ISSN 2063-5346

ENERGY MANAGEMENT SYSTEM FOR MICROGRID

Chaudhari Trisha N.[1], Ashish Shah[2], Falguni Talajiya[3]

Article History: Received: 02.07.2023 Revised: 15.07.2023 Accepted: 23.07.2023

ABSTRACT:

Microgrid model with an energy management system is presented in this research. The microgrid is made up of a battery storage system and solar panels. Delivering a dependable and ideal generation from a variety of sources in the microgrid is the aim of the EMS. To manage the load's energy requirements, the proposed system effectively reschedules and organises the power flow between energy storage systems, grid power, and photovoltaics. During times of peak demand, the power grid has the ability to supply electricity to the load, as well as to take in extra power from the intended system when load requirements are low. As a result, a user has the choice to make money by selling the extra power in the system as intended. The system was thoroughly simulated, and the results show how effective the plan is at controlling the energy from different sources.

Catchphrases- Energy Management system, Battery control ,PV control, inverter, MPPT control, converters, inverter, transformer.

[1]Student, MTech (PS), Faculty of Electrical Engineering, PIET, Parul University

[2]Assistant Professor, Faculty of Electrical Engineering, PIET, Parul University

[3]Assistant Professor, Faculty of Electrical Engineering, PIET, Parul University

DOI:10.48047/ecb/2023.12.9.256

INTRODUCTION

The use of renewable energy sources to provide electricity in rural regions has increased. Microgrids made of intermittent renewable energy sources like solar Photovoltaic (PV) provide difficulties for a dependable electricity supply. The installation of microgrid systems has been prompted by the rise in energy consumption in outlying locations. To supply energy in these locations, renewable energy sources including solar power, micro-hydro, wind, and biomass have been selected. A microgrid is often a low-voltage network made up of distributed energy resources (DERs), battery storage, and standby diesel generators [1]. RERs, or renewable energy resources, are gaining popularity as a result of their abundance and environmental friendliness. Photovoltaic (PV) energy is now one of the renewable energy sources with the fastest-growing market share due to substantial advancements in solar cell design, large-scale production techniques, and system component technology. Due to significant improvements in solar cell design, large-scale production methods, and system component technology, photovoltaic (PV) energy is currently among the renewable energy sources with the fastest-rising market share.[2]

The incorporation of renewable energy sources into microgrids has increased recently. The microgrid incorporates many energy sources to provide a dependable electricity supply. As a result of the requirement for scheduling, management, and appropriate sizing, the introduction of several generations into the microgrid also presents additional difficulties, such as inefficient power delivery. Therefore, EMS is essential for a microgrid because it provides dependable, sustainable, and cost-effective operation while covering both supply and demand side control. Additionally, EMS offer other advantages including greenhouse gas reduction, frequency management, reactive power support, cost-reduction, and energy savings [3].

Microgrids (MGs) are now the subject of a lot of discussion and are seen as the future of power distribution systems [4]. Due to the erratic output of renewable energy sources (RESs), it is crucial to maintain the power balance in a microgrid for stability[5]. A microgrid is a type of power system that includes loads, distributed generation, energy storage, and a variety of control systems that may be used independently or in conjunction with the larger grid[6]. An energy management system (EMS) is a system that was developed using renewable energy sources to reduce overall energy consumption. The imbalance between energy supply and demand makes RES reliability a critical duty. To improve the system's dependability and stability, an energy management system or battery storage system is devised and implemented.

A load, a network, a battery, and a solar panel were all utilised in this project. In smart grids that integrate energy producing systems with energy consumption systems and storage devices, the Microgrid Energy Management (MM) in particular is frequently handled as an optimisation issue [4] The goal of this framework is generally to balance the flow of energy between the supply and demand sides while reducing the cost of energy for utilities and/or end customers [5]. At MM, the significance of adopting energy storage stems primarily from the ability to store the energy generated by RES so that, where possible, it can be used to replace demand during peak loads without burdening the distribution system.

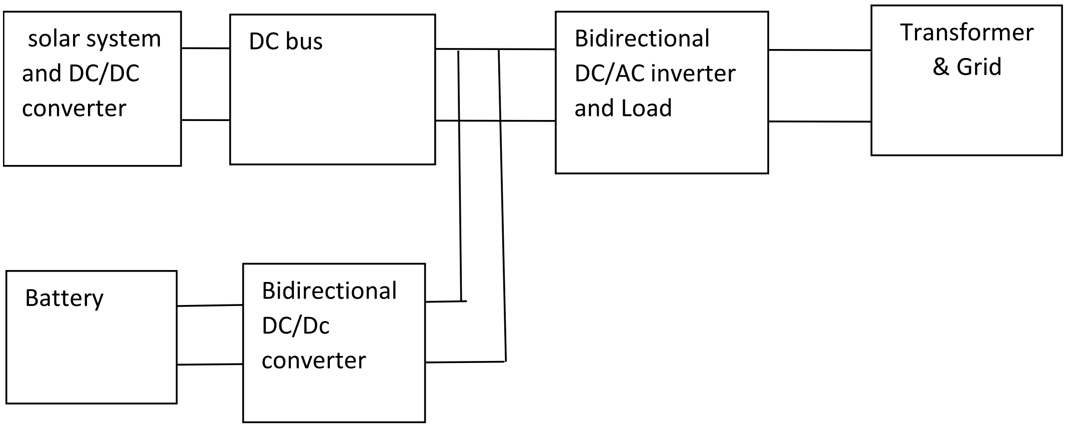


Figure 1. Block diagram of the system

1. SIMULATION COMPONENTS OF PROPOSED SYSTEM

This approach demonstrates how the current EMS concept may be combined with renewable energy sources and battery storage systems. The block diagram of the system is given in Figure 1.

This section arranged as per the following subsection: a section 2.1 solar side system, a section 2.2 grid side system, a section 2.3 battery side system and a section 2.4 Management block.

2.1 solar PV side system

In this side system contain PV, unidirectional DC/DC converter and HVDC bus. The photovoltaic system is directly connected to the EMS. The system is rated 5 KW and is defined by a current voltage look-up table. In this system, PV and the storage device models are developed in order to make the EMS to operate in integration with renewable energy resources. To track the maximum power from the solar panel MPPT technique has been applied which manages the operating point of the array in such a way that it always obtains the maximum power in the different varying conditions. here the subsystem of solar PV array shown in Figure2.

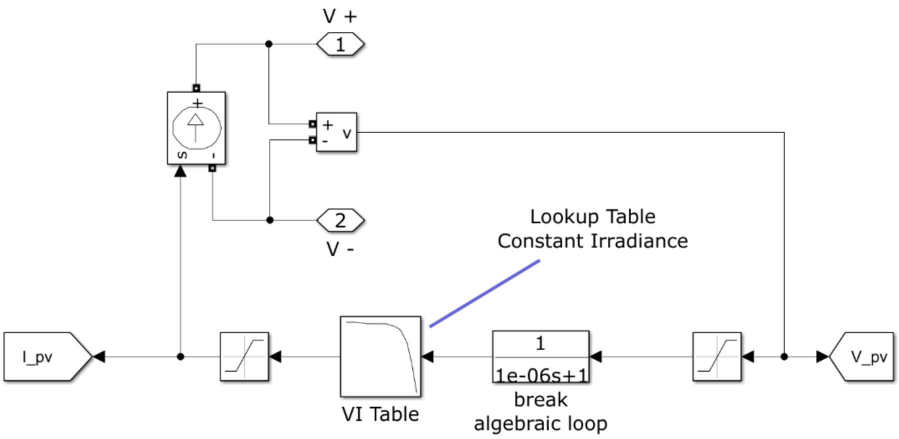


Figure 2. solar PV system

The maximum power point tracking (MPPT) control takes maximum power from the solar panel using a unidirectional DC/DC converter To track to maximum power point, as calculated by the MPPT control, a cascade control mechanism drives a unidirectional DC/DC converter. The cascade control mechanism is a series of voltage, current and PWM generator.

2.2 Grid side system

The power grid is connected to the load from a pole mounted distribution transformer. It can absorb star plus power from the EMS or demanded supply power to the EMS. The connection between the grid and the EMS is controlled by a bidirectional DC/AC inverter.

Total loads of 3 KW each are used in the proposed system, and it was found that when both loads were turned on, the solar panel was not sufficient to provide power, since the total capacity of solar photovoltaic is 5 KW.

2.3 battery side system

The power grid is connected to the load from a pole mounted distribution transformer. It can absorb star plus power from the EMS or demanded supply power to the EMS. The connection between the grid and the EMS is controlled by a bidirectional DC/AC inverter.

Total loads of 3 KW each are used in the proposed system, and it was found that when both loads were turned on, the solar panel was not sufficient to Since solar photovoltaic panels have a 5 KW overall capacity, they must supply power.

Table 1 : Battery specification

S.no	Battery Parameter	Values
1.	Nominal Voltage	24 V
2.	Ampere-hour	40 Ah
3.	State of Charge (SOC)	80%
4.	Fully charged voltage	232.7 V

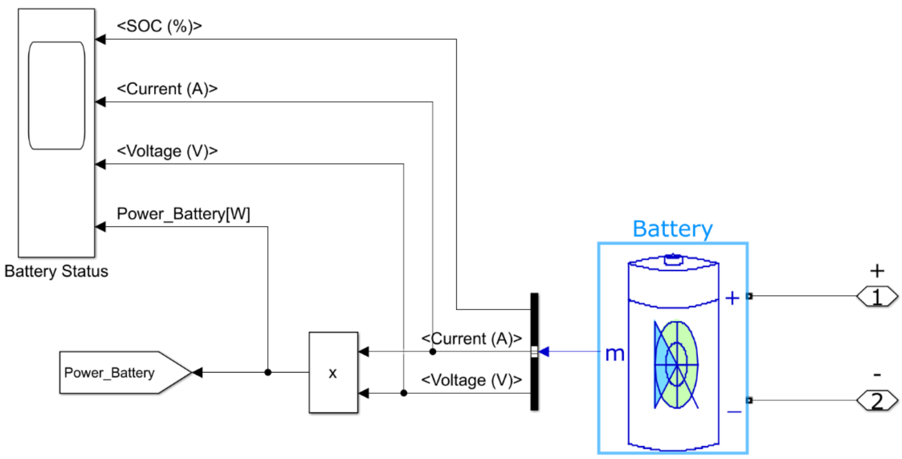


Figure 3. Battery system

2.4 Management system

The Management system block contain MPPT controller, PV controller, Inverter controller and Battery controller and PWM controller. MPPT Algorithm place in MPPT controller to track the maximum power.

2. SIMULATION MODEL AND SIMULATION RESULTS

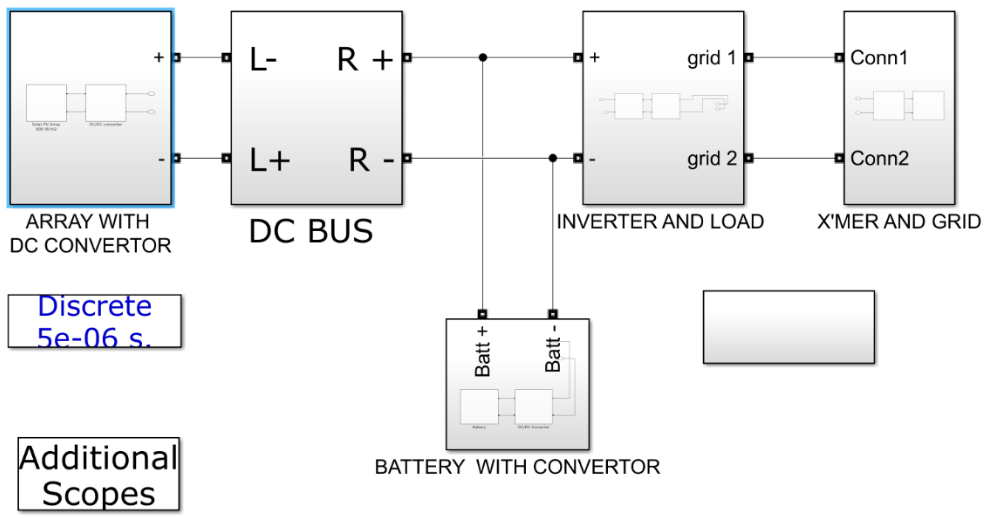


Figure 4. Simulation of the proposed system

First, the battery was not connected to the system, the loads were also disconnected, so all solar energy was transferred to the grid. The power generated by the panel was almost constant at 5 kW and was achieved by the MPPT control algorithm.

Case 1. One of the two 3kW loads was switched on and observed to consume more than half of the energy produced by the solar panel, so the excess energy was fed back to the grid.

Case 2. Both loads are on and the total power demand is up to 6kW, so the solar panel was not enough so the power demand was covered by the grid.

Case 3.Now the loads are disconnected again and the battery is connected so that the total output as a combination of solar and storage is sufficient to meet the load demand when both loads are reconnected to the system the way they were connected.

Figure 4 shows the simulation of the proposed system with renewable sources integrated with the power grid.

Figure 5 shows that initially only one of the two loads was switched at t = 0.5 when at t = 1 s; both loads were on, so the grid must provide additional power to meet the load demand. It is also clear that from t=2s to t=4s the battery was supplying energy, so the power supplied by the grid was zero.

Figure 6 shows the power shares of the grid, the solar energy, which remains almost constant over the period, and the load requirement.

The figure above shows that the power delivered by the different renewable energy sources as well as the power consumed by the load configuration provides better clarity of the proposed system and how it is able to cope with the changing load demands appropriate switching between the RER to be managed and the canvas network.

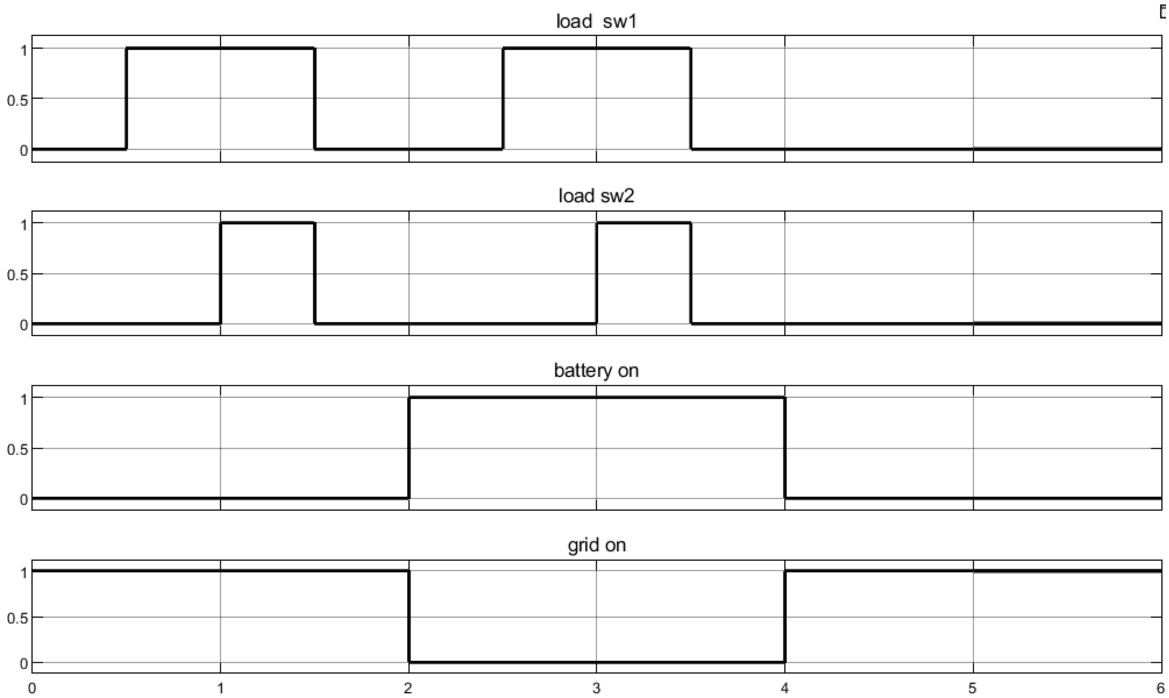


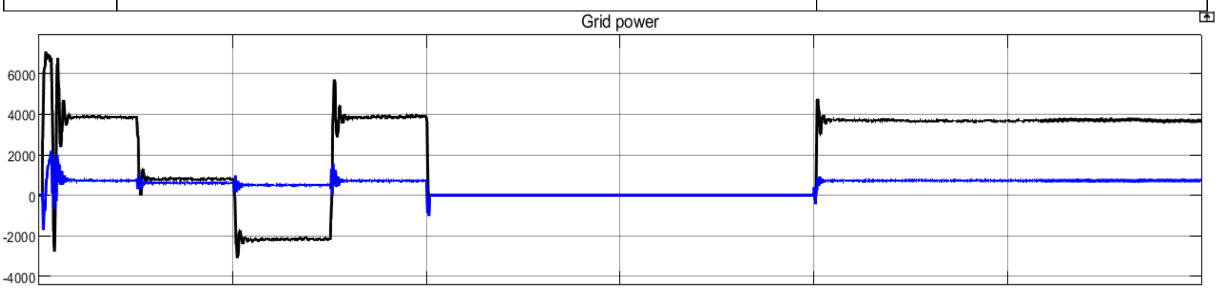
Figure 5. Switching Characteristics of Loads, battery, and power grid.

Continuing the power flow diagram , Figure 6(a) shows the energy consumed by the grid and the energy delivered under varying load conditions and power availability conditions. Figure 6(b) shows the fluctuation of battery power and solar energy required to supply the load in the event of excessive load demand.

Similarly, Figure 6(c) illustrates a shift load chart that clearly shows the maximum and minimum load demand over a period of time. Various system parameters and their values are given in Table 2.

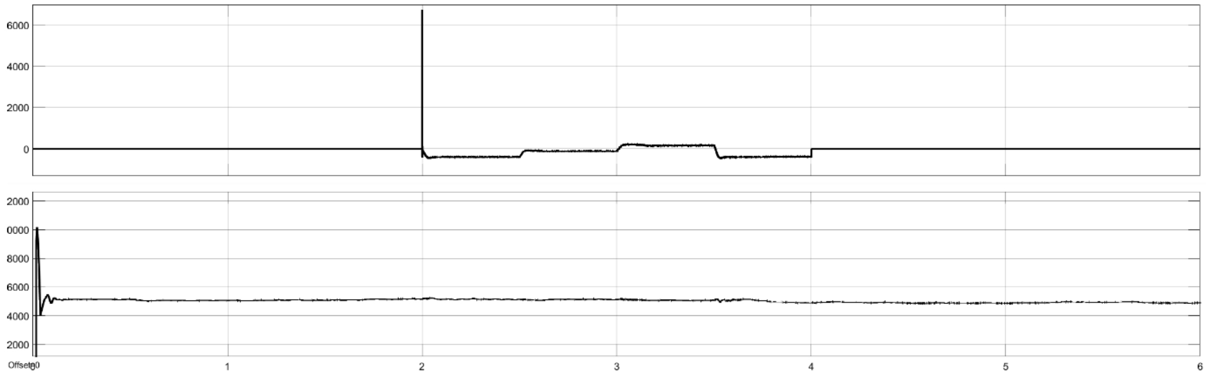
Table 2. System Parameters

S. No	Parameters	Values
1.	Solar panel	5 KW
2.	System Loads (load 1 and load 2)	6 KW
3.	Power Grid (phase to phase Voltage)	66 KW
4.	Switching Frequency	10 kHz
5.	Reference Voltage (Vdc)	370 V



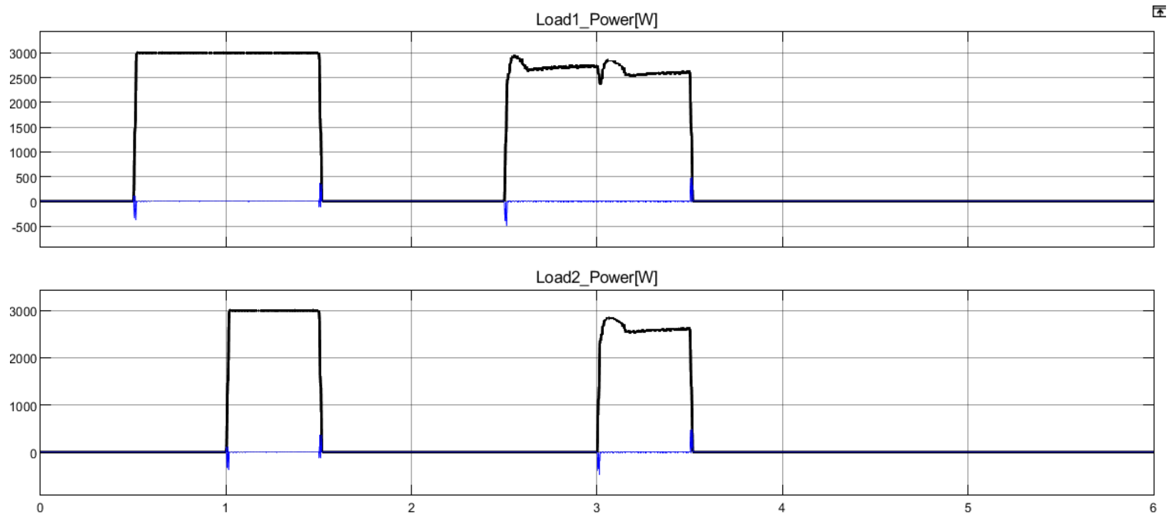
Time (sec)

(a) Grid power



Time (sec)

(b) Battery power and solar Power



Time (sec)

(c) load power

Figure 6. Power flow Diagram

3. CONCLUSION

The article introduces the idea of base and peak load management by integrating power supply with renewable energy sources. It consists of various energy generating sources, namely solar panels and batteries, as well as various energy consuming devices known as loads. Here you can switch between different power sources for power management and display the results in MATLAB. From the above results it is clear that the dependency on the grid is minimized and the consumer can now also export excess electricity to the grid, ultimately increasing the overall revenue. The simulation shows how EM with integrated renewable energy is useful for dwelling load management and further investigations can be carried out to enable EM to handle different dwelling loads in terms of time price per use.

5. DATA AVAILABILITY

Data taken from the "Intelligent Energy Management System for a Smart Home Integrated with Renewable Energy Resources".

6. FUTURE EXPANSION

This project work is covering only simulation based on management system for Microgrid. This project could be extended by using Artificial technique.

7. REFERENCE

[1] Energy management system for PV-Battery microgrid based on model predictive control, Indonesian Journal of Electrical Engineering and Computer Science Vol. 15, No. 1, July 2019

[2] battery energy storage for variable speed photovoltaic water pumping system, arpn journal of engineering and applied sciences, vol. 13, no. 23, december 2018

[3] G. Razeghi, F. Gu, R. Neal, and S. Samuelsen, "A generic microgrid controller: Concept, testing, and insights," Appl. Energy, vol. 229, pp. 660–671, 2018.

[4] Arjun Baliyan , Isaka J, Mwakitalima, Majid Jamil and M. Rizwan "Intelligent Energy Management System for a Smart Home Integrated with Renewable Energy Resources" International Journal of Photoenergy,2022

[5] Almada J., Leão, R., Sampaio R. and Barroso G. "A centralized and heuristic approach for energy management of an AC microgrid, Renewable and Sustainable Energy Reviews", volume (60), 2016

[6] Alvarez G., Moradi H., Smith, M., and Zilouchian, A. " Modeling a Grid-Connected PV/Battery Microgrid System with MPPT Controller", 2017 IEEE 44th Photovoltaic Specialist Conference (PVSC), 2017

[7] Anaswara Santhosh, Yashraj singh, "Simulation of microgrid and study of its operation", International journal of engineering research and technology(IJERT) , vol. 11, issue 01, Jan 2022.

[8] M. F. Zia, E. Elbouchikhi, and M. Benbouzid, ''Microgrids energy management systems: A critical review on methods, solutions, and prospects,'' Appl. Energy, vol. 222, Jul. 2018.

[9] H. Shayeghi, E. Shahryari, M. Moradzadeh, and P. Siano, ''A survey on microgrid energy management considering flexible energy sources,'' Energies, vol. 12, no. 11, Jun. 2019.

[10] Peilin Xie, Josep M. Guerrero, Sen Tan, Najmeh Bazmohammadi, Juan C. Vasquez, Mojtaba Mehrzadi, and Yusuf Al-Turki, "Optimization-Based Power and Energy Management System in Shipboard Microgrid: A Review" , IEEE system journal, vol. 16, no. 1, march 2022.

[11] Sanjeev Pannala , Niloy Patari, Anurag K. Srivastava and Narayana Prasad Padhy, "Effective Control and Management Scheme for Isolated and Grid Connected DC Microgrid" , IEEE transection on industry applications, vol. 56, no. 6, November/December 2020.

[12] L. Xu, R. Cheng, and J. Yang, "A new MPPT technique for fast and efficient tracking under fast varying solar irradiation and load resistance," International Journal of Photoenergy, vol. 2020, Article ID 6535372, 2020.

[13] O. Tremblay and L.-A. Dessaint, "Experimental validation of a battery dynamic model for EV applications," World Electric Vehicle Journal, vol. 3, 2009.

[14] Y. Guo, M. Pan, and Y. Fang, "Optimal power management of residential customers in the smart grid," IEEE Transactions on Parallel and Distributed Systems, vol. 23, no. 9 2012.

[15] M. Lissere, T. Sauter, and J. Y. Hung, "Future energy systems: integrating renewable energy sources into the smart power industrial electronics,"

IEEE Industrial Electronics Magazine, vol. 4, no. 1, 2010.

[16] M. Pipattanasomporn, M. Kuzlu, and S. Rahman, "An algorithm for intelligent home energy management and demand response analysis," IEEE Transactions on Smart Grid, vol. 3, no. 4, 2012.