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An Efficient Energy Management System for Customers Using Renewable Energy Sources

Snehal D. Solunke[1], Vishwashri A. Kulkarni[2]
[1,2] Department of Electronics and Telecommunication,MGM's JNEC
Aurangabad,Maharashtra, India.

Abstract: *Life as we know it would be impossible without electricity. But as our supply of fossil fuels, energy source for electricity, continues to dwindle, we face a majorchallenge. Renewable energy that we get from the environment is a commendable option for providing green energy to homes. A high efficiency power management system for solar energy harvesting applications is proposed. Admiring efforts have been made recently in transforming the power grid into smart grid by means of unifying extensive information and communication infrastructures. In this paper a versatile stochastic optimization approach has been proposed for smart grid, to meet the need of the residential customers in an efficient energy management comprising high penetration of renewable and distributed energy sources, market based online electricity pricing, large scale storage of energy and high quality demand side management, mitigating monetary expense.The concept Boost converter used in this paper increases the throughput of solar panel voltage. Smart energy meter, an added advantage of the proposed system provides a two way communication between the utility board and residential unit.*

Keywords: Power grid, smart grid, smart energy meter, solar energy, boost converter, solar panel.

I. INTRODUCTION

An increasing Global warming, currently occurring on this 4.6 billion years old earth, is a very critical issue to be addressed by the modern society that has been enjoying economical growth by consumption of fossil energies Since the Industrial Revolution in Great Britain, much carbon dioxide (CO2) has been emitted as a result of the combustion of petroleum and coal. In the past 200 years, the carbon dioxide concentration in the atmosphere has increased by as much as 25%. Now the entire earth is, so to speak, situ three of the most prominent issues facing the world today are escalating climate change, energy security and meeting the increasing global demand for electrical energy generated from renewable sources.Renewable sources are also called Echo friendly technologies are very important due to their pollution free energy generation and having sustainable growth. The electrical power grid is by nature is a complex adaptive system and it regards with significant amount of uncertainties [1]. The existing grid faces some sensitive problems which are major factors of concern. They can be specifically mentioned as follows:

1) Limited delivery system.
2) High cost of power outage and power quality interruption.
3) In efficiency at managing peak load. 4) Increase in global warming and hazardous emissions.

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This adverse impact of global warming and greenhouse effects is indeed a curse to the entire existence of life on earth. So for the sake of saving our earth it is very important to switch towards renewable energy sources. Since smart grid encapsulates this peculiar features of utilizing this renewable energy sources, smart grid integrate large amount of renewable generation in specific solar to meet our overwhelming electricity energy demands [2]. Smart grid introduces another worth mentioning feature say smart meter. Smart meter is a device that is connected to power distribution system which embeds a scheduling unit that helps in implementing shifting of workload [7], [9]. It also helps in receiving periodically the updated pricing information from various utility companies and the scheduling unit incorporated within it arranges the various household appliances for operation during different time intervals

II. PV TECHNOLOGY

Photovoltaic (PV) systems involve the direct conversion of sunlight into electricity with no intervening heat engine [7]. PV devices are solid state; therefore, they are rugged and simple in design and require very little maintenance. PV systems produce no emissions, are reliable, and require minimal maintenance to operate. They can produce electricity from microwatts to few megawatts. (Figure 1)

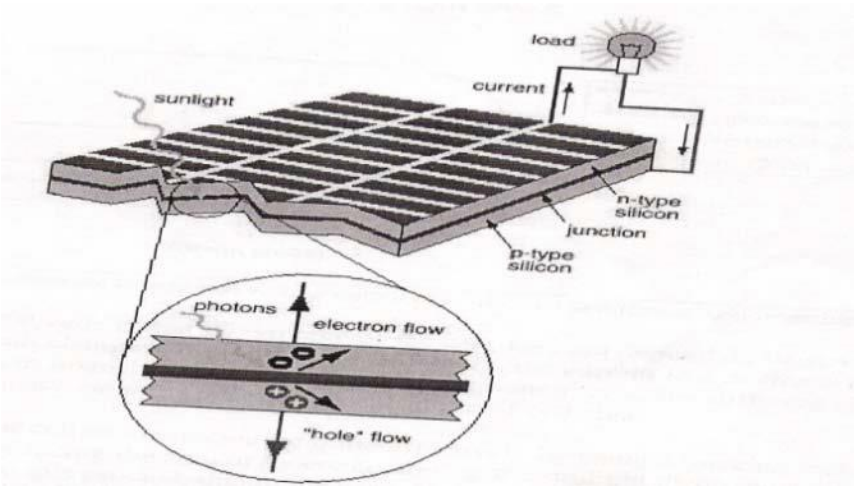

Figure 1.Electricity generation by solar (PV) Module

III. SYSTEM ARCHITECTURE

Owing to uncertainties under the real time pricing environment this paper mainly focuses in minimizing the electricity expenses of customers through optimally scheduling the operation and energy consumption for each and every appliance. Figure 2 depicts the architecture of energy management system used in residence. The following subsections are included in this model.

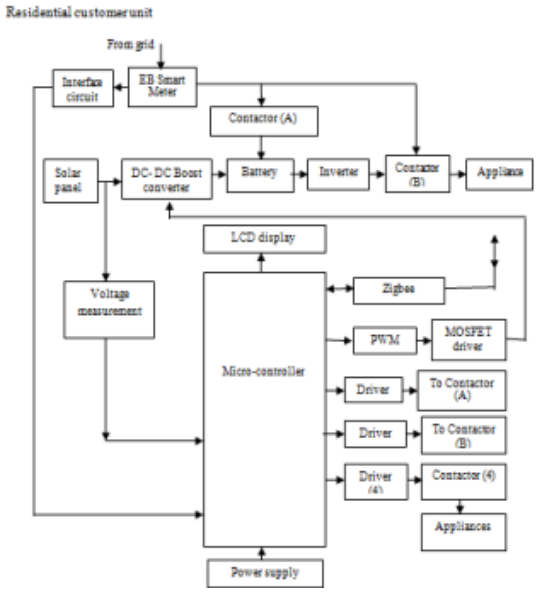

Figure 2. System Architecture.

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A. Utility control unit

The utility control unit performs the usage patterns and the other analytics associated with it. In this system, there persist a mutual usage data communication between the smart meter and the control unit. A cluster of meters is together assigned with a single control unit which helps in optimal utilization of the same.

B. Residential customer unit

The residential unit includes the below mentioned household appliances: air conditioner, washers, coolers, etc. The complete functionality of this residential unit is achieved by the inclusion of the following modules as shown in Fig.3.

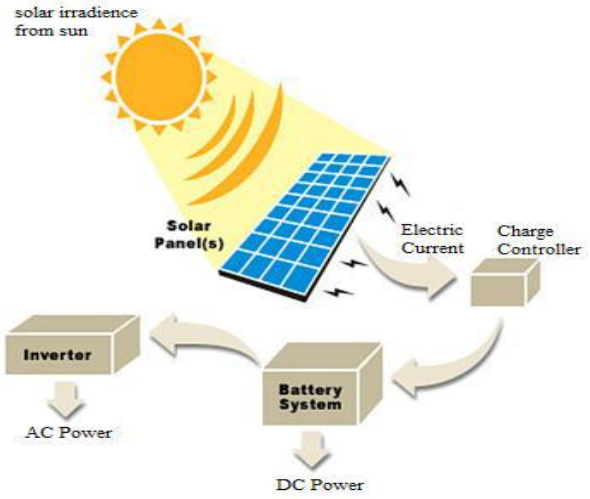

Figure 3.Electricity generation for residential unit using solar panel

1) Renewable energy generation: The resources are fast depleting with proportionate increase in energy demand, which ultimately results in providing a significant importance in the generation of renewable energy. Renewable energy source that is adopted in this paper is photovoltaic cells which promise a clean and cost effective factor that simultaneously turns out to be an opaque medium against harmful reactions to our ecosystem. PV cell uses the technique photoelectric effect which helps in converting the sunlight of certain wavelengths into direct current.

Generally a single PV cell cannot suffice the residential customer needs, so it is mandatory to connect them in series and parallel for the purpose of achieving the targeted voltage and current levels. As the PV cell generated voltage is intermittent by nature, the boost converters are included which aids in boosting the voltage, thus helps the PV cells in maintaining an ever sustainable voltage.

2) Boost converters: A boost converter or step up converter is basically a DC-to-DC power converter which functions with an aim of producing an output voltage greater than its input voltage. Power is a factor that must be conserved and hence as a result of these criteria, always output current is lower than the source current.

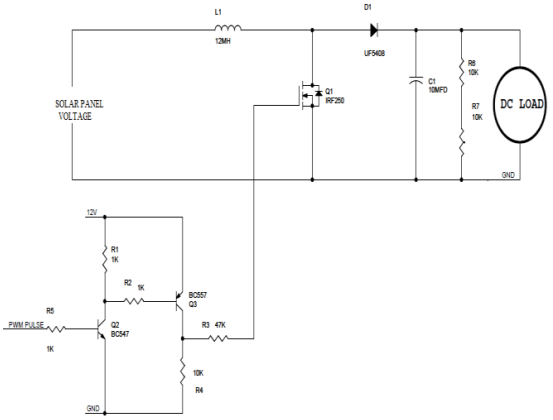

Figure 4. Boost Converter.

The role of maximum power point converter is felt by the presence of boost converters which is ultimately merged with the output load of solar panel. The voltage from the solar panel is given to the controller which in turn generates the relevant PWM waves that is further fed back to the boost converter's switch control input. The core functionality of boost converter is storing current in its boost inductor when the switch is closed or just delivering the currents from its inductor to the load when the switch opens and it is shown in Figure 4. The output of boost converter is fed to energy storage block.

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3) Energy storage: There most frequently exists an energy mismatch between the PV profile system and the residential energy demand. To synchronize this mismatch the concept of energy storage is introduced, which is used to store the excessively generated electricity at daytime, which forms as a supplement form of power usage that can be released at night time to meet the residential customer needs. This phenomenon paves way for appreciable amount of reduction in tapping of electricity from grid.
Overcharging and discharging will affect the operational life of a battery and hence it must be protected from these phenomena by incorporating a controller that helps in regulating the charging and discharging cycles [8].
4) Inverters: Generally battery produces the DC power, but the household appliances requires AC power for its operation, for that reason the inverter is used to convert this 12V DC into 230V AC household voltage. The voltages from these inverters are used by appliances through contactors.

IV. SMART METER

A smart meter is an energy meter that records utilization of electric energy in short intervals of time and sends the relevant details to the utility unit for scrutinizing and billing purpose, in predetermined time intervals. A two-way communication between meter and the central system is aided by smart meter. The Advanced Metering Infrastructure (AMI) is a technique incorporated by smart meter and this notable feature is absent in traditional AMR. This helps to reduce the monetary expense charged to customers in the real time pricing arena. The following worthy features are encapsulated in smart meter: eliminates the payment of bill in person at the EB office, provides consent for fetching details regarding updated pricing power utilization, accuracy of bill is verified, inclusion of multiple buildings to the wireless methodology does not alter the uniqueness of the network.

V. CONCLUSION

The concept introduced in this paper provides an efficient energy management for household appliances based on real time pricing released by utility companies in predetermined time intervals. The methodology proposed in this paper is to store the excessively generated renewable energy for future use and thereby to charge the battery at times of low electricity price and simultaneously discharging them during peak pricing time to minimize the monetary expense. It can be concluded that power scheduling approach using RTP combined with the IBR pricing model is a better way compared with the RTP alone pricing scheme. As a future vision of this paper super capacitors are used as energy storage that can charge faster than batteries, last longer and overcome physical toll that wears down the batteries in charging and discharging. This concept will help to the consumers for lower billing rate and also to save the energy that is produced from the natural resources.

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