AC Loads Supply Continuity in Connected and Islanded Microgrids Systems

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Received: 09-03-2023 **Accepted:** 28-07-2023 **Published:** 01-08-2023

Abstract

In the pursuit of establishing a sustainable and highly reliable microgrid, the continual operation and system dependability in both grid-connected and islanded configurations emerge as paramount objectives. Our vision centers on the implementation of an intelligent Energy Management System (EMS), complemented by cutting-edge optimization techniques and well-suitable resource sizing. These synergistic components empower the microgrid to adeptly manage peak demands, surmounting even the most adverse weather conditions, all the while liberating it from external resources or any additional draw from the grid facility. Conducting a compelling case study, we delve into the efficiency of our EMS algorithm, thoughtfully realized through MATLAB Simulink, by analyzing pertinent load profiles and power consumption data from buildings within our esteemed institution, IGEE (Institute of Electrical and Electronic Engineering). To transcend the confines of conventional grid-tied PV systems Inverter, we ingeniously propose a novel approach, coordinating a Diesel Generator-Photovoltaic panel (DG-PV) synchronization, thereby seamlessly enabling the grid-tied PV system to function in off-grid scenarios. This concept lies in achieving optimal performance through the deployment of uniform Distributed Energy Resources (DERs) sizes for Photovoltaic (PV) and Battery Energy Storage Systems (BESS) in both grid-connected and islanded modes. Supplemented by sophisticated control algorithms and real-time monitoring, the microgrid flawlessly transits between operational modes, ensuring unrivaled efficiency and unwavering dependability.

Keywords: Grid connected/Islanded mode, microgrid, supply continuity, grid-tied PVs, Diesel Generator, Battery System

Tob Regul Sci. ™ 2023;9(1): 3779-3796
DOI: doi.org/10.18001/TRS.9.1.266

Introduction

Both grid-connected and islanded-mode microgrids bring significant advantages and concerns in the context of power supply continuity. In grid-connected mode, the microgrid easily interacts with the main power grid, delivering a reliable and regular power supply while also offering the potential of selling surplus energy back to the grid via net metering. However, this connection exposes the microgrid to possible power outages originating from problems on the main grid.

On the other hand, the islanded mode allows the microgrid more autonomy and control by depending on its own Distributed Energy Resources (DERs), such as solar panels, wind turbines, and Energy Storage Systems (ESS). This design proved especially helpful in remote or off-grid settings where a link to the main power grid may not be accessible. Nevertheless, providing a continuous and dependable power supply becomes more manageable when the microgrid has the backup assistance of the main grid in the grid-connected mode. Careful evaluation of individual needs and conditions is crucial in establishing the best appropriate microgrid design for a site or energy use [1], [2],[3].

The grid-tied PV solar system stands out as a widely valued renewable energy alternative owing to its connection with the main power grid and the employment of photovoltaic (PV) panels to produce electricity. This sustainable method powers buildings and feeds extra energy back to the grid, decreasing electricity bills and diminishing dependency on conventional fossil fuels. The decrease of carbon emissions further underscores its ecologically benign character. Another useful element is the net metering feature, allowing households to obtain utility bill credits for extra energy. Nonetheless, this solar system also comes with downsides. Its dependence on the main grid means it can only produce energy while the grid is available, making it powerless during disruptions. Moreover, efficiency might be reduced by shade. Nonetheless, the grid-tied PV solar system remains an appealing alternative for individuals seeking cost reductions and sustainable energy solutions [4], [5].

Integrating a Diesel Generator (DG) into the system shows to be a stable and dependable option, successfully resolving the key shortcomings of a PV grid-tied system during cases of main grid outage. The DG acts as a vital power reference, supplying the appropriate voltage amplitude, frequency, and phase for perfect synchronization and functioning of the grid-tied solar inverter. A major factor for effective DG-PV synchronization is the Minimum Load Factor (MLF), which is commonly set at 30-40% of the DG's full capacity. This highly tuned MLF guarantees that the engine performs ideally, resulting in greater performance and endurance while successfully decreasing maintenance costs. By keeping the DG within this ideal range, it considerably decreases fuel usage and pollutants, making it an ecologically conscientious and economically feasible option [6]-[7].

Today's Microgrids (MGs) need asset to provide a steady and regular power supply, which is a challenge while operating in both connected and islanded modes. It is difficult to effectively optimize energy generation and storage capacity as well as manage power demands under varying weather conditions because the current infrastructure of these MGs is based on a wide range of

Distributed Energy Resources (DERs) technologies, each of which comes in a variety of sizes. This situation makes the power supply unreliable, which raises maintenance and energy consumption expenses as a result. Finding a solution to this challenging issue is crucial if microgrid operations continue to be inexpensive and sustainable in the future.

This paper provides a fresh approach to the topic at hand. Our strategy entails using a novel technique that uses the same DERs technology while accurately scaling the Energy Storage System (ESS) and Photovoltaics (PVs) for both connected and islanded modes. Additionally, we provide an innovative Energy Management System (EMS) that can dynamically adjust to changing power needs in order to guarantee a steady and dependable power supply in both situations (GCM and GIM). We undertake a case study using buildings from the IGEE load profile and power conception to show the efficacy of our suggested strategy and algorithms. This case study demonstrates how our method maintains a consistent and predictable power supply during times of high demand in two Microgrids modes running in adverse weather.

2.System Description And Sizing

In this paper, we discuss two distinct microgrid modes: the Grid-connected mode and the Grid-Islanded mode. The Grid-connected mode refers to the seamless connection of our microgrid to the main conventional grid, enabling two-way energy flow. On the other hand, the Grid-Islanded mode includes the microgrid being completely disconnected from the traditional grid, mandating the use of its own resources to satisfy the energy needs[3].

Fig.1 depicts the microgrid setup and the overall system architecture in Matlab Simulink. The Energy Storage System (ESS), the Photovoltaic Generator (PV), and the Diesel Generator (DG) are the three main parts on which the system principally depends. The traditional grid is also included in the system when it is operating in grid-connected mode.

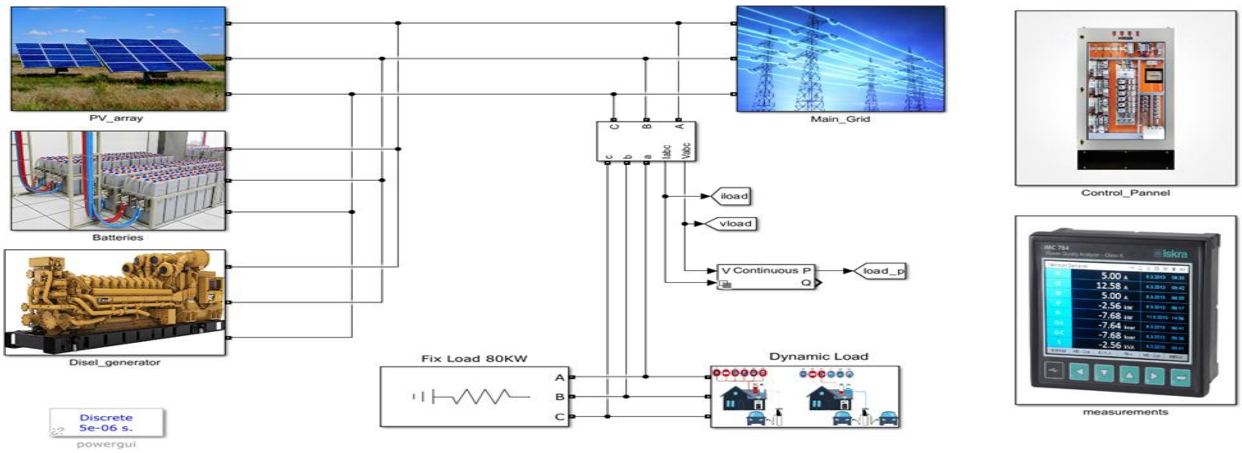


Figure (1) : The Overall System Architecture In Matlab Simulink

2.1 Sizing of ESS

In this work, Lithium-ion (Li-ion) batteries are used. They have one of the finest energy-to-weight ratios, no memory effect, and a moderate loss of charge while not in use, making them one of the most preferred battery kinds right now. Because of their high density, Li-ion batteries are becoming more and more desirable for use in military, automotive, and aerospace applications [8],[9].

Sizing an appropriate battery bank in terms of its power and energy rating might assist reduce peak demand; as well as, storing any extra renewable energy and provide electricity when it is insufficient [10],[11]. Considering the following:

- [80 to 100] KW load overnight for a [8h to 12h].
- [250 to 300] KW load time for [1h to 2h] (working side by side with a minimum of 20% power from the PV system capacity during peak shaving).
- [5h to 10h] charging time from the PV system (400KW).

The battery capacity required is:

$$(100KW * 12h) + (80\% * 300KW * 2h) = 1.6MWh \quad (1)$$

Therefore, a 2MWh lithium-ion Container BESS is used, with 80% DOD (90%-10% SOC) to provide a 1.6MWh capacity. Its specifications are given in Table 1.

Table 1. BESS Container Specifications [12]

Items	Technical Parameters
Battery Type	LFP Battery
Rated Power	2MW
Capacity	2MWh
Standard Charge Current	1520A
Standard Discharge current	3040A
DC Normal Voltage	691.2
DC Voltage Range	540V~788.4V
Battery System Configuration	38 parallel of 691.2V80Ah Packs
Operating Temperature	0~55°C
Protection Class	IP21

2.2 PV System Sizing:

For the sizing of our solar array system, the following criteria must be considered:

- Satisfy our system's total load conception through the day [100KW to 300KW].
- Charge our BESS (1.6MWh) in a decent amount of time [5h to 10h] with [100KW to 250KW] power rate (respecting our load profile and peak shaving time).
- local climate and geography (recommended figure for the total good sunshine hours on a given day)
- The ability to sell power to the grid facility.

The generated power by the PV can be calculated using this formula:

$$\langle (B\_cap)/(Ppv - min\ \_Pl) \approx min\ \_BCT \ \big|\ (B\_cap)/(Ppv - max\ \_Pl) \approx max\ \_BCT \rangle \quad (2)$$

$$\langle 1.6MWh/(Ppv - 100Kw) \approx 5h \ \big|\ 1.6MWh/(\ Ppv - 250Kw) \approx 10h \rangle \rightarrow \ Ppv = 400Kw \quad (3)$$

- *B_cap*: 80% DOD of the 2MWh Battery.
- *min_BCT*: minimum Battery charging time.
- *max_BCT*: maximum Battery charging time.
- *min_Pl*: minimum load power throughout the day.
- *max_Pl*: maximum load power throughout the day.
- *Ppv*: PV System Power

The photovoltaic generator:

The SunPower (SPR-305) 100-kW PV array was chosen, which is made up of 66 strings of five 305.2W modules linked in series (66 * 5 * 305.2 W = 100.7 kW).

Table 2 contains the manufacturer's specs for the module "SPR-305". The PV array module contains a single input that enables us to adjust the sun's irradiance (W/m²). The Signal Builder block will be used that is linked to the module inputs and defines the irradiance profile [13].

Table 2. Solar Panel Specifications

Model name	SunPower SPR-305-WHT
No. of cells	96 in series
Open circuit voltage (Voc)	64.2 V
Short circuit current (Isc)	5.96 At Maximum Power
Voltage(Vmp)	54.7 V
Maximum Power Current (Imp)	5.58 A

Our PV system has four parallel-connected (separate PV arrays) coupled to four DC/DC converter units for the (MPPT and current control). The 'Incremental Conductance + Integral Regulator technique is used for MPPT [13], [14].

$$(PV\ system\ power)\ 400\ kW\ =\ 4\ \times 100\ kW\ (for\ single\ PV\ array) \qquad (4)$$

2.3 Sizing Of Diesel Generator

Diesel generators should be able to provide as much power (Pdg) as needed for the total load (300KW) in an isolated system. To manage the ambiguities or inaccurate predictions associated with renewable energy, the generators often need to have some reserve capacity (Pr). Since this study does not concentrate on determining reserve C, a simple model is used as follows [9],[15]:

$$Cdg\ \times PF = Pdg + Pr \quad \rightarrow \quad 400KVA\ \times 0.8 = 300KW + 20\ KW \qquad (5)$$

- *Pdg* : diesel generators' active power.
- *PF* : Power Factor.
- *Pr*: active power reserve rate.
- *Cdg*: Total diesel generators' capacity.

Table 3. Diesel generators' Specifications

Type	ECO 40-1s/4
Capacity	400 KVA
PF	0.8
Phases	3
RPM	1500
Voltage	400 V
Current	577 A
Frequency	50 Hz

3. The Proposed Control Strategy

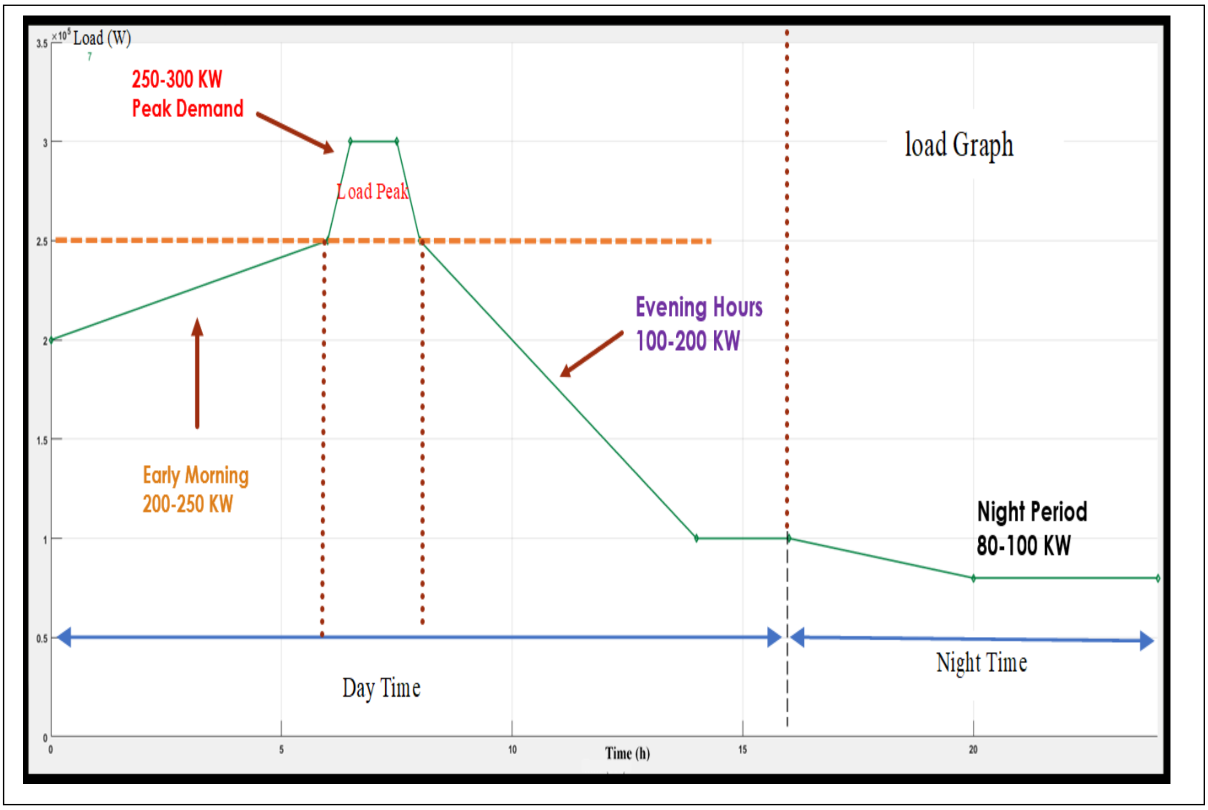


Figure 2.The IGEE Load Profiles during the day and night period.

The load profile and power consumption study of numerous buildings inside our respected Institute of Electrical & Electronic Engineering (IGEE) are insightfully summarized in *Fig.*2. The peak demand phase often takes place while courses and research projects are in full swing in the late morning and early afternoon. A significant increase in power consumption is caused by the active use of several electrical and electronic components during this period, including lighting, heating and cooling systems, computers, servers, and lab equipment. The most significant power consumption is seen during the peak demand period is 250KW to 300KW, which lasts about two hours between [11h:00, 13h:00].

Buildings have a reduced occupancy as the day goes on and courses conclude, resulting in the responsible turning off of lights and electronics. As a result, the demand for electricity starts to decrease. However, certain research projects may continue in the labs far into the night, requiring a steady amount of electricity. Between 100KW and 200 KW are often used during the nighttime hours, from 8h:00. to 4h:00.

Because most buildings are vacant at night, there is a noticeable drop in energy use. As lights are turned off, and heating and cooling systems are programmed to reduce temperatures, energy-saving measures are put into action. Additionally, electronic equipment, including computers, servers, and lab apparatus are turned off. Between 80KW and 100 KW would be used overnight, lasting from 4h:00 to 12h:00.

3.1 Grid-Connected Mode System Functionality Discerption:

A bidirectional Microgrid (MG), which enables energy exchange between consumers and the grid, is formed by the grid-connected photovoltaic (PV) solar power system and the utility grid. Clients may use this configuration to both send surplus power back into the grid and use electricity from the grid as required. Such a flexible structure encourages effective energy use and makes net metering possible for users to save costs[16].

Fig.3shows the three-phase grid-tie inverter with a Proportional-Integral-Derivative (PID) control mechanism that serves as the controller of the grid-tied PV system. The electricity produced by the solar panels and the power provided by the grid is synchronized thanks to this PID control. Consequently, the grid and PV power are kept in phase, resulting in a smooth integration of the two into the overall system. The "Incremental Conductance + Integral Regulator" approach is also used with a Maximum Power Point Tracking (MPPT) Controller to maximize energy extraction from the PV panels.

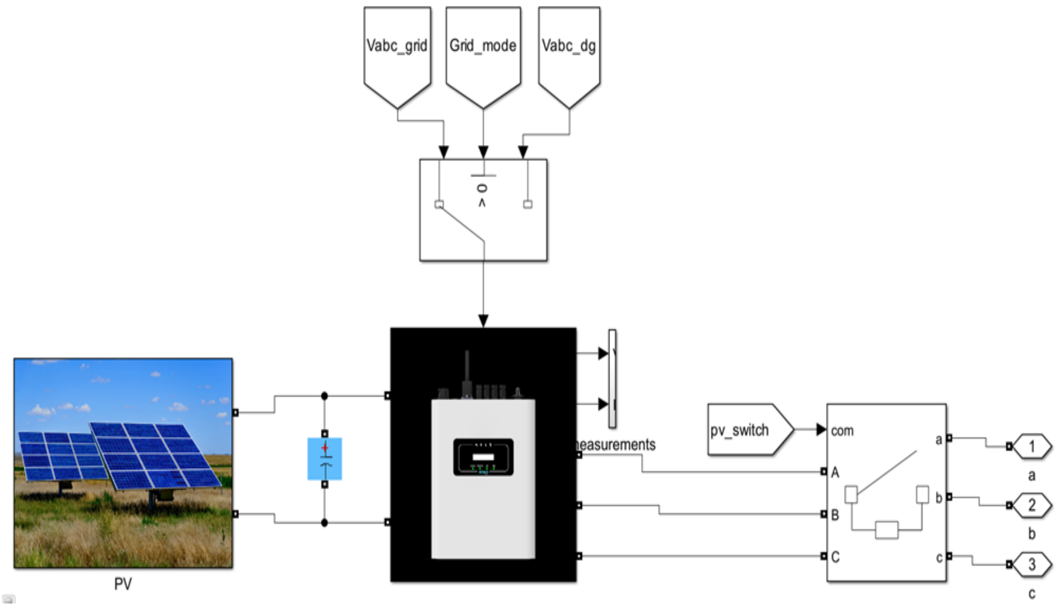
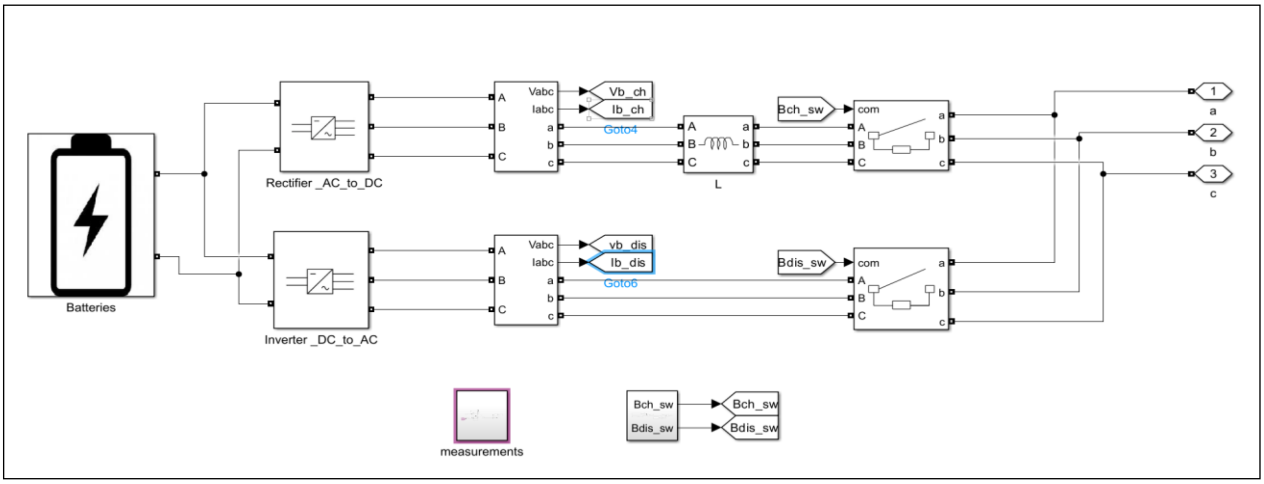


Figure 3 : Three-Phase Grid-Tie PV System Inverter.

The excess energy from the solar panels is sent to a battery storage system when it exceeds its needs. An innovative three-phase inverter with a PID controller is included with this battery system Fig.4 to provide efficient power flow synchronization and control. When the solar panels cannot produce enough electricity, such as at night or on cloudy days, this stored energy can be used during peak-shaving time, lowering the peak demand on the grid when there is a high load. Utilizing the stored energy throughout the day helps decrease grid load, lowering consumer electricity rates.



Figuire.4 : The Overall Battery System Architecture.

An algorithm has been devised to condense the strategy utilized in this system, and it is shown in Fig.5. Additionally, Table 4 offers a thorough list of abbreviations used for constants and variables in the flowcharts of Energy Management Systems (EMS) for both modes of operation,

Table 4. Abbreviations list for constants and variables used in the EMS algorithm flowcharts.

Variables	Constants
SOCb: state of charge of Batteries.	SOCmin : batteries min value = 10%.
Ps : System Resources power.	SOCmax : batteries max value = 90%.
PL : Load power.	DG: Diesel Generator .
Pb : Batteries power.	PV: Photovoltaic System.
Ppv : Photovoltaic power.	Batt: Battery System.
Pdg : Diesel Generator power.	P2G: Power To Grid.
Pg : Grid power.	Pdgm: 30% of DG maximum power
Pch : Battery Charge Power.	
SOCb: state of charge of Batteries.	
PLm: Pl - Pdgm	

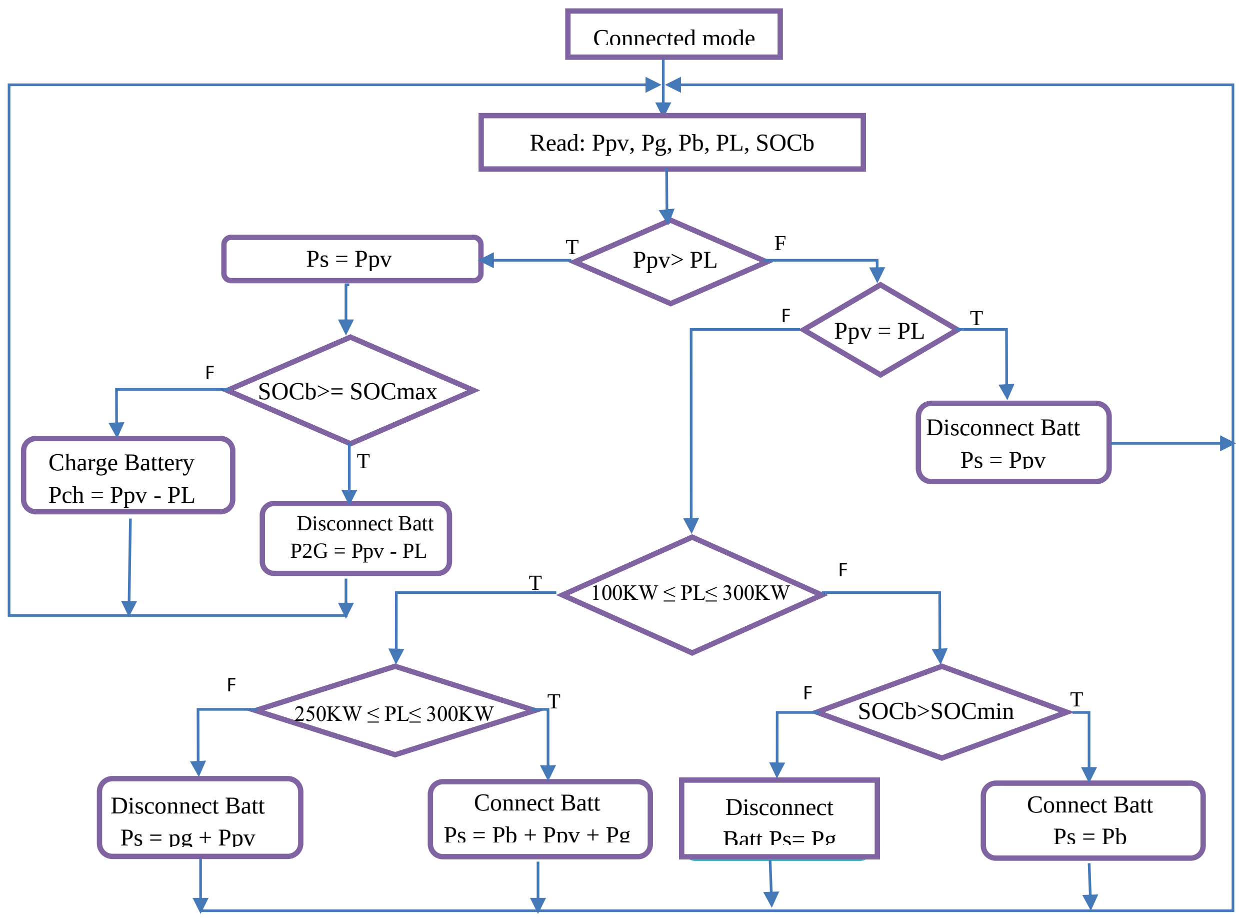


Figure 5: Grid Connected Power Management System Flowchart.

3.2 Functionality of the Grid-Islanded Mode System described

Three essential parts make up our islanded microgrid system: a diesel generator (DG), a photovoltaic (PV) system, and a battery energy storage system (BESS). This integrated system's main objective is to provide a consistent and dependable power supply while successfully managing peak demand via a coordinated and optimized strategy that uses each energy source's distinct qualities.

The diesel generator provides the MG with a stable and traditional power source. The DG may serve as the primary power source during periods of high demand or when the PV system is not working well due to the weather. Additionally, the DG serves as a backup power source if the PV system or the battery system unexpectedly fails or experiences an outage.

Our suggested control algorithm decreases the DG's consumption while boosting the output of the PV system's first priority to improve energy efficiency and lengthen the lifetime of the diesel generator. The diesel generator's minimum load factor (MLF), which is normally set between 30% and 40% of its rated capacity, is considered during this optimization. Following this, MLF ensures the engine runs as efficiently as possible, lowering maintenance costs and extending engine life. Depending on the energy requirements of the MG, the diesel generator dynamically modifies its power output.

Conversely, the PV system with the three-phase grid-tie inverter !!read dg refrance! Fig.3 is a clean and renewable energy source. It becomes the primary energy source when weather conditions permit. The PV system also charges the battery system, which stores extra energy produced during times of low demand. This stored energy may power the MG during periods of high demand or when the PV system cannot supply enough power.

The battery energy storage device performs two functions and is outfitted with a PID controller and a sophisticated three-phase inverter Fig.4. First, it guarantees electricity availability at times of heavy demand or when the PV system cannot deliver enough energy. Second, it makes peak shaving easier by using the PV system's extra energy stored to fend off abrupt increases in energy demand. The battery system may also provide the MG backup power in the case of a PV system or DG failure. The algorithm summarizing this approach is given in Fig.6,Table 4 offers a thorough list of abbreviations used for constants and variables in the flowcharts.

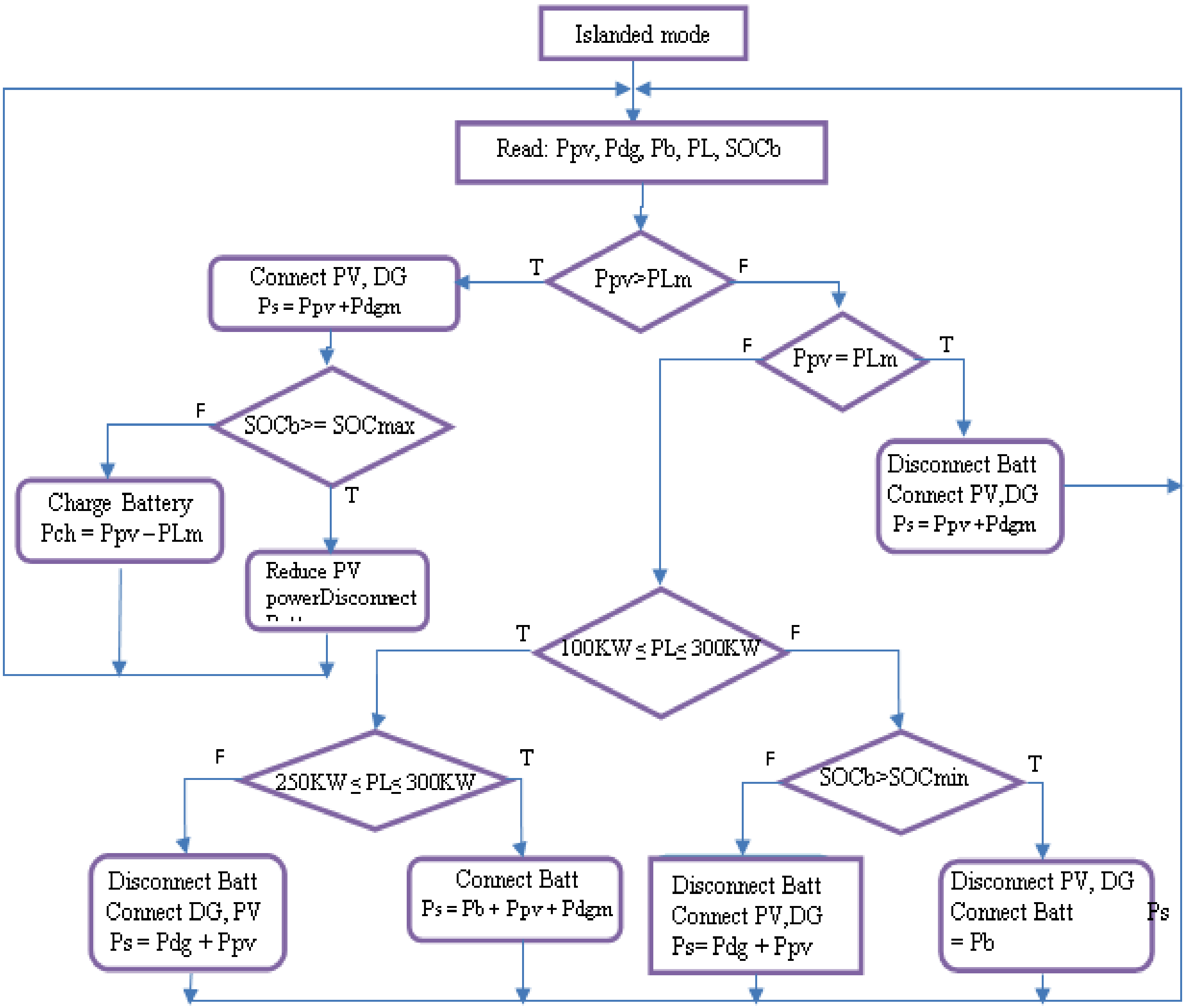


Figure 6: Islanded Mode Power Management System Flowchart.

4. Results and Discussion

4.1 Grid-Connected Mode (GCM)

Between (0 – 6.5) hours (Efficient battery System Charging):

Our carefully designed and optimized PV system excels at supplying the power needs while effectively charging the battery in tandem, assuring stability and top performance. The charging phase, represented in Fig. 2 (Graph 5), shows the excess energy supplied by the PV system, with a remarkable peak capacity of 130KW (notice that negative Battery charge power values indicate the reverse current flow direction into the battery). Over 6.5 hours, the battery's state of charge (SOC) (Fig. 2 Graph 6) increases from 29.00% to 57.00%, and there's potential for even greater levels with good weather circumstances.

Between (6.5 – 8) hours (Peak Demand Management):

During peak demand (6.5 - 8 hours), the graphs exhibit our system's ability to manage power consumption that soared past 250KW, peaking at 300KW for 1.5 hours (Fig. 2 Graph 1). Remarkably, even under severe weather, our PV system could handle the peak demand without pulling any electricity from the grid. We successfully applied the peak shaving strategy when the PV system production went below 300KW (Fig. 2 Graph 2) due to unforeseeable weather conditions by reinforcing the PV system's output with a maximum of 46KW from the Battery (Fig. 2 Graph 3), guaranteeing a consistent and stable power supply to the load. Consequently, the Battery SOC (Fig.2 Graph 6) reduces marginally from 57.00% to 55.00%.

Between (8 – 12.3) hours (Flexible Battery Charging and Grid Interaction):

Throughout the daytime, particularly in favorable weather circumstances, our PV system successfully provides the load needs (Fig.7 Graph 1) while also diverting extra power to charge the Battery (Fig.7 Graph 5) at up to 5KW for a continuous 4-hour period. This charging surge boosts the Battery SOC (Fig.7 Graph 6) from 55.00% to 56.00%. Furthermore, with bidirectional power flow, any extra energy can be fed back into the grid, allowing us to sell electricity to the grid facility when our Battery SOC hits or surpasses 90.00%.

Between (12.3 – 16) hours (Performance of Grid-Tied PV System):

Demonstrating the Grid-Tied PV System's capabilities throughout the daytime, when PV solar radiation reduces due to bad weather conditions, nighttime hours, or brief cloud cover are apparent (Fig.7 Graph 2). However, our system reacts efficiently using grid power (Fig.7 Graph 4) to provide a steady 100KW power supply to the load.

Between (16 – 24) hours (Nighttime Power Supply):

The last 8 hours constitute nighttime (as represented by the load graph in Fig. 27Graph 1), during which power consumption declines to its lowest point, ranging from 100KW to 80KW. To ensure a consistent and continuous power supply throughout the night, our Battery system effortlessly takes over, using the stored energy collected by the PV system during the daytime. Consequently, the Battery SOC (Fig. 7 Graph 6) steadily declines from 56.00% to 20.00% throughout the 8-hour overnight period.

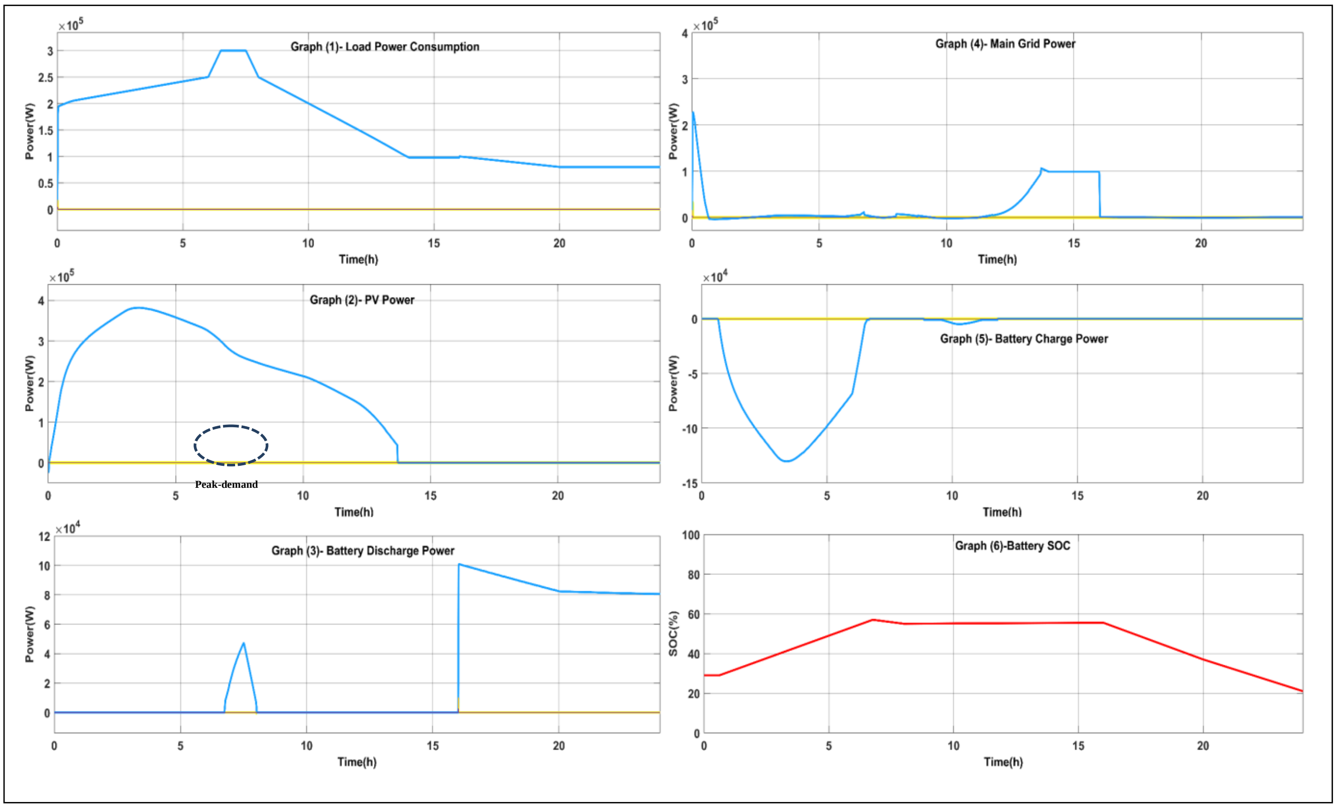


Figure 7. Simulation Results For Grid-Connected mode.

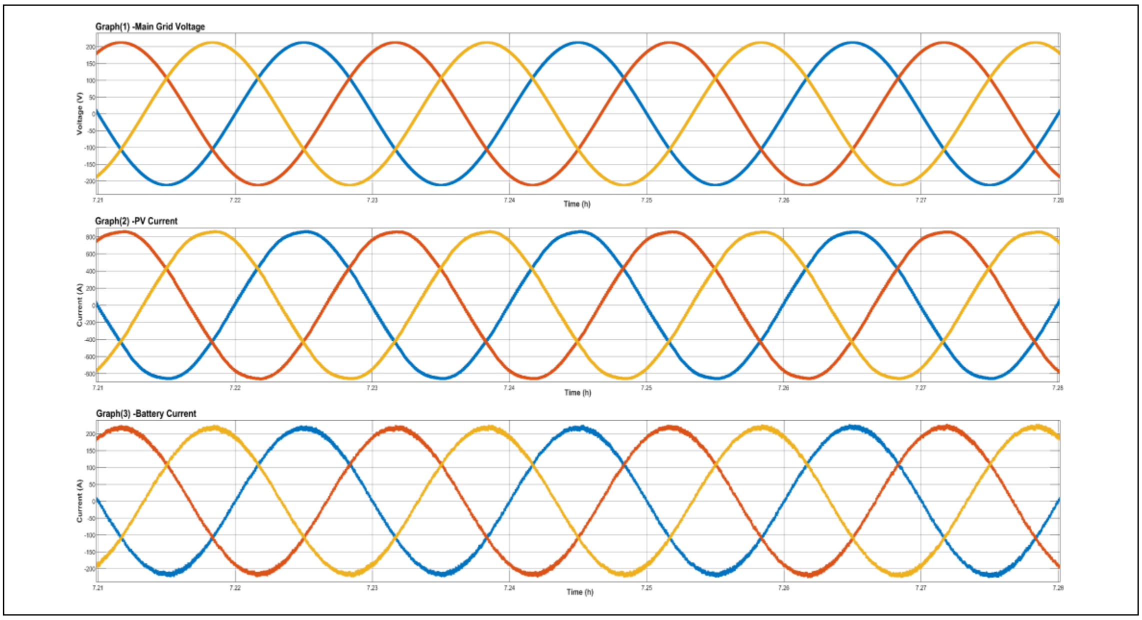


Figure 8. PV And Battery Current Synchronization With Grid Voltage.

Fig.8 depicts the main grid voltage graph (1), PV current graph (2), and battery current graph (3) during the grid-connected peak shaving period. The remarkable synchronization between PV and battery currents with the grid voltage, where the PV current and battery current are perfectly in phase with the grid voltage, showcases the high efficiency of our grid-tied inverter in optimizing energy management. This seamless integration ensures peak demand is efficiently managed while promoting grid stability and reliability.

4.2 Grid-Islanded Mode (IGM)

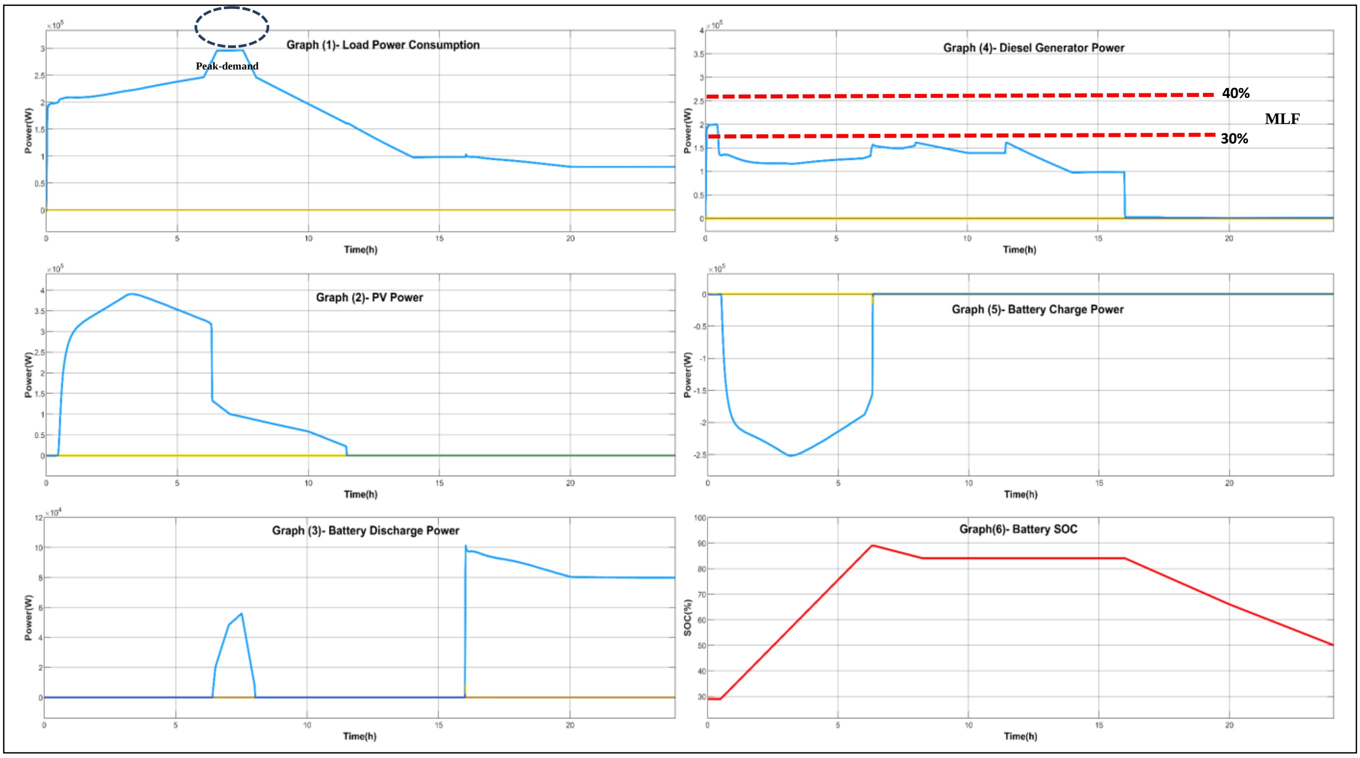


Figure 9. Simulation Results For Grid-Islanded Mode.

Between (0 and 6.3) hours (Battery charging phase):

In Fig. 9 Graph 4, we note that the DG works at a minimum load MLF (30% to 40%) of its rated power (400KVA) to guarantee a consistent frequency and voltage reference for our grid-tied PV solar system, allowing for efficient power synchronization. Throughout this 6.3-hour period, the PV system (Fig. 9 Graph 2) provides sufficient electricity to fulfill both the load power demand and charge the battery (Fig. 9 Graph 5) with remarkable stability and efficacy. The Battery charge Power represents the extra energy generated by the PV system throughout the day, which may reach an elevated value of 252KW (Fig. 9 Graph 5) or even more, dramatically raising the battery SOC from 29.00% to 89.00% (Fig. 9 Graph 6) during this 6.3-hour window.

Between (6.3 and 8) hours (Peak-shaving phase):

During the peak demand time, lasting for 1.7 hours, the load power consumption increases from 250KW to 300KW, while the PV system power indicated in Fig. 9 Graph 2 sees a decrease owing to unanticipated weather circumstances. Consequently, the battery charging process is stopped (Fig. 9 Graph 5). To handle this problem, the Battery system power is integrated to support the PV system using the "peak shaving" approach, delivering a maximum power production of 56KW (Fig. 9 Graph 3) for 1.7 hours. This strategy efficiently decreases the

Battery SOC from 89.00% to 84.01% (Fig. 9 Graph 6) without pulling more power from the DG.

Between (8 and 16) hours (PV-DG synchronization performance):

As the time advances between 8 and 16 hours, the PV system power (Fig. 9 Graph 2) begins declining, possibly owing to reasons like bad weather, evening time, or brief cloud cover during the daytime. Despite this, the system's load remains substantially greater than 100KW. In response, the DG (Fig. 9 Graph 4) immediately adjusts to the changes in PV power, delivering a stable and continuous energy supply to satisfy the system's needs.

Between (16 and 24) hours (Nighttime):

The final part of the graph displays the 8-hour nighttime period, during which the load power consumption reaches its lowest point, ranging from 100KW to 80KW. Consequently, the DG (Fig. 9 Graph 4) is disconnected, and the Battery system (Fig. 9 Graph 3) takes over to give steady and continuous power, peaking at 100KW over these 8 hours. This power is produced from the stored energy generated by the PV system during the daytime, essentially bringing down the battery SOC from 84.01% to 50.00% during the overnight period.

Fig.10 illustrates the voltage profile of a diesel generator (Graph 1) along with the PV current (Graph 2) and battery current (Graph 3) during grid islanding mode peak shaving period. In this scenario, the system operates in a standalone mode with the grid disconnected. The synchronization between PV and battery currents with the diesel generator voltage highlights the exceptional performance of our grid-tied inverter in facilitating effective energy management even during islanded operations.

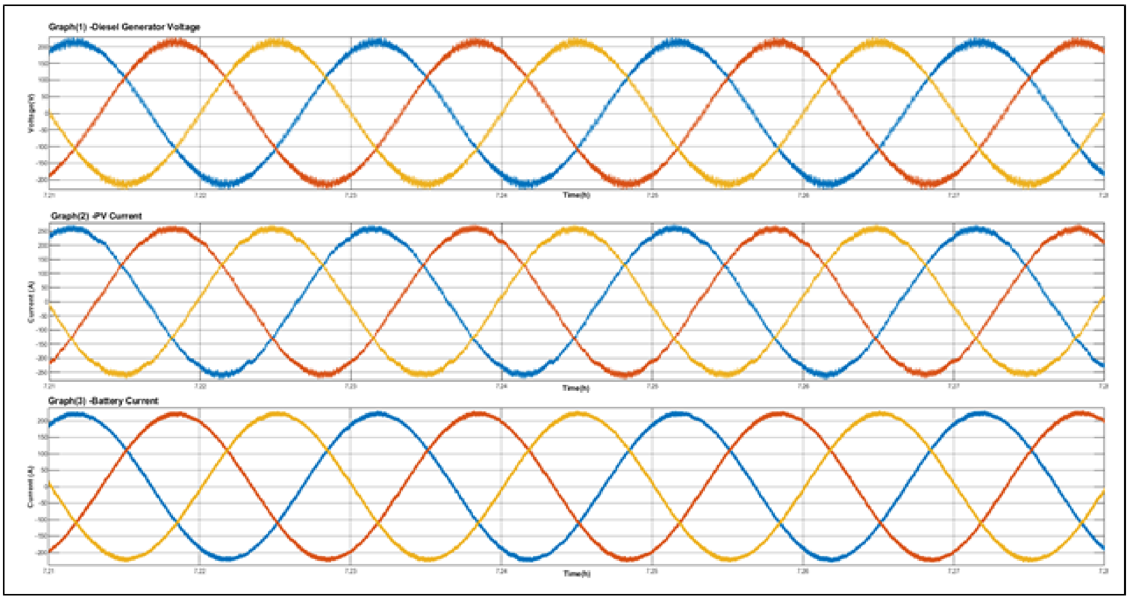


Figure 10. PV And Battery Current Synchronization With DG Voltage.

5.The Two Modes Comparison:

Table 5. Grid-Connected and Grid-Islanded Mode comparison.

Comparison factors	Islanded (GIM)	Connected (GCM)
Storage system refill time	During the daylight, the DG will consistently provide the load with 30% to 40% (MLF) of its rated capacity. Thus, the PVs may supply more electricity to charge the battery even quicker.	During the daytime, the battery charge power depends on the PV's surplus power, which implies that the load power consumption will decide the battery charging power.
Grid teid PV system exploitation	In (GIM), only 100% of the PV electricity may be used to charge the battery. If the PV system provides more electricity than the battery can store, the PV output must be curtailed to meet local demand. This limitation ensures optimal battery charging and energy usage within the islanded microgrid. Equation: Lp >= 30% Pdg + Ppv (relates to power condition between PV and DG).	In (GCM), all of the PV electricity may be completely used at any time. The extra energy produced by the PV system may either be stored in the battery or sold back to the main grid facility. This bidirectional flow enables efficient utilization and possible income from surplus electricity.
Net mettering	In GIM, the microgrid functions autonomously and is separated from the main grid. Consequently, any additional power produced by the GIM can only be utilized to charge its battery storage. If the microgrid creates more energy than it can store, it must limit or lower its power production to meet local demand and minimize waste.	Conversely with a GCM, the microgrid system can draw power from the primary grid when required or inject surplus energy back to the grid facility when its battery system is fully charged. This enables the microgrid to sell excess electricity to the main grid and receive credits for the energy supplied.
Supplay contինity and Relaibility	In the context of GIM, our system's reliability exclusively depends on the reliability of our Distributed Energy Resources (DERs), allowing us greater oversight and control over our system's performance and dependability"in press" [17].	Within the GCM framework, the reliance on our system becomes inherently tied to the primary grid's reliability. This reliance provides substantial issues in monitoring and renders the system susceptible to unexpected power disruptions emanating from the grid facility. "in press" [17].
Recovery Time and Fault Isolation.	Higher resilience and speedier recovery. Operates autonomously, enabling speedier fault separation and autonomous system restoration, leading to speedy recovery following grid outages.	Longer recovery time following grid failure due to dependency on the main grid's reliability. Fault isolation and system restoration could need cooperation, resulting in delays.
Maintenanceand Operation Costs	DG electricity generation costs vary with variables, including fuel pricing	In (GCM), we pay for grid power consumption and earn credits by sending

	and maintenance. Running the DG at 30% to 40% capacity all day for synchronization raises expenses. Islanded microgrids demand considerable initial expenditures but contribute to long-term savings by lowering dependency on the main grid and associated expenses..	surplus solar energy to the grid via net metering. Initial costs are reduced owing to leveraging existing infrastructure, but long-term expenditures rely on utility pricing and eventual grid access fees.

Based on the simulation findings and the comparison in Table 5, both systems indicate the capacity to sustain a continuous power supply. Each system has its pros and weaknesses, as illustrated in the Six comparative variables from Table 5. For Grid-Islanded Microgrid (GIM), the most important benefits lay in quicker battery charging times and increased reliability management and oversight. These features make GIM a more efficient and viable solution for assuring supply continuity, avoiding unexpected disruptions from the main grid. Conversely, Grid-Connected Microgrid (GCM) excels in PV exploitation and bidirectional power flow. This reduces cost through net metering since surplus electricity may be sold back to the grid facility. In this research, the major element evaluated is the reliability and continuity of the power supply. Thus, GIM is the more desirable solution owing to its relatively simple monitoring and control management, resulting in a stable and continuous system operation. Sophisticated technology and resource optimization strategies may enhance the bidirectional power flow in GIM.

5. Conclusion

In conclusion, our research analyzed the efficacy of the Energy Management System (EMS) algorithm in managing the power supply for our institution's load profile (IGEE). We effectively handled peak demand through MATLAB Simulink simulations while providing a dependable power supply in grid-connected and islanded modes.

Both grid-connected and islanded modes maintained supply continuity, each with particular benefits and drawbacks depending on consumption factors. Choosing one system over the other depends on emphasizing supply continuity, notwithstanding cost and net metering limits.

The grid-tied inverter significantly supported smooth transitions between grid-connected and islanded operations, assuring continuous power supply to essential loads.

While our research recognized the potential for additional development and optimization in the islanded mode microgrid, future work will focus on boosting power exchange and optimization. Exploring excess power exchange across microgrids for overall grid stability remains a topic for a prospective study.

In summary, our investigation revealed the efficiency of the EMS algorithm in regulating power supply throughout different operating modes. The effective utilization of the grid-tied inverter in both grid-connected and islanded modes, together with increased power exchange and optimization during islanded operation, showed the stability and flexibility of our microgrid system. We have set a basis for a more sustainable and robust energy management strategy by emphasizing supply continuity and exploring novel solutions, such as net metering.

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