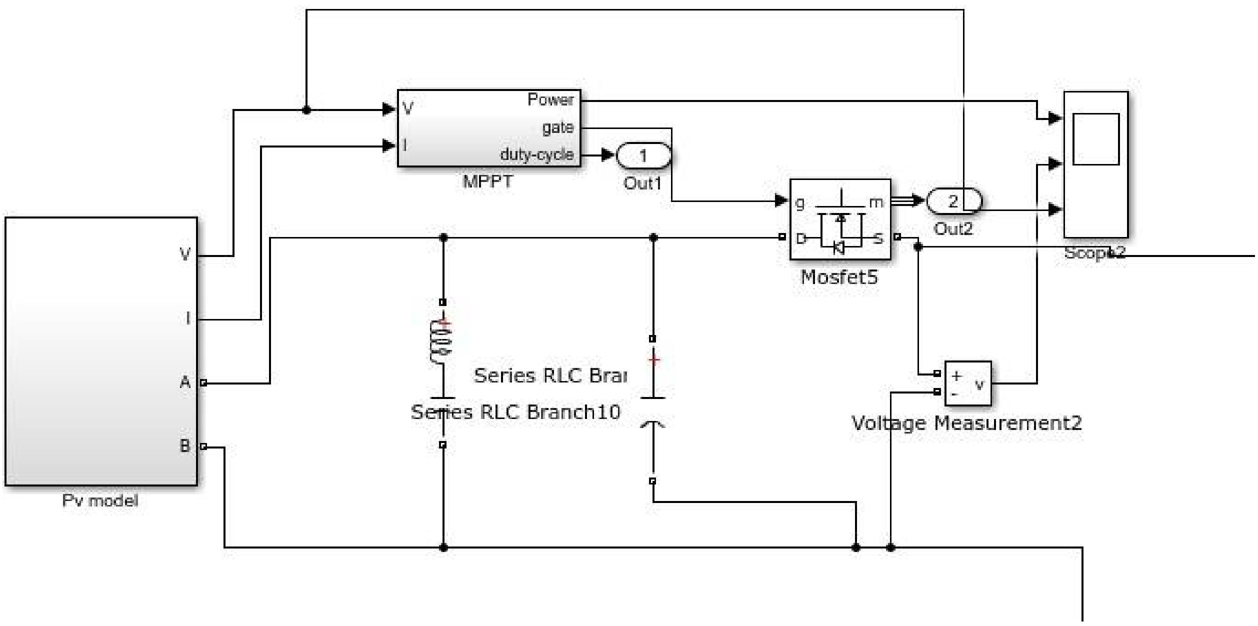

Figure 4 Simulink model of PV model and MPPT

The hybrid power system is designed in such a way that the PV array has the highest priority to supply the load. If the load is not met by the PV power, the battery bank is used to supply the required load. If the battery bank is less than 20% charged, the controller sends the signal to start up the diesel generator. The diesel generator is then used to supply the desired load and charge the battery bank simultaneously. On the other hand, if there is excess power available from the PV array, the excess power is used to charge the battery bank. If the battery bank is 95% charged, the excess power is sent to a resistive dump load, which can be used for space-heating purposes. In the Simulink model, the roundtrip efficiency of the rectifier/inverter and the internal loss in the battery bank per cycle was considered as 90%.

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Energy storage devices can buffer the variable PV system output to provide smoother diesel loading. These storage devices help to align energy production and consumption, when short-term energy imbalance occurs, and when integrated with variable energy sources, the combined system becomes dispatchable for short periods. In this study, a Li-ion battery energy storage system has been considered. When a significant amount of PV output drops rapidly, off line diesel generators may start but they require 1-2 minutes to synchronize with operating generator(s). The batteries will discharge during this transient period to prevent severe frequency decline, which if not arrested may lead to cascading tripping of the generators and system blackout.

The Battery Model block consists of the battery bank and controller. The Battery Model has the second highest priority to supply the load. Once the RTU is installed at load location, it will regulate the power output of the diesel generator, the PV array, and the battery bank through digital/analog output capabilities that enable equipment to be switched "on" and "off." The control settings and set point configurations are programmed into the memory of the RTU. These set points of the RTU can be changed while the simulation is in progress in order to further optimize the system.

IV.RESULT ANALYSIS

The study of solar PV-diesel hybrid minigrid based on the time of system loading fluctuation are developed in MATLAB simulation tool has been analyzed. After the optimization analysis for the minimum levelized cost of electricity, the most optimum configuration from each case study is taken for comparison. The component sizes and key parameters of the best system from each system are given.

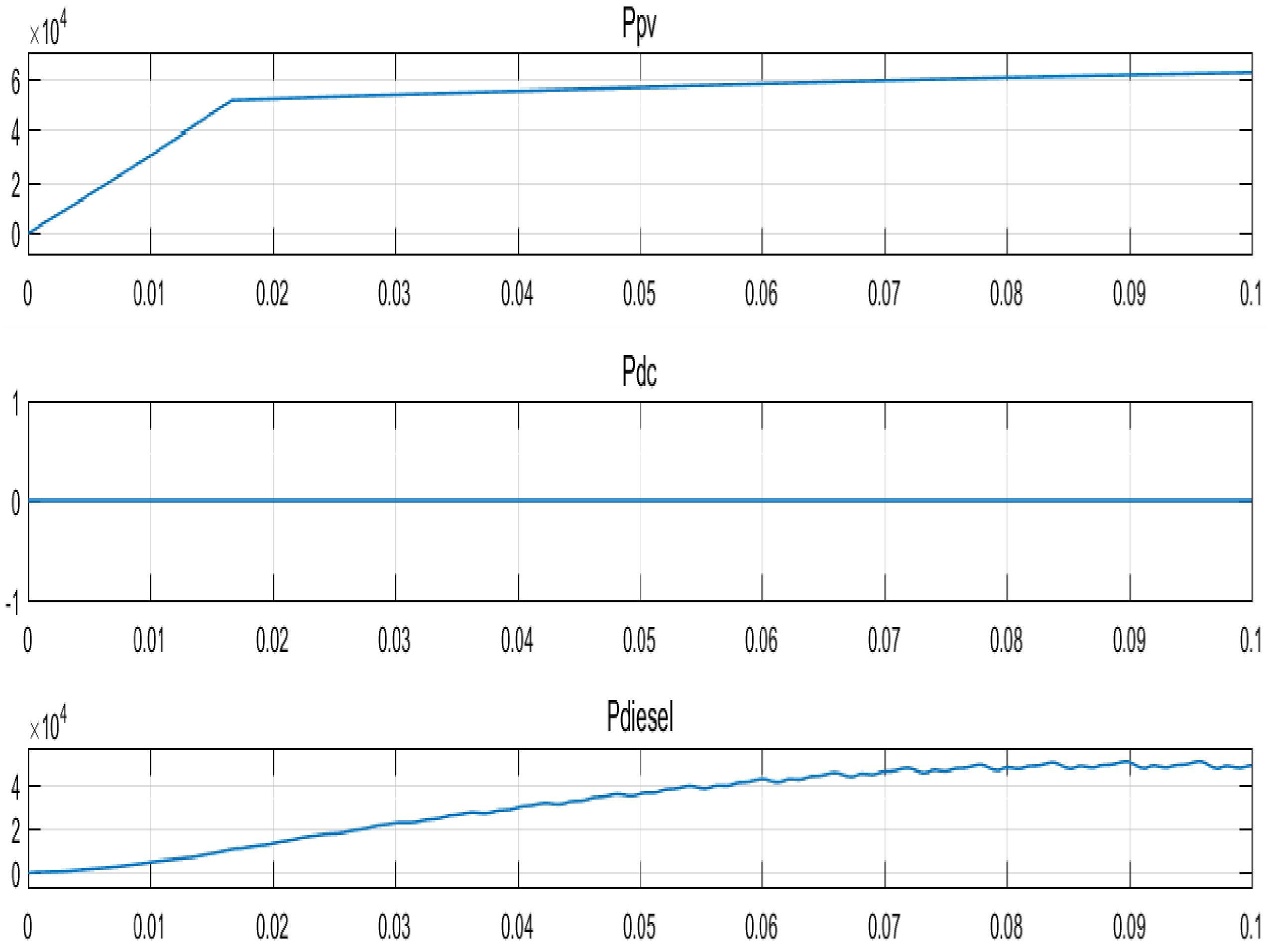

Figure 3 Showing the wave form of Power getting from solar, storage unit and diesel unit

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When moving to the side of diesel generation speed of governor and terminal voltage of generator varies according to their phenomenon value as represented in figure 4. The value of different parameter of diesel are represented in per unit. Their effective value represents the system behaviour.

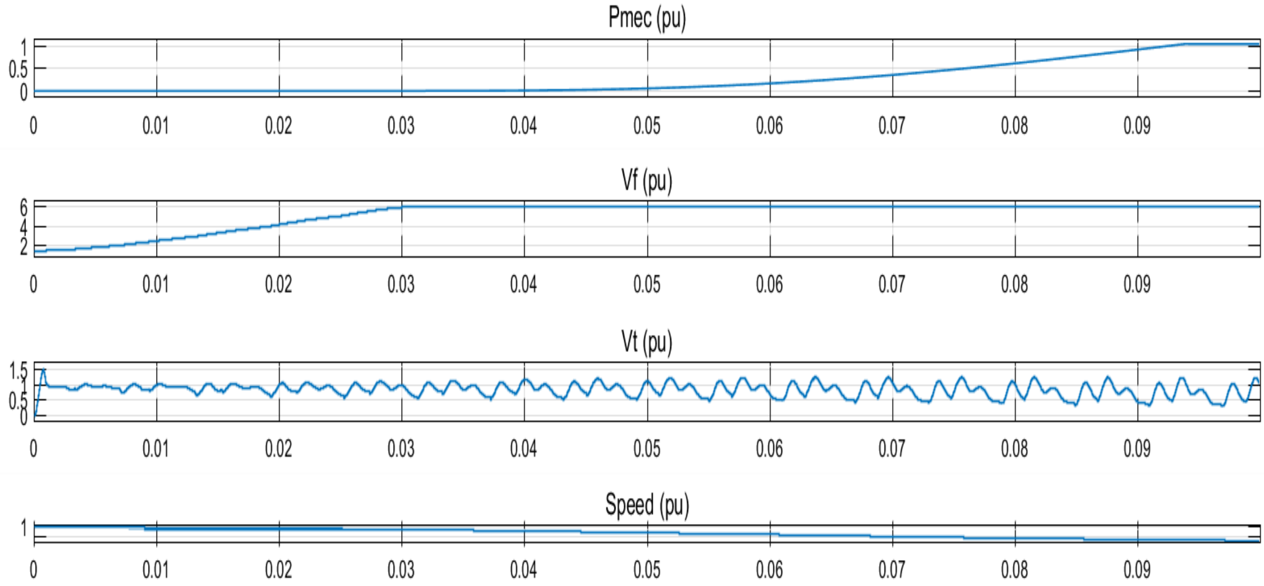

Figure 4 Showing the pu unit value of different parameter getting from diesel generation unit

The diesel generation is illustrated above with different parametric value. Similarly, solar generation power and voltage are displaying below. First one shows the power generated from solar unit and second waveform having voltage waveform. Energy storage devices can buffer the variable PV system output to provide smoother diesel loading. These storage devices help to align energy production and consumption, when short-term energy imbalance occurs, and when integrated with variable energy sources, the combined system becomes dispatchable for short periods.

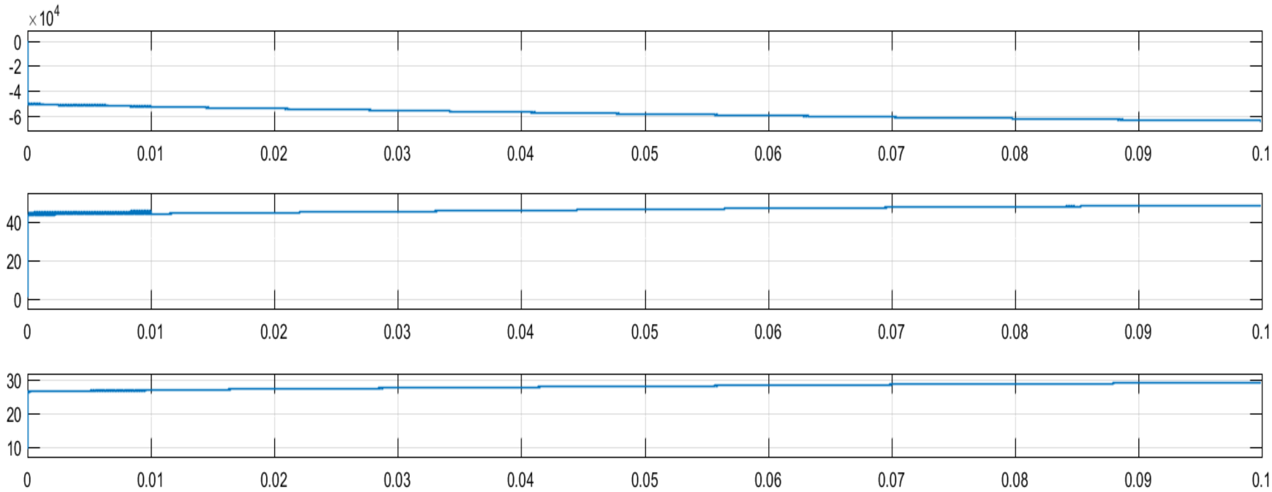

Figure 5 Displaying power and voltage waveform of solar generation unit

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V.CONCLUSION

The study has attempted to explore the possibilities of integrating solar PV and diesel into systems networks to reduce the fossil fuel consumption and to promote environment-friendly solar PV resources for electricity generation. It has been demonstrated that integrating a good amount of centralised PV generation capacity into diesel network is techno-economically feasible. The design of an energy storage system needs to be aligned with the solar unit and the excess amount of electricity which can be stored. Distributed PV systems could be an excellent choice, as soon as consumers can bear the higher PV-battery upfront cost. By integrating the diesel an independency occurs in the system behavior. This above gien results illustrate the system integration with solar pv and diesel. And find optimum results in this system total power generation from solar PV and diesel is 111.3 kW and system costing is about one lakh dollar. The different issues regarding environmental health are also analyzed in index form in per unit. CO_2 having the pollution index 0.6848 where as NOx have 0.01524.

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BIOGRAPHY

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