Home Energy Management System With Hybrid Electric Sources

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Abstract - The preference for renewable energy sources is growing as a result of the depletion of fossil fuels and the harm they cause to the environment. Photovoltaic (PV) system is one of the renewable energy sources, and their use is becoming widespread day by day. However, since PV sources are intermittent energy sources, PV systems must be operated with energy storage systems in many areas. In this paper we proposed a Home Energy Management System with Hybrid Electric Sources, considering PV array, Battery, and Power Grid. Additionally, for the system to be operated with high efficiency, it must be operated at the maximum power point (MPP). For this purpose, battery charge control, which can follow the maximum power point, was carried out with the Perturb & Observe (P&O) widely used in the literature. The system is designed and simulated on MATLAB Simulink software and successfully obtained the results.

Keywords: HEMS, PV array, Hybrid electric source, Power Grid

I. INTRODUCTION :

The challenge of reducing energy consumption is one of the most challenging tasks of the 21st century. The challenge of electrical system security is an additional obstacle to electrical power management such as the insecurity caused by the forecast of future electricity demand. Furthermore, limitations in the development of large power plants, the increasing proportion of renewable energy, and the increasing consumption of electricity by both producers and consumers create challenges in the industry. In the traditional electrical system, the electricity created cannot be stored for later use. Each location and time of electricity demand must have the same level of production during the same period. So, the technology of energy storage has transformed the operation of electricity completely. This is because the amount of electricity produced no longer has to match the amount of electricity required at every instant. In turn, this reduced the cost of electrical systems by increasing flexibility; for instance, storing electrical energy that was produced at a lower cost for later use at a higher cost, or storing excessive electricity from renewable energy produced during off-peak demand to be used at peak demand.

II. PROPOSED METHODOLOGY:

In the project, Home Energy Management System for Hybrid Electric Sources we are proposing a methodology in which the blocks are connected as shown in fig. The solar panel, DC-DC Converter, DC-Bus, AC-DC Inverter (bidirectional), and Power Grid are the main components used. So as given in home electricity is supplied from both sources i.e. solar and power grid. Solar energy is generated within the house using dc conversion and then transmitted into the bus for distribution afterward it is converted into ac supply via an ac-dc converter and then supplied to the home. This ac-dc inverter is bidirectional so if the amount of electricity generated by the solar panel is greater than the requirement in the home it will be passed to the bidirectional dc-dc converter and then stored in the battery which can be used in a power cut-off situation and if the power required by the home is not sufficiently generated by the solar panel we can take electricity from power grid through pole mounted transformer. In case of raw weather or cloud cover conditions, the solar system won't be working efficiently which can cause power cuts from grid so what we have as a backup electric source is the battery. Therefore, having multiple electricity sources help us in getting electric supply continuously 24/7 seamlessly.

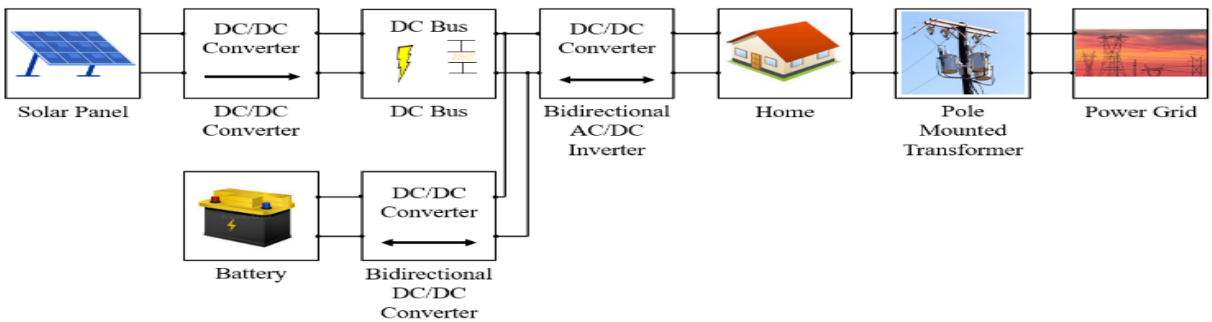


Fig.1 HEMS Block Diagram

III. COMPONENTS DESCRIPTION

PV ARRAY

A photovoltaic (PV) system is a power system designed to supply usable solar powerusing photovoltaics. It consists of instrumentation of several components like solar panels, coverter, and inverters. Solar panels absorb and convert daylight into electricity. Solar panel contains several solar cells. Solar cells produce electricity directly from sunlight through an electronics process that occurs naturally in semiconductor materials. Solar panels will be installed on the rooftop. However, it should be ensured that the power produced by PV cells will meet the residential demand of electricity. By the way for additional backup distribution transformer fed with the grid will connect with the house. The PV array block is available in MATLAB Simulink. It is fed with two inputs that are temperature and irradiance.

Temperature – Temperature of the surface of the PV array.
Irradiance – Power per unit area received from the sun.
Daily electrical power output can be written as :

$$E_{pv} = \sum_{h=1}^{44} E_{pv.h}$$

Parameters	Value
Temperature (°C)	25
Irradiance (W/m2)	1000
No. of Series Connected Modules	3
Cells per Module	60
Open Circuit Voltage (V)	36.3
Short Circuit Current (A)	7.84

Table No. 1 PV Array Parameters

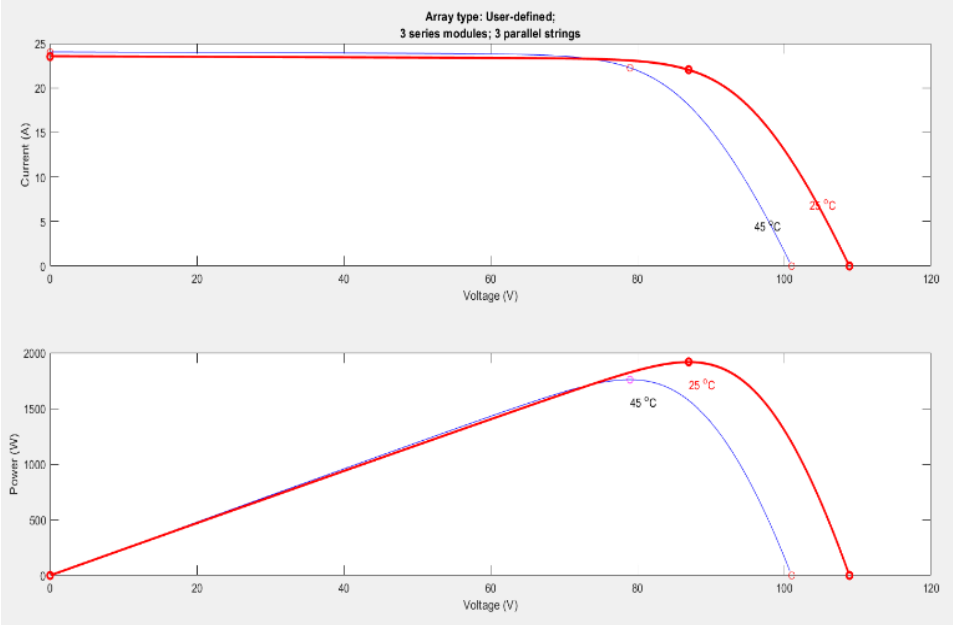


Fig.2 PV Voltage vs. Power Curve

BATTERY

An advanced battery technology known as a lithium-ion (Li-ion) battery makes use of lithium ions as an important part of its electrochemistry. Lithium ions are moved between the anode and the cathode of lithium-ion batteries by use of an electrolyte that is both electrically insulating and ion-conductive. Lithium atoms in the anode are ionized and separated from their electrons during a discharge cycle. For applications that specifically call for high power and energy density, the lithium-ion (Li-ion) battery emerges as the most attractive battery candidate. Particularly in the field of cutting-edge portable devices, Li-ion batteries have displaced older battery types based on various chemistries, such as Ni-Cd and NiMH cells. Li-ion batteries have recently demonstrated considerable promise as a flexible power source because of significant advancements in flexible electronics.

Li-ion batteries' electrodes can be made of a variety of materials. The cathode and anode materials that are most frequently used in portable electronic devices, including laptops and cell phones, are lithium cobalt oxide (cathode) and graphite. Lithium iron phosphate and lithium manganese oxide, which are used in hybrid and electric vehicles, respectively, are other cathode components. Various materials can be used as electrodes in Li-ion batteries. The cathode and anode materials that are most frequently used in portable electronic devices, including laptops and cell phones, are lithium cobalt oxide (cathode) and graphite. Lithium iron phosphate and lithium manganese oxide, which are used in hybrid and electric vehicles, respectively, are other cathode components.

Parameter	Value
Type	Lithium-ion
Nominal Voltage (V)	48 V
Rated Capacity (Ah)	200 Ah
Initial state of charge	80 %

Table No. 2 : Battery Parameters

MPPT CONTROLLER

The output power of a PV module is nonlinear and mostly dependent on the temperature and irradiance (amount of solar radiation). Moreover, a PV panel's output power depends on its terminal voltage for the same temperature and irradiance. For each specific scenario, there is only one value for the terminal voltage that corresponds to the maximum output power. Maximum power point tracking is the process of looking for this voltage (MPPT). The MPPT makes the panel output voltage so that, when multiplied by the current, it produces the highest feasible power for each set of operating conditions when applied to the switching control in the DC-DC converter.

"*Perturb and Observe Technique*": This approach is frequently utilized. Due to the straightforward feedback structure and a limited number of control perimeters, it is widely used. The basic concept is to first increase or decrease the voltage for testing purposes, and if this results in a rise in power, make a subsequent perturbation in that direction, or vice versa. This approach is easy to handle and manipulate. However, because of the delay caused by this kind of perimeter monitoring, it is challenging to locate a real-time maximum power point.

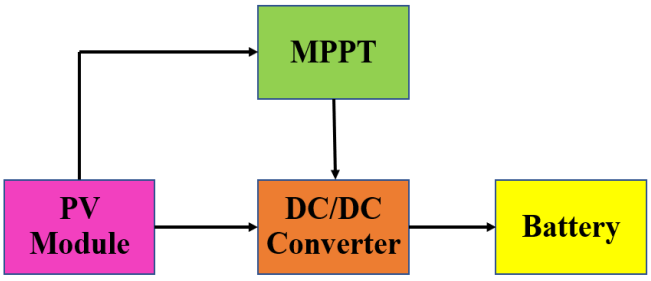


Fig.3 : MPPT Controller Block Diagram

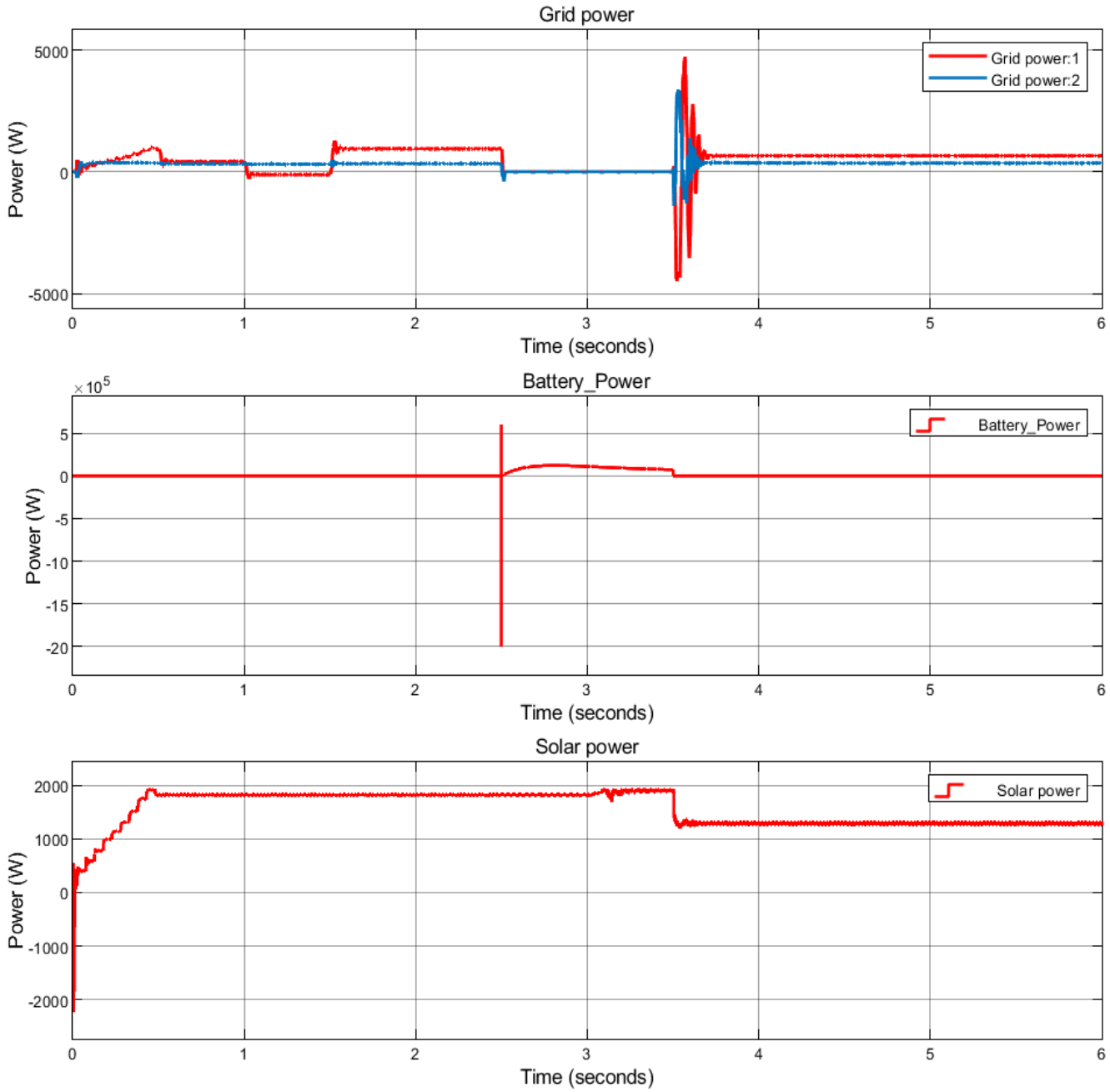
HOME LOAD

In our simulation model, we have taken two RLC load blocks, each of 1000 W, connected in parallel. The power grid is also connected with the load. If a solar array generates more power than needed then it will be given to the grid.

IV. SIMULATION MODEL:

The design of a home energy management system using hybrid electric sources is shown in Figure. The model was created using the MATLAB/Simulink software.The boost converter is based on IGBT, and it is used to connect the PV array to it. The IGBT of the DC/DC converter will receive a gate pulse from the MPPT controller.The lithium-ion battery and bidirectional dc-

dc converter are connected in parallel to the dc bus to charge the battery and send power from the PV array to the load at the same time. DC power from the PV array will flow through the dc bus. The battery and solar power supplies are connected to the dc to ac inverter, which will convert the dc power to ac and supply the home load. Four IGBTs in a dc to ac inverter will be activated by a gate pulse produced by the inverter controller.The bidirectional dc/dc converter's gate pulse will be generated by the battery controller.Also, the power grid is connected with the home load through a single-phase pole-mounted step-down transformer. It acts as an auxiliary source. When there is a requirement of power from home load in the absence of PV array and battery gird will supply the load. When the Power generated by the PV array is more than the load demand then excessive power will be sent to the power grid.



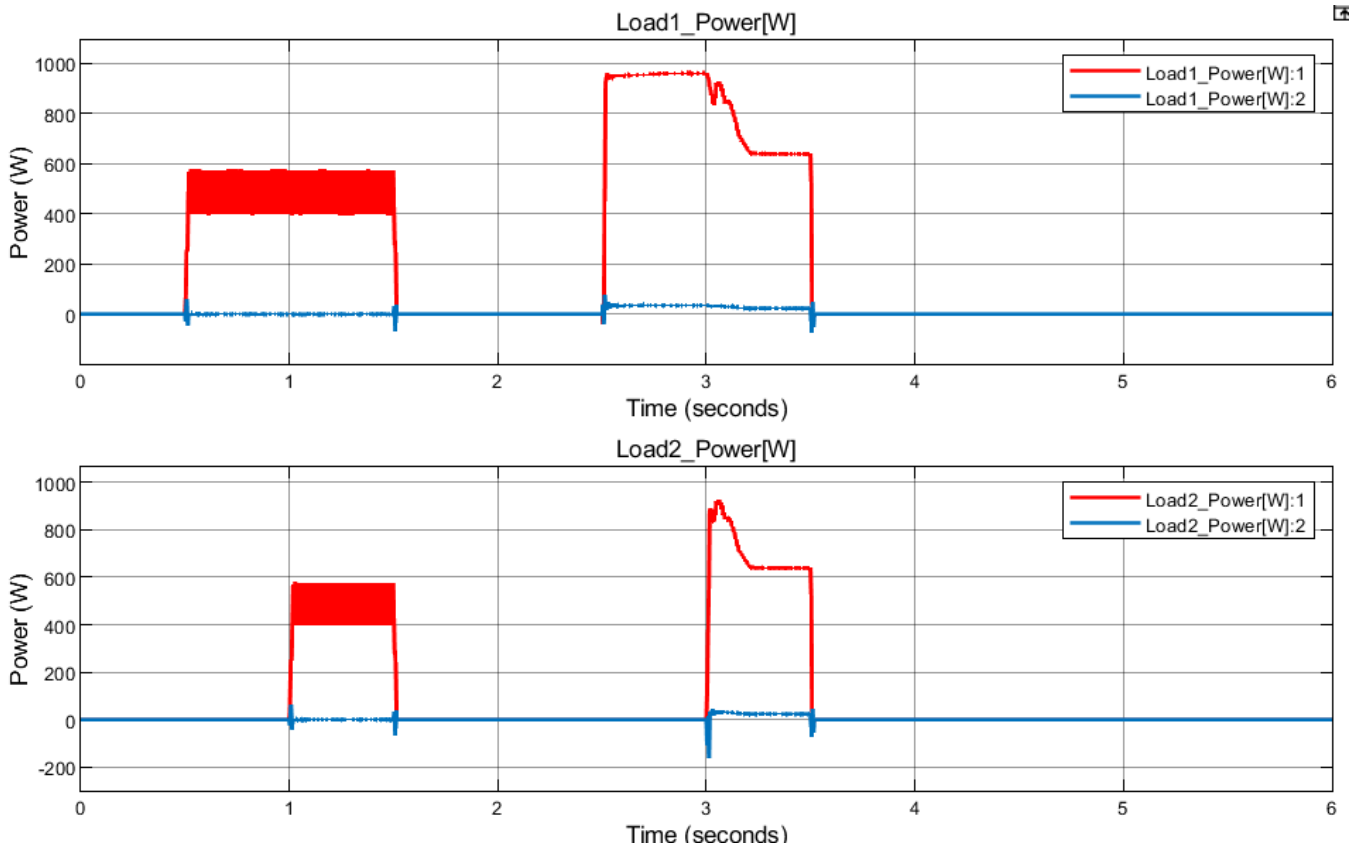


Fig.4 : Simulation Results

V. CONCLUSION:

Renewable energy sources are used in residential buildings and homes to reduce the cost of electricity. InHome Energy Management Systems, consideration of energy consumption is more crucial. In this paper, an energy management system combining PV array, battery, and grid power was proposed for home loads, and voltage optimization with the help of MPPT was introduced to further improve the power efficiency. The proposed method is expected to improve HEMS and reduce electricity costs by considering power supply and consumption. The real-time performance and effectiveness of the proposed Energy Management System were validated by simulation. The simulation results show that PV array continuously supply to Home loads. When battery will provide supply the grid will remain off. In case of unavailability of both PV array and battery, power grid connected to the load will fulfill load demand. Also when power generated by PV array is more than load demand then it can be directly fed to the grid.

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