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Grid Blackout Area PV System Stand-Alone Operation Simulation Model

T. Vijay Muni

Department of Electrical and Electronics Engineering, Koneru Lakshmaiah Education Foundation, Vaddeswaram, Andhra Pradesh 522502, India

Mail id:

vijaymuni1986@gmail.com

Abstract: A stand-alone setup is widely utilized for PV systems. Power fluctuations are normal in an energy-generating system based on solar photovoltaics (PV). When solar PV systems are operated off-grid to meet local power demands for a dependable power supply, alternative energy sources, such as hybrid grid-tied or energy storage systems, may be found. This study proposes a practical solution to the power generation problem in the home market using a novel PV system that can operate both grid-connected and stand-alone. The system includes a block of storage battery with enough dimensions to ensure the continuous power supply of a residential building with an average electricity demand of 10 kWhA stand-alone setup is widely utilised for PV systems. Power fluctuations are normal in an energy-generating system based on solar photovoltaics (PV). When solar PV systems are operated off-grid to meet local power demands for a dependable power supply, alternative energy sources, such as hybrid grid-tied or energy storage systems, may be found. This study proposes a practical solution to the power generation problem in the home market using a novel PV system that can operate both grid-connected and stand-alone. The system includes a block of storage battery with enough dimensions to ensure the continuous power supply of a residential building with an average electricity demand of 10 kWh.

1. Introduction

Microgrids are low-voltage networks that include combination of distributed (DG) units, energy storage systems (ESS), and load, controlled demand that can operate as stand-alone modes [1]. In a state, the microgrid modifies power leveling in free enterprise activities by getting power [2]from the main system or providing electricity to the grid to improve operational benefits. The microgrid is separated from upstream distribution systems [3]in stand-alone operation, to maintain a constant power supply to the customers who use DG. Different types of methods are used as elements [4]of the microgrid to minimize the power swings of non-dispatchable DG units, such power dynamic of every distributed energy generating unit, charge and discharging of ESS, and load variations[5].

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A network-controlled dependent voltage-sourced converter (VSC) [6] or a networking framing agrees to take two modulation techniques utilized in a microgrid[7]. To achieve stable and cost-effective functioning, a microgrid normally requires [8]a powerful platform to enable dynamic referencing power factor, ensuring collaboration among the controlled components [9]. With the quick rise in fossil fuel prices, and the sharp rise in the construction price of building normalized pattern facilities [10], there is a renewed focus on alter- native generating systems that use energy more efficiently [11]. The electricity sector gets increasingly competitive as a result of activities and reorganization of power networks[12]. Solar, freshwater, air, geological, and wastes [13] generated are the most common alternative energy sources. Solar energy is widely available and may be used in practically anyplace [14]. Many countries have taken major steps in the new millennium to tap into the vast and environmentally [15] benign solar energy supplies [16]. These countries invest much in both development and public awareness campaigns aimed at environmental protection [17]. High-quality studies will lower manufacturing costs while also improving the efficiency of allied solar energy-harvesting equipment [18]. Furthermore, public understanding will raise the demand for these devices in the industry. As a result, the technology will be given out at a cost-effective rate [19].

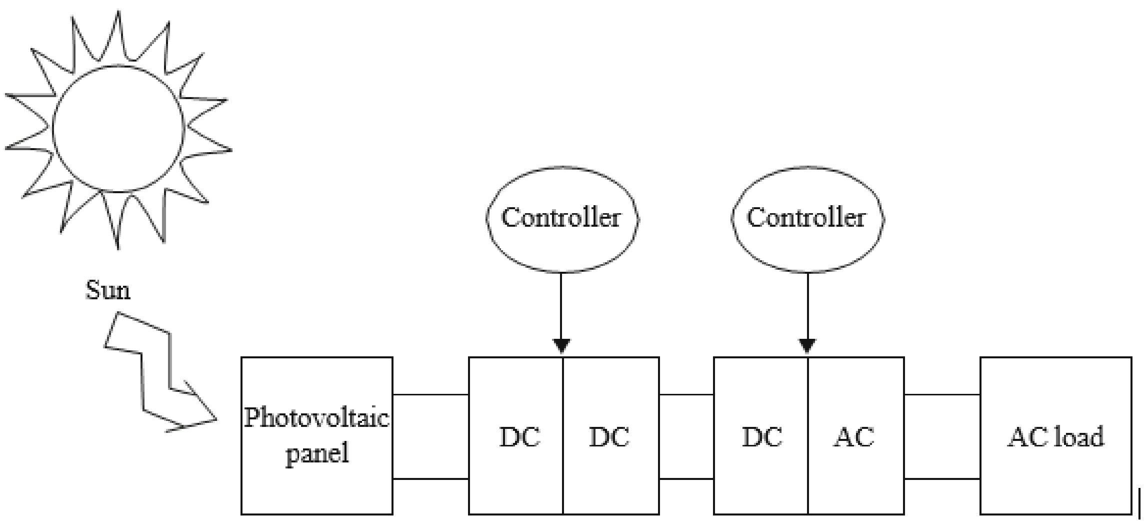

Figure 1: Stand-alone photovoltaic system.

1.1 Proposed Method of PV System.

The suggested PV scheme can be used in either grid-connected or stand- alone configurations[20]. Figure 3 displays a structure of a system [21]. The photovoltaic panel, cell battery, power converter devices, and control method are the essential components [22].

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1.2 Photovoltaic Generator.

PV modules are connected to the circuit, [23]based on the power and voltage of the DC supply [19]. Monocrystalline or crystalline silicon photovoltaic modules were chosen because [24]of their excellent quality and reduced depreciation over long durations when compared to other PV systems[25]. The photovoltaic module is helpful to improve the quality of the generator [26]. In it, the PV module was connected to the control bus [27]. This control bus carried the control signals from the PV module to the inverter. This module was connected to the battery [28]. The inverter circuit connects with the AC power supply. Then, the input current quality was enhanced by the PV module [29].

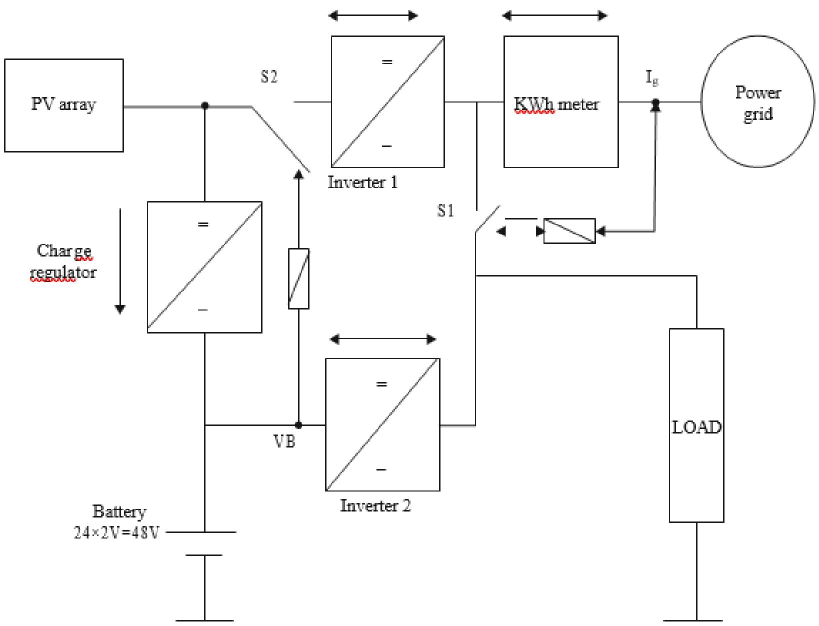

Figure 3: Photovoltaic backup system.

2. Result and Discussion

The observed simulation results showed it during 9 months of every year, generated PV power surpasses the demand needs [30], resulting in a maximum battery state-of-charge (SOC) in an area. The performance of the PV-interfaced power converter's topology functioning in charging modeis verified by simulation. The simulation findings are depicted and detailed in the previous figures[31].

Figure 4 depicts the PV system's monthly power generation and the load's monthly power usage. During the 9 months of March to November, [32]the energy generated bythe PV outnumbers the energy used. The extra power pro- duction will be used to partially recharge the battery block and the remainder to supply the system. The PV electricity generated, [33] and the demand electricity demand are

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extremely close throughout the final three months, which validates the suitability of the executed PV system design, culminating in a PV peak output of 3.2 kW. Figure 5 depicts the system's everyday energy production (kWh/kWp), which fluctuates across 2.6 and 5.4 kWh/kWp among January and July, respectively. This translates to 90% and 66.25% performance ratios[34], respectively. During the summer season, such as July, the performance index degrades because of better capacity PV power damage caused by relatively high temperatures.

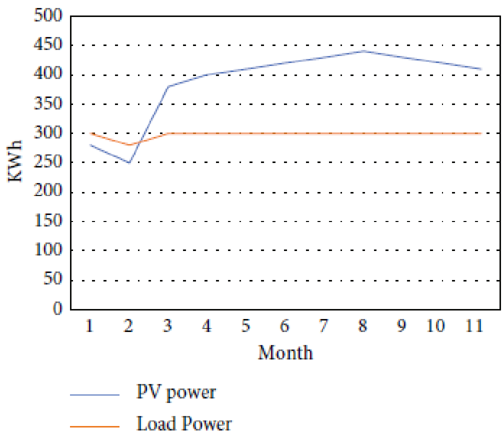

Figure 4: The PV system's regular energy production.

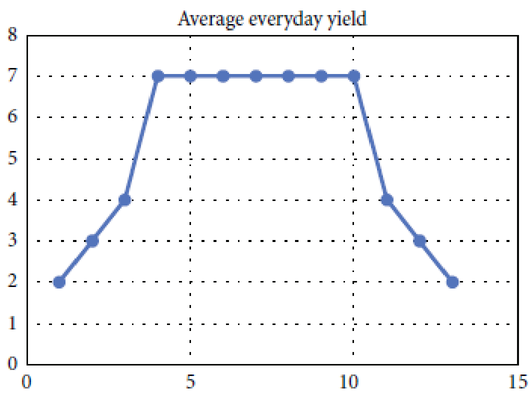

Figure 5: Average everyday yield and load usage.

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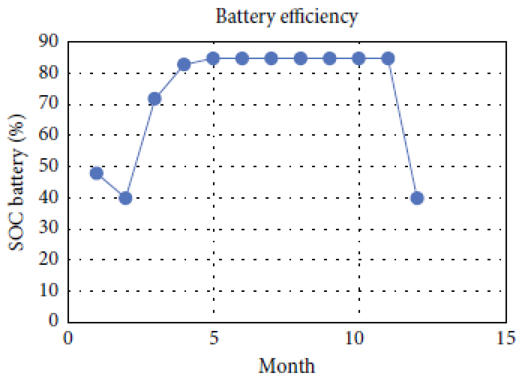

Figure 6: Block of battery SOC.

December when the energy from the sun was minimal. The SOC drops to around 30% during such periods, as can be shown. The input variables are dependent on the preceding sec- tion's predicted design parameters. The discharging cutoff level is the proportion of the fast charger below which the

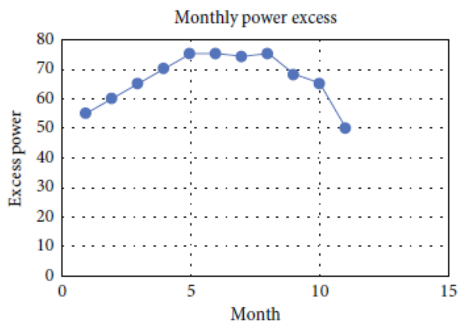

Figure 7: Excess PV power on monthly.

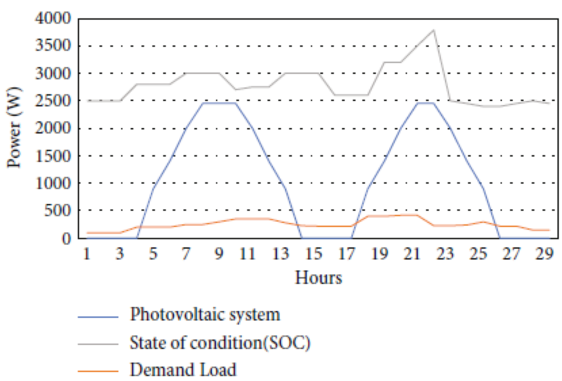

Figure 8: Three days in the month of April

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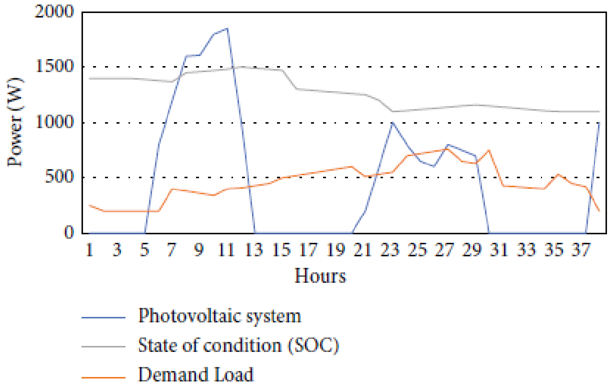

Figure 9: Three days in the month of December

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battery cannot be discharged. The discharge cutoff level is 30% since the release depth is 70%. Figure 10depicts the battery capacity of an intended off-grid device. According to the numerical simulations, the batteries remain powered up about 75% of the time over the year, with just 0.05% of the time having an empty cell, and the amount of energy not absorbed owing to a set of batteries is 4371 Wh.

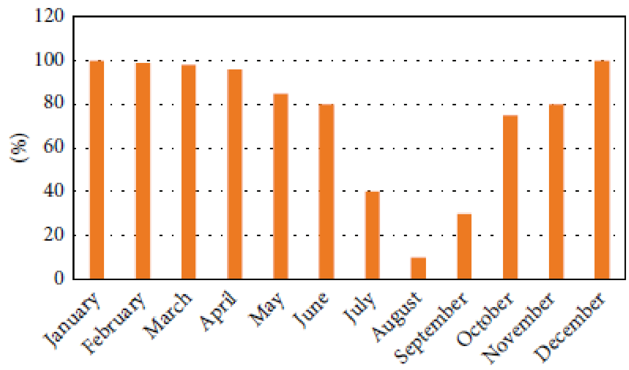

Figure 10: Performance of battery on a stand-alone system.

2.1 Performance Ratio.

The energy production to targeted power ratio is shown by the performance ratio (PR). The goal energy is calculated by multiplying total irradiation (kWh/m^2) by a capsule's STC effectiveness and actual implementation area (m^2). PR indicates the losses caused by inverters, cable, shade, cell mismatches, reflections, black- outs, module heating, and other factors. The PR of a photo- voltaic system deployed at the study location is measured by the 71.2% and 75% achieved in the preceding sections. According to the PV specifications, a PR of 80% or higher indicates a high-performing PV system, whereas less than 75% suggest a concern. Nevertheless, in the instance of a building-integrated photovoltaic (BIPV) network, a PR of less than 75% may be considered acceptable. Due to increased temperature applications and the shielding impact, PR below 75% may be considered standard in the situation of a building-integrated PV (BIPV) network.

Conclusion

The residential home used in this study has a daily energy usage of 10k Wh, which translates to an average power range of 200–730 W. A photovoltaic system evaluated at 3.2 kWp with a battery block volume of 19.2 kWh could provide most of this residence's power, depending on the outcomes of the modelling. The power generated by a PV system exceeds the load requirements for almost nine months out of the year (Mar-Nov), and it is almost enough to power a charge even during the last three months

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(Dec-Feb), when ultraviolet irradiance is at its lowest. These results confirm the capability of the proposed PV system development to handle power supply problems in residential applications. Furthermore, whereas a PV tracking system is anticipated to have a PR of 75% at this site, a building integrating PV system is predicted to have a PR of 71.2%. The ability of air circulation behind PV systems, which was unrestricted in the monitoring system, was found to be the cause of this fluctuation, enhancing conditioning and subsequently module effectiveness. The battery block state of charge fluctuates in the range of 73-85% over the course of nine months (March to Nov.) and 40-49% over the course of three months (Dec.-Feb.), showing that the suggested PV system can satisfy the demand requirements while maintaining the batteries' state-of-charge at an appropriate level. The daily energy output of a photovoltaic system varies between 2.6 and 5.4 k Wh/kWp in January and July, which corresponds to conversion efficiencies of 90% and 66.25%, respectively. The low performance index in July reflects the extreme temperature variation that was experienced all summer long.

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