A Solar Hybrid Grid System with Efficient Battery Management

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Abstract— Solar power is the major renewable energy source used by developing countries as stand-alone or grid enabled system. Since it is reliable it has been preferred at many households and will be a major power source in coming years. Despite its widespread use, solar has lagged in its efficiency to generate power at a desirable rate mainly because of non-efficiency of storage of charge. And hence many technologies are developed to make solar as efficient as possible. Batteries are used in storing charge, charge which ultimately produce electricity. The batteries which are available in market are not so cheap to buy one for storing charges regularly for longer durations. Batteries tend to become so expensive because of various factors including its battery management system and its approximated cycles of charging and discharging due to safety issues and hence tends to become obsolete after some amount of time. The proposed system integrates the smart solar hybrid grid system with efficient battery management.

Key words: Microcontroller Unit, Efficient Battery Management, Solar Hybrid Grid-Tied System

I. INTRODUCTION

Despite the hype given by various international organizations like Tesla, Forward Labs, Anu-solar and other superpowers in renewable energy, solar hasn't been a game changer in the world of non-renewable energy sources. The reason behind goes to its inefficient use hence not able to provide enough power to generate a high rate of output, high initial cost, no guarantee of good Return on Investment(ROI), etc. We have focused on the inefficient use of solar technology where batteries define a major role in reducing the lives of the system. For this, used up 18650 cells from laptop batteries will be taken and packed according to the amount of voltage and current required.

Since the introduction of Tesla Roof's Power-Wall, various DIY projects and indeed startups have emerged to study and analyze the Tesla's power-wall, replicating the power-wall or making their own modules to use 18650 battery cells reusable with safety features induced into them. So for DIY projects, used thrown away batteries were taken and reused, making sure that those cells are fit for use and safety features induced into them.

The major drawback of non-conventional solar energy source is the variations in the supply of solar energy during the 24 hours which causes many technologies go inefficient. The solar energy is not in sync with the peak demand of the energy. The energy is mostly produced at the daytime and its consumption increases at some other time of the day hence we require batteries (to store the charge) and inverters (to convert the DC coming from solar into AC, since we use appliances working on AC). If excess power (more than the requirements of the user) is produced from solar it is literally wasted, repeated overcharge or undercharge leads to degradation in battery life, and inverter has too many losses to use, since in conventional system all DC is converted to AC. [5]

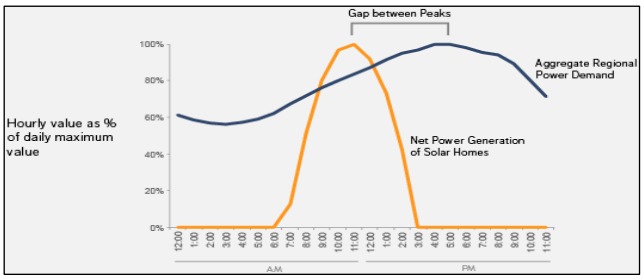

Fig. 1: Use of solar during a summer day

Hence we propose to make a Solar Hybrid Grid-Tied System. This system refers to the method where the power from solar if not sufficient, extra power is taken from the grid system and if extraneous power is produced after the charging of battery, this extraneous power is sold back to the grid via net metering. Where the battery as a pack of lithium-ion 18650 cells of used laptop batteries are managed smartly by avoiding undercharge and overcharge using microcontrollers and relay system to change the direction in which the current flows. These 18650 battery cells which are stacked into a combination of series and parallel along with battery management system to give required wattage according to the usage. MPPT charge controller will charge the battery from the DC supply coming from the solar panels with suitable current and voltage so that the battery is charged with maximum efficiency. Lithium-ion batteries are prone to overcharge defects hence external circuitry is necessary to avoid it. Charge controller or locally made battery management system can be used to maintain optimum value of current and voltage to charge the battery stack. In case of li-ion batteries state of charge (SoC) decides the efficiency of the battery: [4]

If 75-65% SoC →longest cycle life
If 100-25% SoC →long runtime, but reduced battery life
If 85-25% SoC →prolonged battery life

Batteries are declared dead in laptops because of the following reasons of the Battery Management System (BMS): [5]

1) After approximate cycles of charge and discharge the battery will automatically die out despite the working of its cells.
2) If the temperature of the battery rises above the expected level the battery will die out even if only one of the cells gets defective.
3) If any one of the cell dies out or gets damaged, whole system (battery pack) is taken down, hence the battery is marked as failure by the battery management system.
4) If BMS fails the whole battery is declared dead by the system.

If the battery level is above the upper threshold level the current coming to the battery is bypassed to the loads, if the battery is below the lower threshold level the battery is compulsorily charged and loads are sufficed through the battery charge. Since solar can sometimes produce higher outputs than the required amount, the extraneous power is

sent back to the grid via step-up transformers hence making up of the investments done into the system. Many appliances use DC power for their operations. It's quite intriguing why the conversion from DC→AC→DC is done. Hence we propose to use DC from solar directly to the appliances via suitable voltage regulators. In a nutshell, many parts of the existing solar hybrid grid system design have been proposed to improve into a smart intelligent system to maximize the efficiency.

II. RELATED WORK

Nowadays there are many companies which have found the problems in the conventional use of solar power and hence many have gone into the intricacies of the system. 'Tesla Solar Roof' has started dispatching their kits to customers in the US where Tesla batteries are used to store the charge of the solar and boasts of giving maximum throughput. Tesla being a big enterprise has the ability to make their own battery cells (2170 cells) and hence the battery bank (called as Power-wall). Since the inception of tesla it has stormed the market, making use of efficient 2170 cells into the not-so efficient hybrid grid solar system.

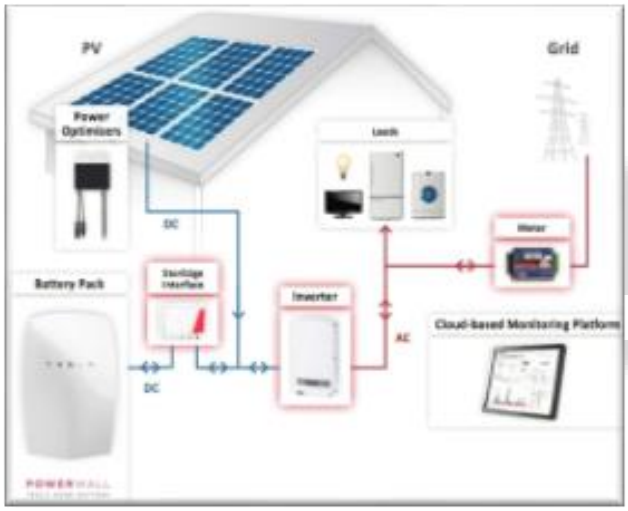

Fig. 2: Tesla Solar Roof System

Other companies too have identified the drawbacks and one of them is Su-Kam which uses smart inverters to manage the loads. There are people working on rechargeable reusable batteries to cut costs and hence started using the old 18650 cell out of discarded laptop batteries. The secondary market provide these batteries at much lower costs and hence projects are economical with these cells.

DIY projects like Jehu Garcia's SAMBA project, EV project use this method to save electricity and provide people assistance to make it a popular economical method of usage of electricity. The 18650 cells are first checked thoroughly with their voltage, current and temperature ratings so as to be safety precautious.

Fig. : 18650 cells out of laptop batteries

Fig. : 18650 batteries arranged in stack

III. SMART BATTERY MANAGEMENT SYSTEM

In our proposed system we are using optimum solution for the solar hybrid grid system. We propose to not to discharge the li-ion batteries below a level of 25% and not to charge it above 85% like that of in electronic vehicles so that prolonged battery life can be obtained[4]. Also converting of DC into AC and again into DC seems not as a viable option to be used along with this conversion of DC electrical energy into chemical energy and again to DC electrical energy which has its own losses to inverter is also minimised by directly connecting the solar DC output to inverter. Hence we propose a system where the appliances which use DC (AC in homes has to be converted into DC) will be given directly DC supply coming from solar through controller.

We say our implementation as Smart Management because here the battery is managed using Micro Controller Unit (MCU) which switches the current going through battery using an intelligent program. At first, battery is compulsorily charged above 25% along with the loads sufficed through the battery, after this both the battery charging and AC loads are sufficed. This is done to avoid undercharge of the battery which in the long run lessens the battery life. For avoiding overcharge the battery is not charged completely and hence after 85% charge level the solar power is given to the inverter (for AC loads) and if the charge is not used by the AC load completely the extra power is provided back to the grid.

The main aim of the project is to integrate the newly developed hybrid grid system with the the reused cells battery bank. Usage of old 18650 cells may seem to be dangerous but these cells are double checked before its use in the battery bank. Its voltage(4.2 Volts) is checked and if its below the specified rating of 4.2V those cells are clustered and charged. Now if the cells shows any abnormality in charging the cell is discarded. Abnormality like rise in temperature is taken

into account. Hence we get only the cells which are working properly.

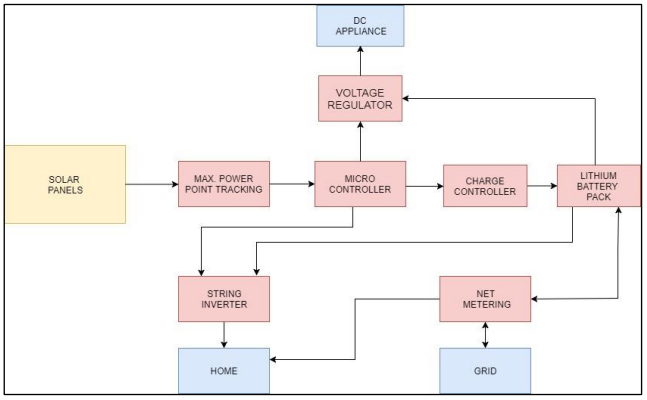

Fig. 3: Block Diagram

Smart battery management refers to using the battery in non-conventional manner to optimize its use so that the efficiency of system is improved. The system is as follows:

A. Algorithm

- Step1: Selection of 18650 cells from the laptop's discarded batteries by their voltage ratings.
- Step2: Making a battery pack from these cells by arranging them in series and parallel combinations.
- Step3: Integrate this system with solar hybrid grid system.
- Step4: Keep the State of Charge (SoC) in between 25-85% so that maximum battery life can be obtained by implementing steps 5 to 10.
- Step5: Read the battery level.
- Step6: Provide PV system's DC output to a fixed DC voltage regulator for DC appliances.
- Step7: If battery level >85%, suffice the AC loads by bypassing the battery also if necessary provide electricity from the solar back to the grid via net metering.
- Step8: If battery level <85% and >25%, provide electricity from the solar to charge the battery and also provide it to the home appliances which work on AC via the inverter.
- Step9: If the battery level is <25%, compulsorily charge the battery through the grid and suffice the loads via battery and do not provide electricity back to the grid.
- Step10: If the battery level is <25% and PV system is also not producing desired output charge the battery via grid and suffice loads via battery.

IV. IMPLEMENTATION

Here we will discuss how the proposed system can be implemented into hardware model. Discarded laptop batteries are to be. The unit which will control the direction of charge flowing is the MCU (Micro Controller Unit). This switching between the lines can be implemented by relay where MCU will act as controlling unit. Since we will have to switch more than one line we have to use multiple relays which have to be interfaced to the MCU unit via relay driver circuit. An LCD display can also be used to show the battery level and where the charge is being directed to.

V. EXPERIMENT RESULTS

The experimental results successfully formalize our theory of efficiently managing battery. We validate this by testing conventional system throughput and proposed system throughput, we discover that the DC supply which we have provided contributes to the efficiency of our system since the conversion is not used.

VI. CONCLUSION

The paper in a nutshell intends to integrate the efficiency of both Solar Hybrid Grid System using Efficient Battery Management with used 18650 Cells from discarded laptop batteries as its primary battery. It is battery management system where solar energy after the conversion into electricity is efficiently managed and switched onto different lines. For standalone projects, this system can be useful. This system can also be used for Uninterruptible power supplies provided further electronics are added. By using battery this way we can increase the life of the battery making the system economical. To avoid undercharge of battery, it will be charged compulsorily no matter what through solar or grid. Further to avoid overcharge of battery, the extra energy produced during the daytime is stored in the battery and then if the battery level is above 85% then this extra is provided to the grid via net metering and hence selling the electricity back to the grid, proving it to be an economical project.

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