# EXTENDED BATTERY LIFE WITH SUPERCAPACITOR IN STANDALONE PV SYSTEM

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**ABSTRACT:**

***The new options for the small hybrid island system, which has gained considerable popularity in remote areas and insular areas, are neither economically nor technically feasible. However, due to sudden and unlearned climate change, renewable energy sources are inherently intermittent, so power generation from renewable energy sources does not always meet load demand. Therefore, energy storage is needed to ensure a continuous supply of energy. Hybrid renewable energy systems can provide efficiency, reliability, safety and reduce operating costs compared to grid-connected systems. This article is based on a discussion of the various energy storage systems used in hybrid energy systems. In this paper, we have described a new operation and control strategy for a hybrid power supply system for self-sufficient operation. The proposed hybrid system consists of a solar cell unit, a super capacitor, a battery storage unit, an intermediate circuit, and a series of loads. The main purpose of this system is to ensure proper control and coordination of all systems. All work is simulated in MATLAB software to verify system validation***

**KEYWORDS:** *BES, CAES, EMS, HESS, PV, MPPT, SMES, WS-CAES etc.*

## 1. INTRODUCTION

The world is currently facing the problem of reducing its reliance on fossil fuels. Fossil fuels, such as carbon-based fuels, natural gas-based fuels, etc. cannot be renewable. The need to create alternative sources of electricity is crucial to avoid rising global air heat due to the effects of fossil fuels [2]. Fresh and renewable energy sources require a long-term replacement of fossil fuels and carbon dependency. In particular in the residential and industrial sectors the use and requirements of power are now developing quickly [3]. Renewable sources of energy are gaining popularity now. The energy produced using natural resources such as solar, wind, biomass etc. All of these solar systems are more achievable because they don't have moving components, are noiseless, need less maintenance and are safe than wind turbines. But there are certain constraints. The presence of the sun is the main constraint of the solar energy system. This depends entirely on the climate behaviour. An energy storage scheme is therefore needed for the use of solar energy.

The ESSs have numerous applications throughout contemporary electric grids, including the changing of renewable energy sources, intermittent handling and improving power quality. Many power storage technologies are available for network applications depending on power density and energy density needs. Compared to other power sources for residential and distributed networks, Battery ESS is widely recognized for its ease of deployment and geographical independence. The renewable energy battery ESSs should be designed to cope with the high and rapid power variations associated with intermitted

renewable energy production with higher power density. However, the batteries have limited energy, which means that a large number of batteries must be combined to achieve the energy required. Furthermore, battery power systems should have sufficient power to support renewable time shifts. However, the cycling life of the ESS battery is limited, and battery life depends on conditions of the battery.

In this paper here discuss the work associated with energy storage system for renewable energy based system. Here discuss the different researchers work in the field of increasing storing capacity of the renewable energy sources. A proposed control methodology is discussed in which super capacitor and battery is used for energy storage purpose in solar system. The whole work is simulating in the MATLAB environment to validate the control strategy of the proposed system.

## 2. RELATED WORK ON HESS

The current hydro, air compressed battery, fly-wheel, condenser, super-capacitor, magnetic and thermally superconducting systems are discussed in a comprehensive review[4]. The study compares the features of these systems and presents the status and cost of the capital to develop their technology. Some guidelines for future work are also available. In[5] discussion of recent applications that require a certain amount of power for a short period and the restrictions on air quality that have become more stringent in recent decades, The energy storage system (ESS) of the power grid played an important role in this. It fully covers various aspects such as the development of historic ESS, technical features, application of ESS, etc.. It is particularly important to have a connection between the intelligent grid (SG) and micro-ground applications on the one hand, and the ESS on the other. ESS technologies from various aspects are presented in state-of - the-art wind integration [6]. Modern ESS technology has been first and foremost implemented with possible wind power integration support applications. Second, a review will be carried out of the ESS application plan problem for wind integration, including the selection of the type of ESS and the optimum ESS size and location. The existing literature critically presents an updated cost base for analysis of the cost of the electricity storage system lifecycle costs (capital, operational, maintenance and replacement costs) in[7]. The Monte Carlo approach is also used to analyse life cycle costs and higher electricity costs for insecurity management. A paper to mitigate the energy storage problem through the provision of the latest available technologies and where they can be fully and clearly integrated in the power and delivery systems is discussed. The paper[8] begins with an overview, divided into six main energy stored categories, of functioning principles, technical and economic performance characteristics and current research and development of the key EES technology.

The gap in the energy storage system is discussed in detail by analysing the true application and effectiveness of the different energy storage technologies [9]. They talk about the concept of energy storage, the various technology of energy storage which emphasizes secondary storage (electricity and thermal) and a detailed analysis of several energy storage projects worldwide. In[10] you will see an overview of renewable storage. This report focuses on renewable like photovoltaic and wind energy systems, including an examination of some economic aspects of different storage technologies and hydrogen storage systems, batteries and flywheel systems. Finally, MATLAB and Simulink investigate the behaviour of PV and wind power and flywheel storage systems. The HESS concept, hybridization principles and proposed topologies, architecture interface, energy management and control strategy and scenarios for use in this context, as well as a wide spectrum of literature survey [11]. The Hybrid Energy

Storage System (HESS) concepts lie in the existence of complementary density of power, life cycle, and response rate and so on in heterogeneous storage technologies (ESS). This means that ESS units have a high response speed, but a low reaction rate is present in this high-energy ESS unit.

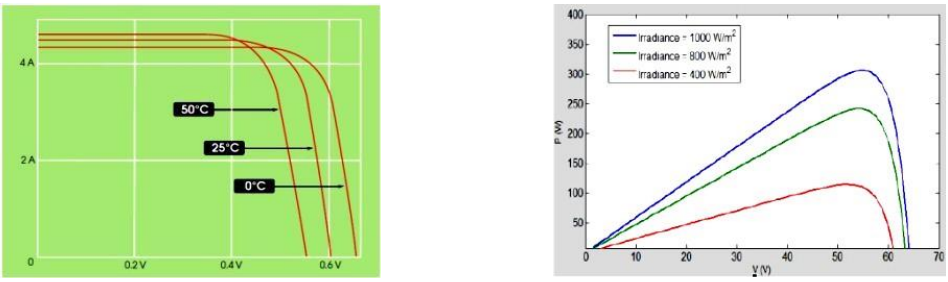
The proposal for the solution of an energy storage problem is a new hybrid wind-solar compress air storage system (WS-CAES)[12]. The WS-CAES system provides unstable wind and solar power for stable electricity output. The WS-CAES system also combined with the Organic Rankin Cycle (ORC), the waterfall energy utilization with different qualities. For this system, the analyses of energy, exercise and parametric sensitivity were carried out in order to achieve optimum performance. A new Smart Energy Management Algorithm was proposed in the 3-phase Hybrid Energy Storage System (HESS) for the 3-phase photovoltaic (PV) grid connected power system[13]. It is made up of a battery and traditional condenser as a power storage unit for energy sustainability from the solar PV system. The proposed SEMA analysed and tested various cases of HESS operations. The application to several European scenarios for energy supply is discussed in the application of the high resolution REMix model with three ratios of solar and wind, CSS including solar shares, with theoretical VRE shares of 0 to 140%[14]. They analyze measures of equilibrium, reductions and costs and compare results with past conclusions that CSP is seen as a back-up option among other disposable power plants. The findings indicate that CSP potential is widely exploited in most of Europe. The system costs of wind turbines or balanced wind and solar mixtures have shown to be the lowest and, overall, the VRE ratio for the future high price scenario was between 40% and 80%. In a class kW of a dynamic voltage restorer (DVR) design and evaluation of GdBCO a mini energy storage magnet (HES) is available in the REMix-based high-resolution energy system application[15]. HES-based DVR concept includes a single superconducting power storage unit (SMES) and one high-capacity battery storage system (BES). In SuNAM, the most advanced GdBCO tapes and structural design, management process and finite-element simulation are presented in a 3.25 mH/240 Magnet-wounds. An SMES battery storage energy system is available in[16] to stabilize a photovoltaic-based micro grid under different defects. The corresponding theoretical modelling and SMES methods for battery control and co-ordination are suggested with its technical features: power capacity, energy density, speed of reaction, etc.

## 3. STAND ALONE PV SYSTEM

A standalone PV system is a multi-string structure system, where multiple PV panels are connected in series and connected to a low power DC / DC converter. Multiple strings of several DC / DC converters are connected to one DC / AC converter. The type of multi-string construction can make optimal MPP for each string; it can be flexible by string design, it does not require an additional diode in series connected by a string (less power loses), each string works independently and all other strings can still feed the load if one fails. This structure can be configured as follows with the super-capacitor as a storage system:

A. Unidirectional Configuration
B. Bidirectional Configuration

It is essential to ensure that the maximum possible energy is extracted constantly from the system for the efficient operation of the PV system. Nevertheless, because of many factors like weather changes and shadows of objects in the environment causing an irradiation or temperature change, the maximum power available may change rapidly. The maximum power determination is a time-changing issue. The panels also have only a point in which the solar panel provides maximum power for a given ambient temperature and irradiation condition; the cell performance of these variables is shown in Figure 1.




(a) (b)

**Fig. 1** PV Cell Performance (a) Temperature Effect on I-V Characteristics (b) Irradiance Effect on PV cell Power Output

## 4. SC BASED DC-DC BIDIRECTIONAL CONVERTER

A bidirectional converter, as shown in figure 2, is the dc-dc super-capacitor converter. This converter controls the DC bus voltage within a smaller band, depending on the instantaneous power budget, by acting as a resource or discharge. The architecture proposed is based on direct solar energy transfer in the bus loading system. The energy discrepancy between source and charge, which manifests itself under or over tension conditions in DC buses, is normal because of the intermittent nature of Solar Energy. Super-capacitor acts as a shock absorber and reduces fluctuations in the system energy.

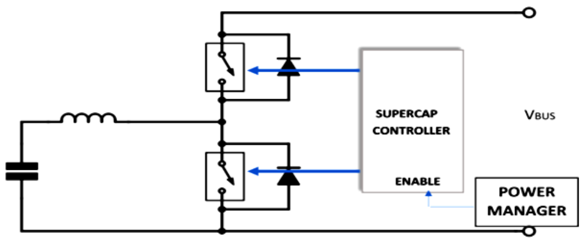



**Fig. 2** SC based DC-DC Bidirectional Converter

## 5. SIMULATION & RESULTS

Figure 3 shows the proposed methodology for enhancing life of the storage unit.

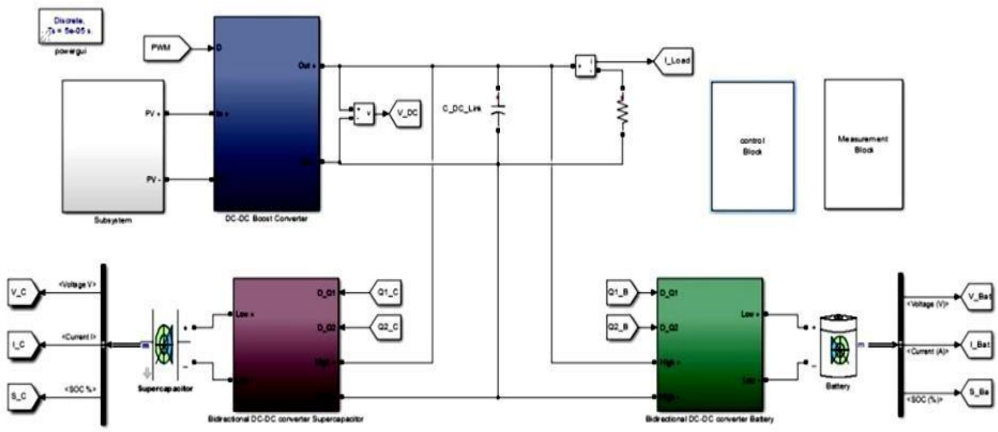



**Fig. 3** SIMULINK model of Proposed SC Based ESS

In this proposed system here uses two different energy sources for storing the energy of the PV system. Here battery is working as a primary source and the super-capacitor working as secondary sources. The main application of the super-capacitor is to increase the life of the battery with hanging of the current ripple produced by the PV system. The whole proposed system is developed in MATLAB software. Table I shows the parameter used in the simulation.

Table 1. SIMULINK parameter used in Proposed Work

| Parameter | Value |
|---|---|
| **PV Panel Details** | |
| Number of Series Cell | 96 |
| Open Circuit Voltage | 64.2 V |
| Short Circuit Voltage | 5.96 V |
| Series Resistance | 0.18Ω |
| Shunt Resistance | 360 |
| Number of Module in series | 2 |
| Number of Module in parallel | 2 |
| **DC-DC Converter Details** | |
| Inductor Size boost | 3.3 m H |
| Capacitor Size boost | 4700µF |
| Bidirectional Inductor | 3 m H |
| DC Link Capacitor | 4700 µF |
| **Super-Capacitor Details** | |
| Rated Capacitance | 500 F |
| Rated Voltage | 16 V |
| Initial Voltage | 16 V |
| Leakage Current | 5.2 m A |
| **Battery Detail (Ni-Cd Battery)** | |
| Nominal Voltage | 1.2 V |

| | |
|---|---|
| Rated Capacity | 6.5 Ah |
| State of Charge | 100% |
| Full Charge Voltage | 1.4 V |
| Nominal Discharge Current | 1.3 A |

Figure 4 shows the PV output voltage with different irradiation pattern.

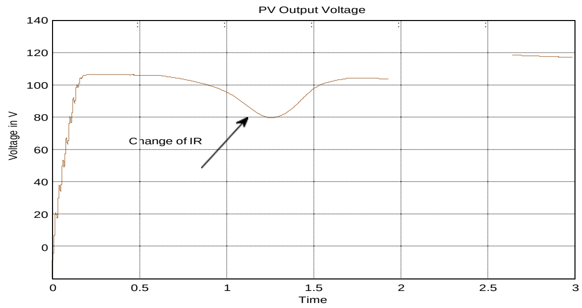



**Fig. 4** Voltage output of the proposed standalone system

Here initially output increases with increasing of the solar irradiation. At t= 1 s the irradiation of the solar get change due to some climate issue the output also get change.

Figure 5 shows the output current of the standalone PV system.

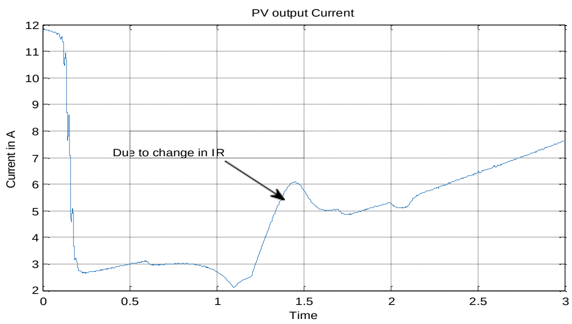



**Fig. 5** Current output of the proposed standalone PV system

Here from the figure it is clearly seen that the output current of the PV system get varies due to variation of the irradiation pattern of the system. It also depends on the temperature of the system. With changing of the temperature of the system it dynamically varied it is clearly seen.

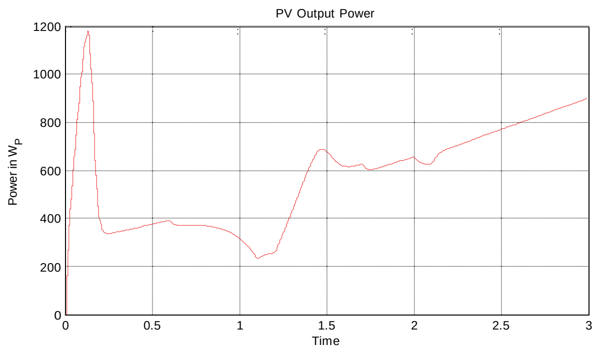



**Fig. 6** Power output of the proposed standalone PV system

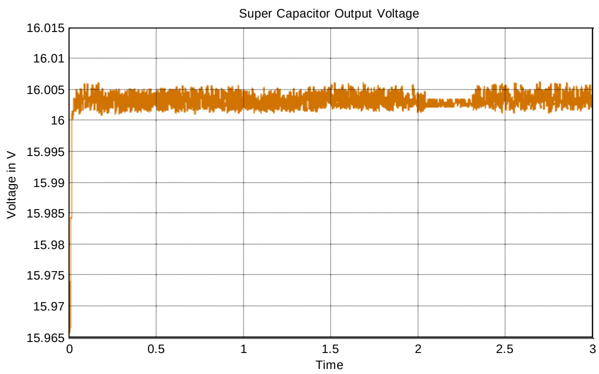



**Fig.7** Super-Capacitor voltage of the proposed system

Figure 6 shows the power output of the proposed system. The power depends on the output voltage and current of the proposed system. It is clearly seen that the power varies with the variation of the voltage and current of the proposed system.

Figure 7 shows the super-capacitor voltage. Here it is clearly seen that the voltage of the capacitor is thought constant due to controller. It helps the increasing the life of the battery.

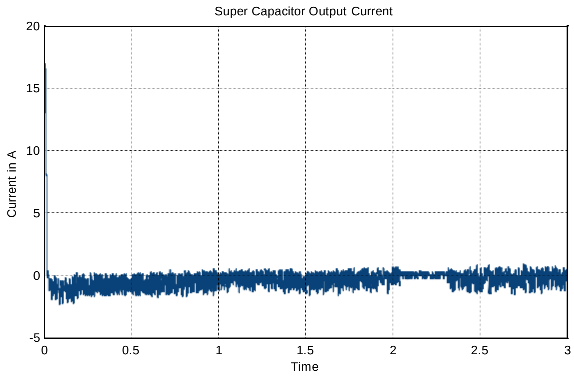



**Fig. 8** Super-Capacitor Current of the proposed system

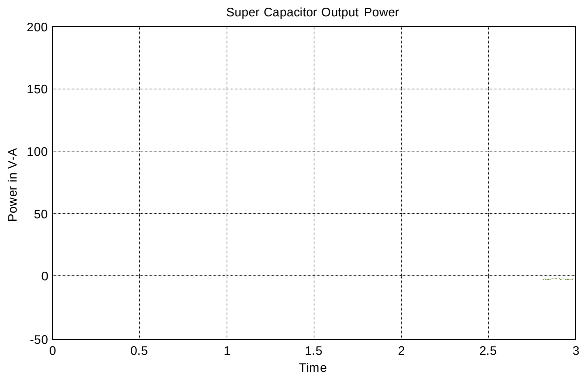


**Fig. 9** Super-Capacitor Power of the proposed system

Figure 8 and 9 shows the current and power of the super-capacitor in the proposed work. Here power is clearly seen that is constant and the negative value shows that it maintain the DC power of the system. So when the PV power varied the capacitor provide the constant power to the battery for charging and maintain the current ripple.

## 6. CONCLUSION

Conventional energy sources have many issues due to the scarcity of the raw materials day by day. The energy requirement increases now due to increasing of the population and industries in whole the world. In this paper discuss the new methodology for increasing the life of the battery with the help of super capacitor application. For completing this thesis, firstly study the work associated in the field of storage of the electrical power by the different authors. Then study a different energy storage system is studied. The new methodology here discuss is based on super capacitor. Here super capacitor works as a secondary source which decreases the problem associate by the current ripple generated with the change in climate to the nonconventional sources. A MATLAB based system is a model in this thesis based on the proposed methodology. The result shows the better life cycle of the battery storage system.

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