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Power Management of Grid Connected Non-Conventional Energy with Battery Energy Storage System

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Abstract- *This paper presents the implementation of renewable energy as source supply to support the load requirements. Photovoltaic is the most efficient renewable energy source. Integrating this renewable energy source into optimum combination with energy storage system to enhance the overall system performance and make the system more reliable and economical to run. The Battery operates as energy storage to flexibly shift the generation from the renewable energy sources without excessively fluctuation between battery charging and discharging. The multifunctional grid connected PV and Battery Energy system operates in different modes of operations: Normal mode, Power Dispatching mode, Power Averaging mode of inverter. The performance of the system under proposed mode of operation modeled and simulated in MATLAB/ Simulink.*

Keywords- PV (Photovoltaic) solar system, Battery Energy Storage System, Inverter, Grid connection, MATLAB

I. INTRODUCTION

India is the fastest growing country in the generation of the energy with different resources like coal, gas etc. but besides it cause the adverse effect on environment too because of pollution. In recent years, renewable energy sources for the production of energy gains outstanding interest in many of countries. The global penetration of renewable energy sources rapidly increase which is absolutely free and eco-friendly. The global penetration of renewable energy sources increases rapidly in this recent year because most of the countries are work on the renewable source energy production to preserve the conventional energies. The renewable energy counted for around 19% of the final energy consumption worldwide in 2012 and continued to rise during the year 2013 as per 2014 renewable global status report. In 2010 the total solar PV installed capacity was 40 GW which increases in 2013 up to 139 GW is followed by 178 GW in the year of 2015. The estimated installed capacity of PV up to 2019 is 540 GW. Since the renewable sources are weather dependent and unstable in nature it is firmly requires optimization with addition of energy storage system which is use as backup in the event of failure of wind and PV system. Which is ultimately enhances the overall efficiency and stability of the system.

II. PHOTOVOLTAIC MODULE WITH BATTERY ENERGY STORAGE SYSTEM

(A) Photovoltaic Module

A photovoltaic (PV) system is able to supply electric energy to a given load by directly converting solar energy through the photovoltaic effect.

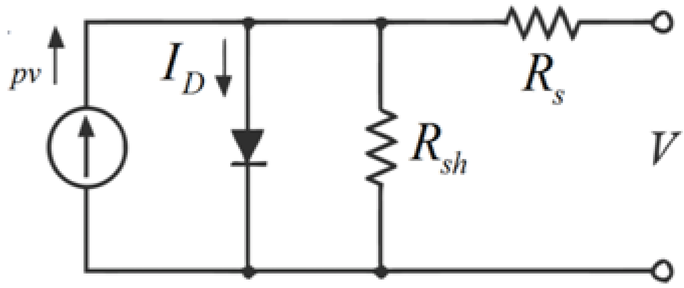

Figure 1 Equivalent Circuit of PV Cell

Figure 1 manifests the equivalent circuit of PV cell. Equivalent circuit has Diode in parallel to current source, Parallel resistor describes the recombination of electron and holes pairs and series resistor resistance of flow of electrons and holes. The equation for equivalent circuit is given below:

$$I_d = I_0\,(e^{\frac{qvd}{\gamma kt}} - 1)$$

Where, γ = Constant for diode
With series and shunt resistance,

$$I_{ph} - I_d - I_{sh} = I_L$$

Diode current,

$$I_{ph} - I_0 \left(e^{\frac{qv_d}{\gamma k_d}} - 1\right)$$

The Photovoltaic benefits are given below:

(1) Smaller PV arrays can supply the same load reliably.
(2) Less balance of system components are needed.
(3) Comparable emission reduction potential taking advantage of existing infrastructure.
(4)Takes advantage of the existing electrical infrastructure.
(5) Efficiently use of available energy.

(B) Nickel-Metal Hydride Battery Energy Storage System:

Many battery applications are well suited to be powered by Ni-MH rechargeable batteries. Nickel-metal hydride batteries are essentially an extension of the proven sealed nickel-cadmium battery technology with the substitution of a hydrogen-absorbing negative electrode for the cadmium-based electrode. The devices that require large amounts of energy and are used frequently are well matched to the performance characteristics of Ni-MH batteries.
Some of the advantages of the nickel-metal hydride battery are:

1) Energy density which can be translated into either long run times or reduction in the space necessary for the battery.
2) Elimination of the constraints on battery manufacture, usage, and disposal imposed because of concerns over cadmium toxicity.
3) Simplified incorporation into products currently using nickel cadmium batteries because of the many design similarities between the two chemistries.
4) Greater service advantage over other primary battery types at low temperature extremes operating at **-**20°C.

(C) Control strategy for Grid Inverter Control:

1) Mode I- Normal Mode:

The PV system penetrates as much power into grid generated by it. The PV supply more stable power output into grid. In this mode inverter is directed to maintain the constant dc bus voltage. Battery is not used in this mode.

2) Mode II – Dispatch Mode:

The control sets desired power injection into grid. The dispatch power can be instructed for the purpose of utility or demand management such as peak-load shaving ad active-load control. Battery is used to compensate power mismatch between generation of PV array and the dispatched amount. In this mode battery will frequent shift the power by charging and discharging states.

3) Mode III – Averaging operation:

The purpose of this mode is to smooth the power fluctuations of the renewable energy sources and transfer more stable power output in to the grid. A simple technique using a low-pass filter was introduced. This technique is simple but effective in mitigating power fluctuation. Use of battery is for balancing the power production and injection.

III. SIMULATION RESULTS

PV and BESS corresponding simulation data details are given in Table 1.

Photovoltaic System	100 KW
PV short circuit Current	192 A
PV open circuit Voltage	745.92 V
Battery Storage	50KW
Nominal Battery Voltage	750 V
Inverter	100 KW
Load	50 KW
Grid Frequency	50 HZ

Table 1. Electrical characteristics data

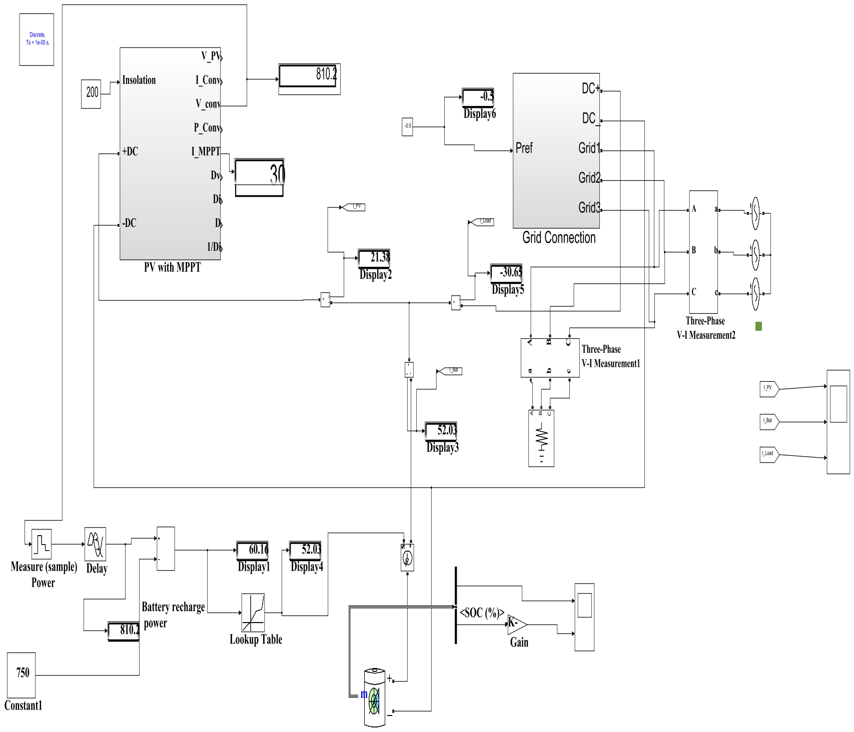

Figure 2. Photovoltaic with Battery Energy Storage System

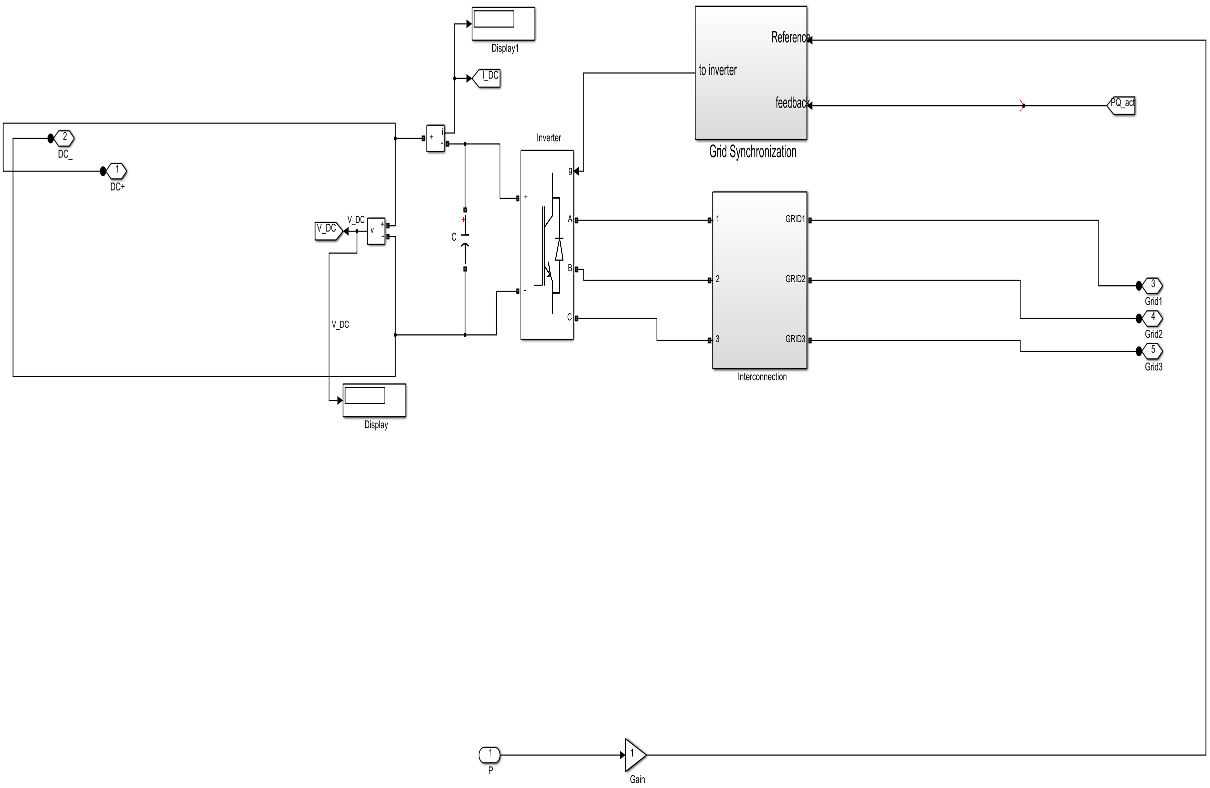

Figure 3.Grid connection of Inverter

Import mode of operation:

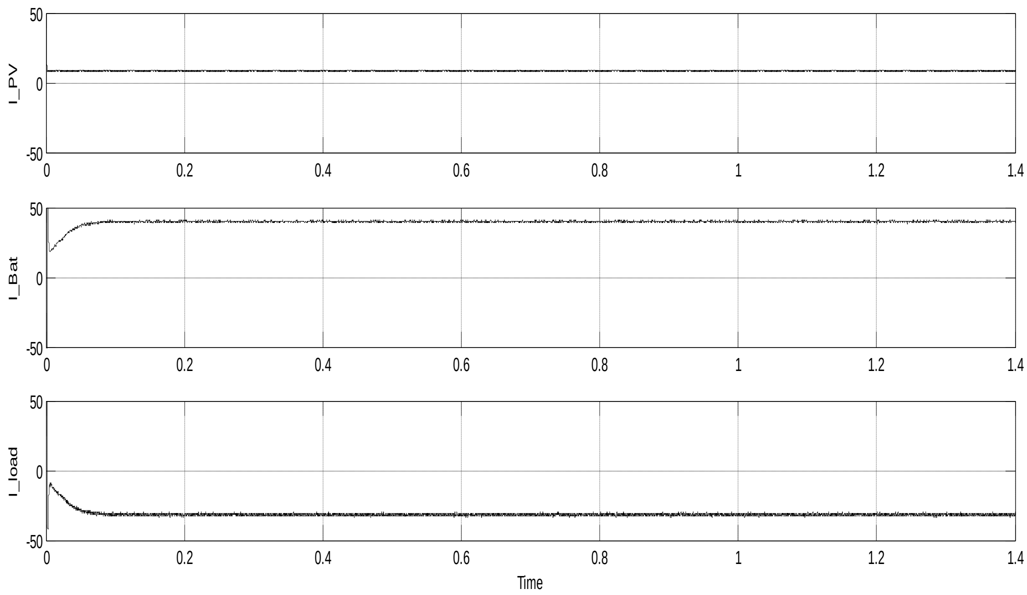

Figure 4 Changes in Current of Battery, PV and Load

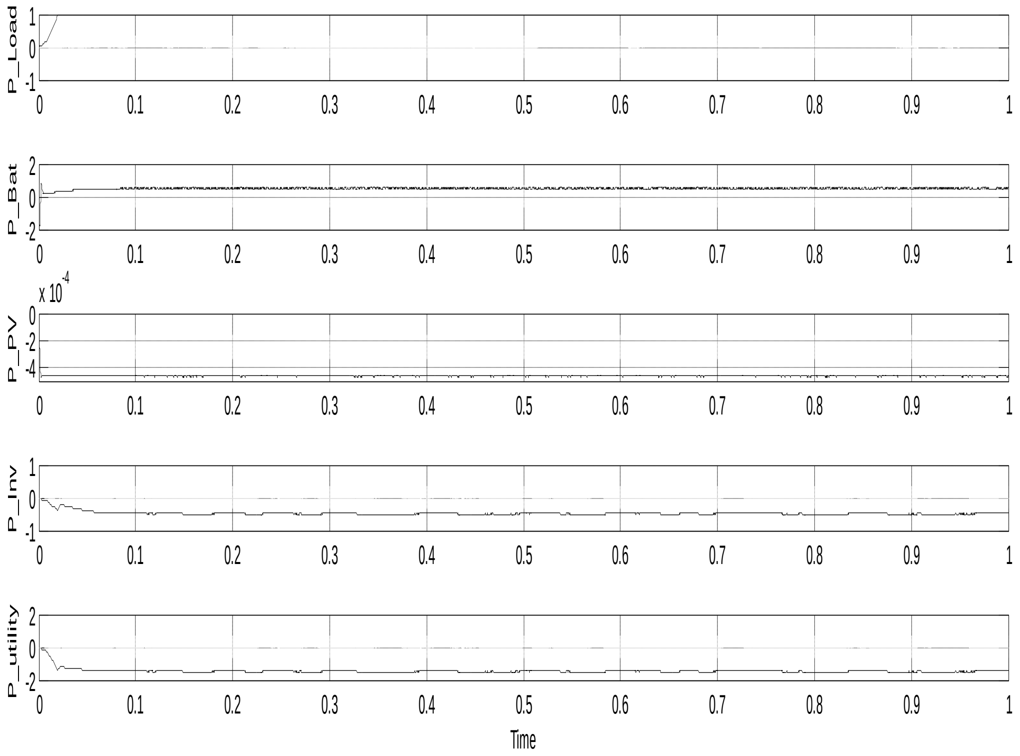

Figure 5.Power analysis of Load, Inverter, Battery, PV, Utility and Inverter

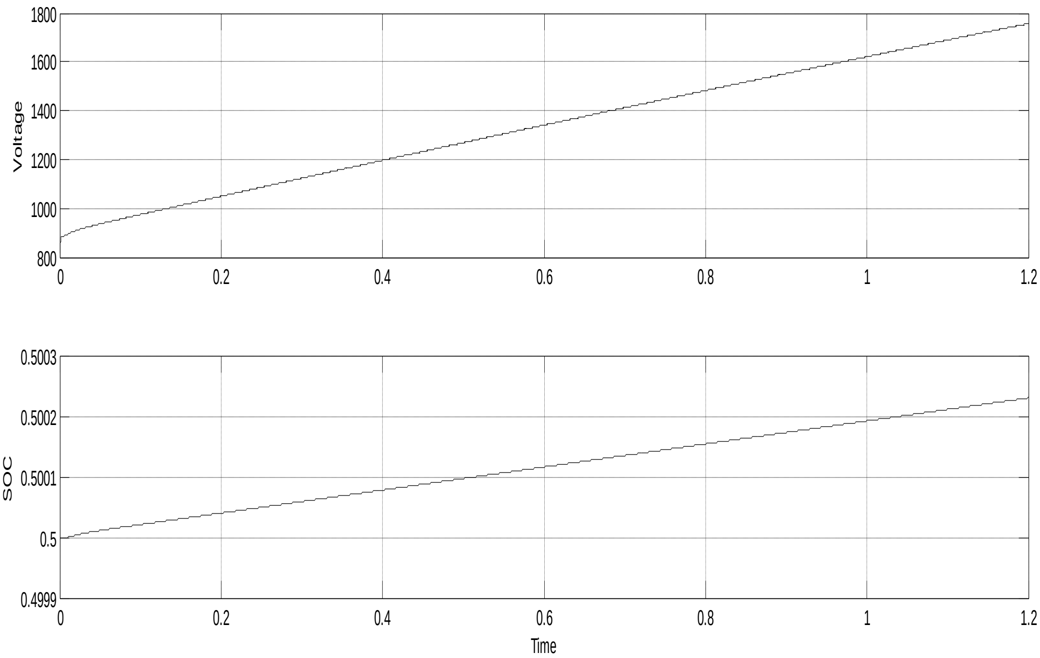

Figure 6.Battery Voltage and State of Charging

Export Mode of operation:

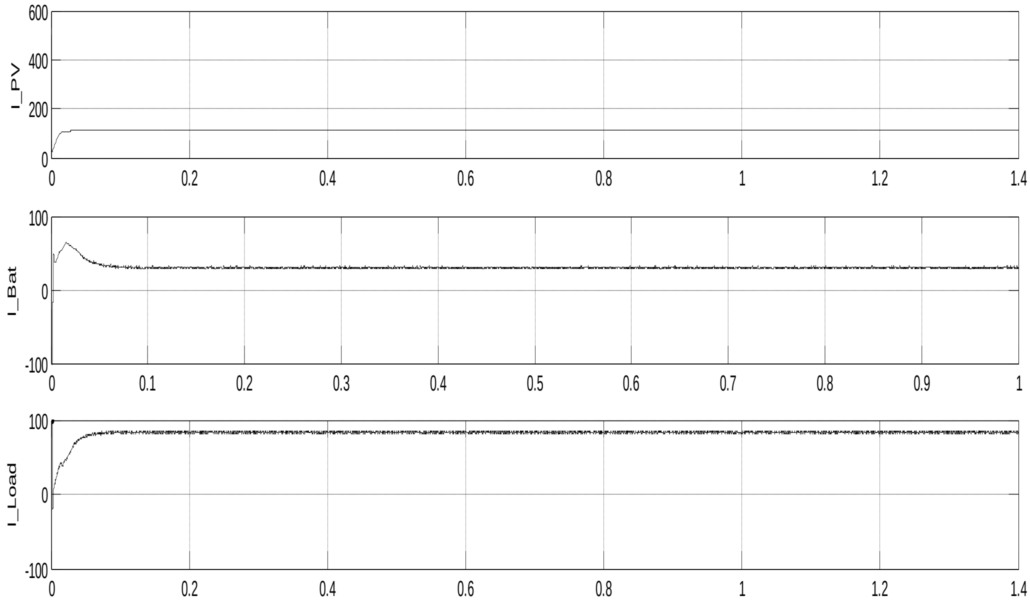

Figure 7. Change in Current of Battery, PV and Load

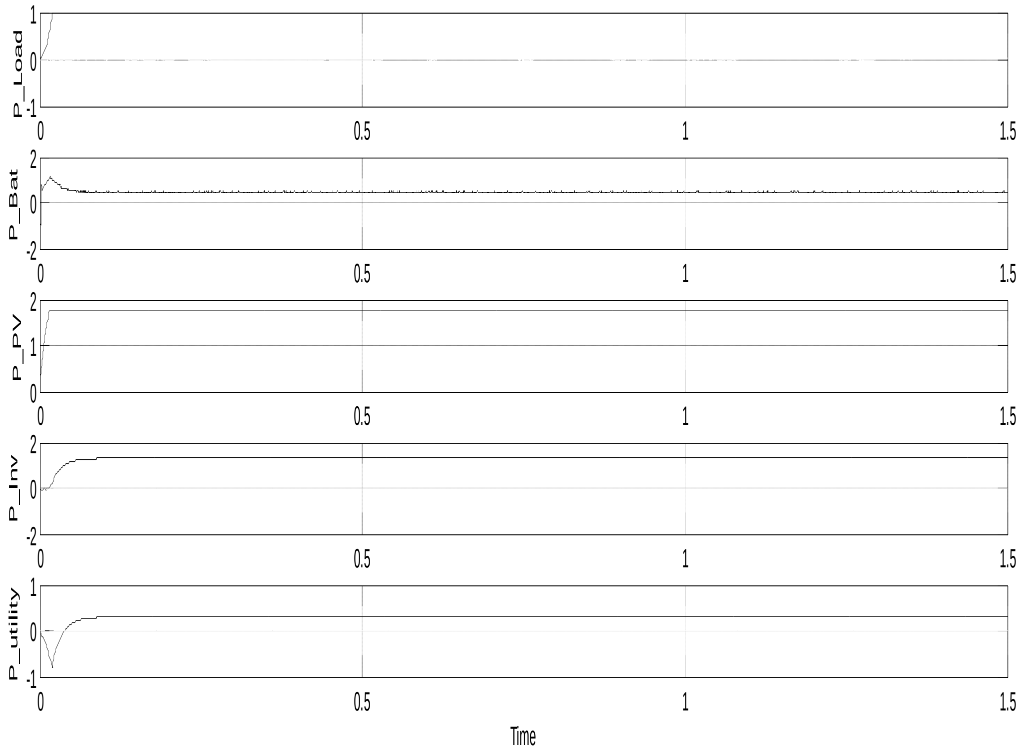

Figure 8. Power analysis of Load, Inverter, Battery, PV, Utility, Inverter

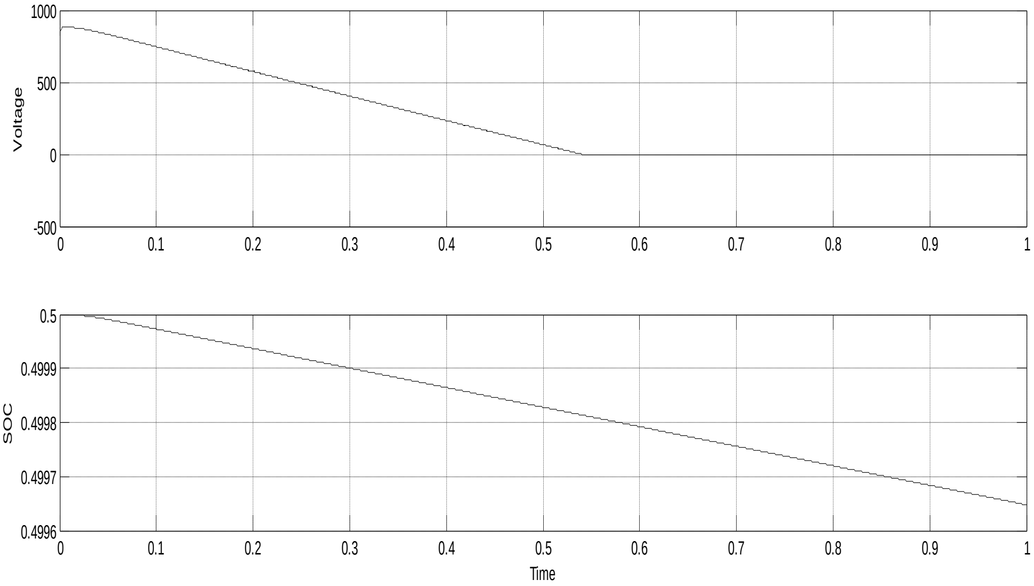

Figure 9.Battery Voltage and State of Charging

IV. CONCLUSION

simulation work execute the operation of the system in three modes like normal mode in which power generated by PV supply to grid directly; in import mode power will be import from grid in the case of PV unable to supply the load and in export mode the additional power produced by PV used for charging the battery which use supply to the load. PV connected renewable energy source is most promising system than conventional source to extract the power to approach the demand which is absolutely eco-friendly and Power control modes use to solve the conflict of energy supply in undesirable condition and capable to supply the required power to the needed consumer..

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