# ENERGY MANAGEMENT OF THE COMMERCIAL BUILDING USING SIMULATION MODELLING

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***Abstract*: Increase in energy demand has directed us to properly manage the use of energy. As conventional sources alone cannot meet the energy requirements, renewable energy is the solution of the problem. This paper models a hybrid system consisting of photovoltaic system and wind energy conversion system acting as renewable sources. The hybrid system is connected to the utility grid. Both the energy sources are parallel linked through a DC/DC converter. The DC/AC converter converts the DC power available from PV array into three phase AC power. Simulation results show that hybrid system provides constant power to the loads even when the power is not available from the utility grid. Excess energy, if available, could be stored in battery storage system.**

***Keywords*: photovoltaic array; wind turbine; battery storage.**

## I. Introduction

The increasing energy demand and limited fossil fuels directed the individuals to shift towards renewable energy sources in the generation of electricity [1]. The most widely used renewable energy sources are photovoltaic (P.V) solar and wind system as they are pollution free and environment friendly. They generate power in tens of mega-watts (MW) to hundreds of megawatts.[7]
A hybrid system combining different renewable energy sources even produces higher amount of power. In the work, dynamic performance of a stand-alone wind and solar system with battery energy storage system is analyzed.[5]
A building connected to the utility grid and having a hybrid system as renewable source could ensure effective use of energy, have continuous supply to the essential loads and minimizes the wastage of energy [4]. A hybrid system providing power to the loads does not care about quality of power delivered but concentrates on less fluctuation of power and the capability of flexible regulating the power. The controlling strategies used in the plant using non-conventional systems would be different from that of used in the conventional systems.[5]
In the work, P.V. system is connected to the 50Hz utility grid. Three phase voltage source converters (VSIs) are used to interface the PV system to the grid. The current controlling part of V.S.I plays an important role in feeding the grid with the high quality power.
The stand-lone P.V. system is controlled with a maximum power point tracker (MPPT) in order to reduce the variation of different irradiation values. The energy conversion system is based on the boost converters with perturb and observe (P&O) MPPT control algorithm.[1]
In case of wind energy generation system connected to the grid. The total active power can be feed directly to the grid. If the power extracted from the wind turbines is more than the local loads, the excess amount of power could be diverted to the dump load or to any of the storage element, that is, battery energy storage system.
The wind generation system uses constant speed wind turbine generators which rotate at a specific speed regardless of the wind speed. The variable speed wind turbines rotate at the wind speed and speed changes in accordance with the wind. In the present time, wind technology has moved towards variable speed wind turbines. The variable speed machines have various advantages: they improve quality and system efficiency, reduce mechanical stresses and compensates for power and torque fluctuations.[2],[10]
The wind energy conversion system using squirrel cage induction generators uses back to back connected power converters. The power converters have the capability of disconnecting the squirrel cage induction generators from the grid thus increasing improved reliability.[10]
In this paper, an hybrid system consisting of photovoltaic system and wind generation system is modelled connecting to the utility grid. The photovoltaic system generates 100KW of power and wind generation system generates 9MW of power. The system could be installed for a commercial building for getting the uninterrupted supply for the essential loads. The generation systems could be connected of disconnected from the utility grid by a change over switch. The excess amount of energy, if available, could be stored in the battery energy storage system connected to the photovoltaic system..

## II. SIMULATION STEUP

The simulation diagram of the wind farm in phasor model generating 9 MW power is shown in figure 1:

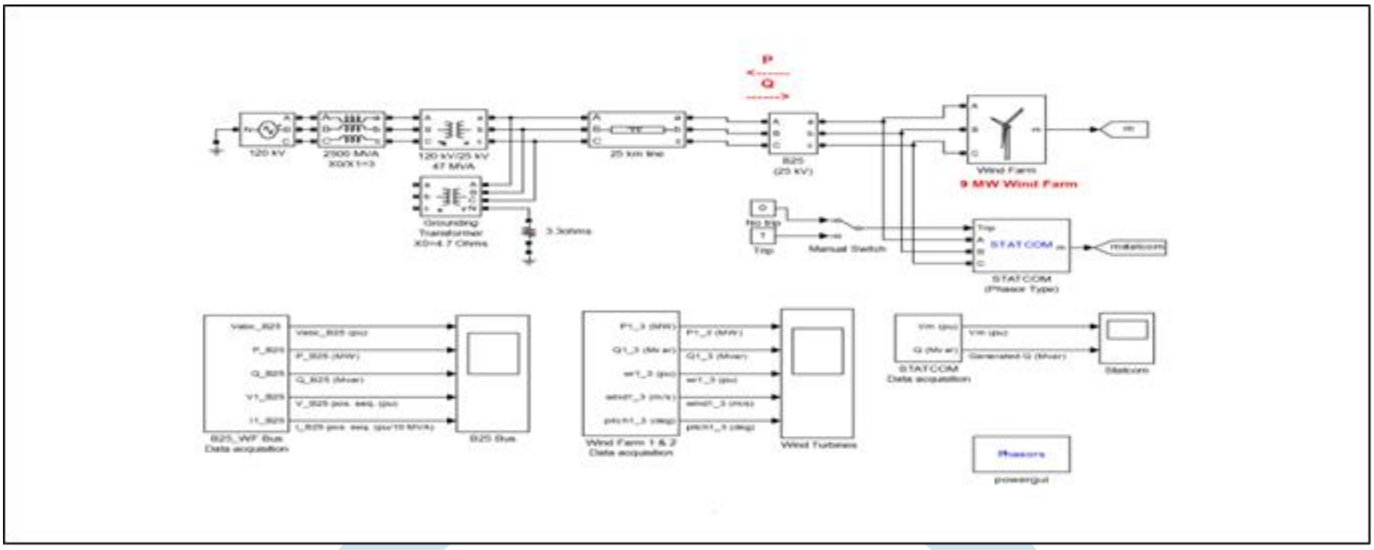


**FIGURE 1: PHASOR MODEL OF THE WIND ENERGY CONVERSION SYSTEM**

The wind farm is equipped with three wind turbine units. Each unit consists of two wind generators of 1.5MW rating. The three wind turbines are connected in parallel supplying power to the grid. The voltage generated by turbines is step-up to 25KV using step-up transformer. The voltage after stepping up
is transmitted to the grid through a π-connected transmission line. The photovoltaic system that is connected with the wind generation system to form an hybrid system is shown in figure 2.

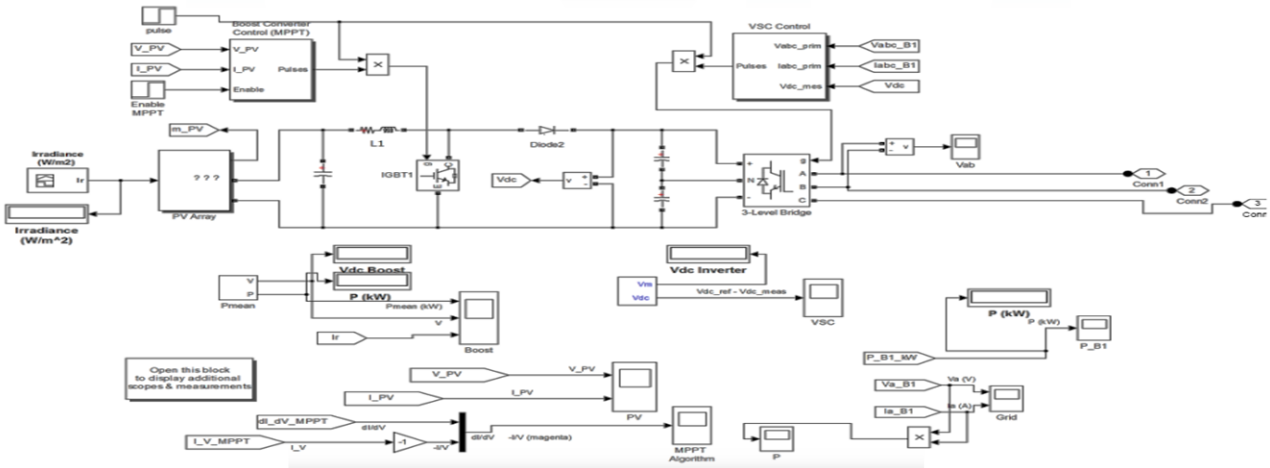


**FIGURE2: MODEL OF THE SOLAR PHOTOVOLTAIC SYSTEM**

The P.V. system is developed in Matlab/Simulink. The main parameters of the P.V array is set according to Sun-power SPR-305-WHT. The irradiation values are varied in between 1000W/m^2 and 250W/m^2. The current in the P.V. panel is calculated by equation:

$$Ipv = Iph - Ip\left[e^{\frac{q(Vpv+IpvRs)}{\eta.k.T}}\right] - \frac{Vpv + Ipv.Rs}{Rsh}$$

Where,
Ipv, Vpv : voltage and current at the output terminals of the photovoltaic cells,
Iph: photocurrent,
k: Boltzman constant
η: quality factor of n-p junction,
q: electron charge,
T: ambient temperature, K
The open circuit voltage (Voc), short circuit current(Isc), maximum power current(Ipm), maximum power voltage (Vpm) used in the PV system is given in the table:

| Open circuit voltage(Voc) | Short circuit current(Isc) | Maximum power current(Ipm) | Maximum power voltage(Vpm) |
|---|---|---|---|
| **64.2** | **5.96** | **5.58** | **54.7** |

PV panel parameters

The three level voltage source converter (VSI) converts D.C. voltage into 3 phase A.C. voltage. A battery energy storage system is also connected with the P.V. system to store the excess amount of energy.

An hybrid system consisting of P.V. and wind plant could be connected/ disconnected from the grid by a change over switch to meet the load demand if the excess of energy available that could be stored in the battery .

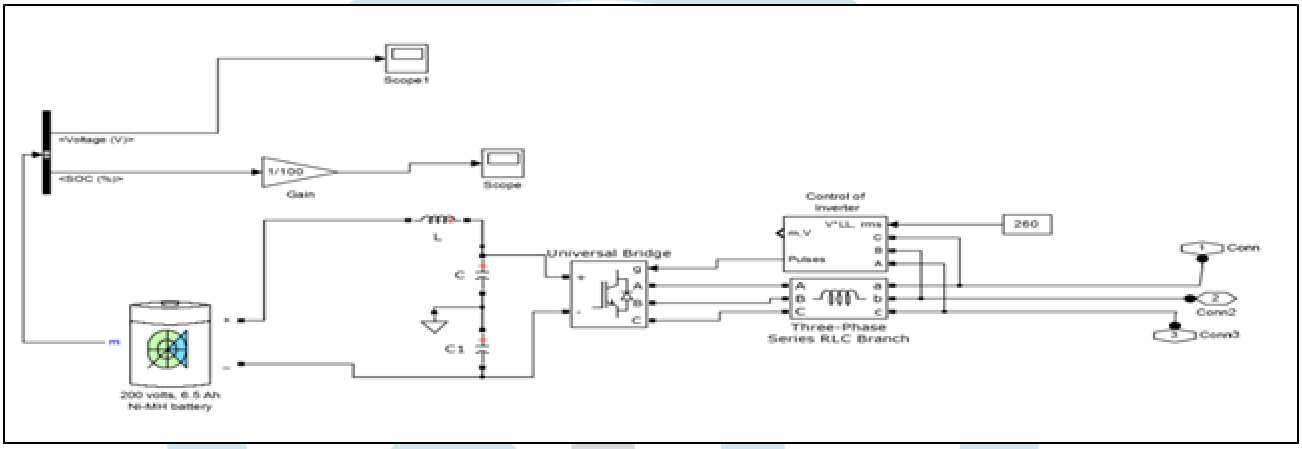


**FIGURE 3: MODEL OF BATTERY STORAGE SYSTEM**

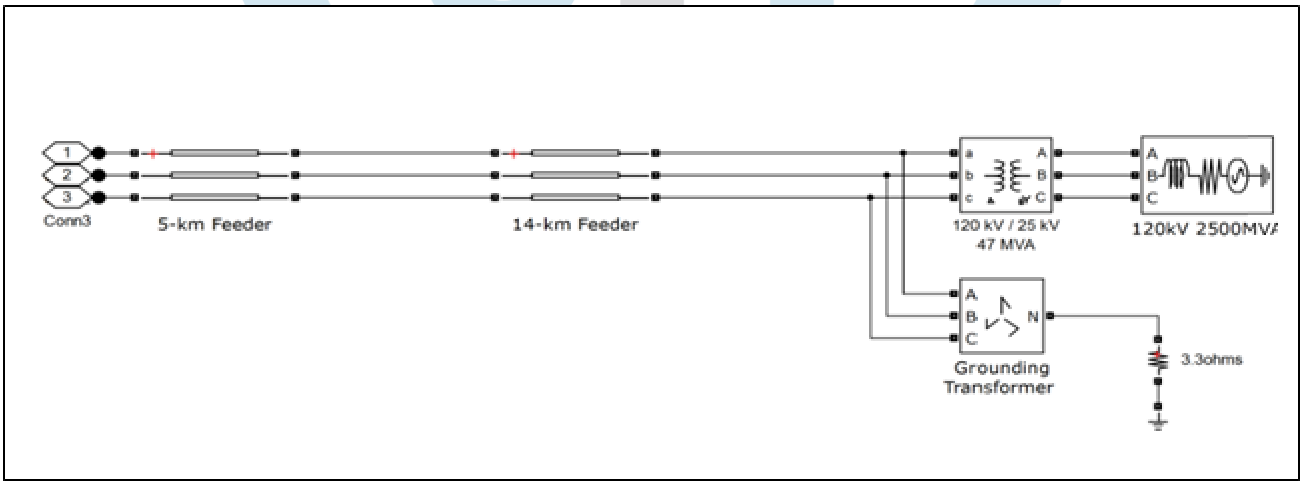


**FIGURE 4: UTILITY GRID**

## **III.** RESULTS:

In the simulation, the PV plant produces a power output of 100KW at an irradiance of 1000W/m2. The wind energy conversion system produces an output of 9 Mw at the wind speed of 11 m/sec.. The hybrid system is connected to the 50Hz grid. At starting the pitch angle of the turbine was at zero degree but when the generated power exceeds 3MW, the pitch angle increases from 0 degree to 8 degree in orer to bring the power to the nominal value.

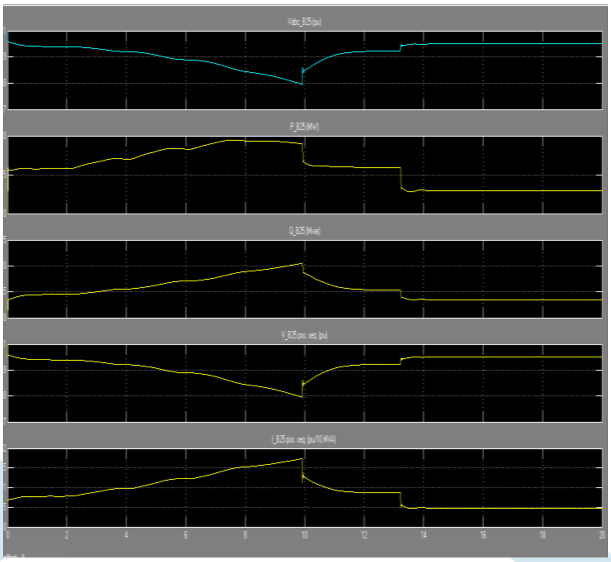

Figure 1: output voltage (V_abc), output power( MW), reactive power(Mvar ), voltage (V_B25), and current(I_B25)

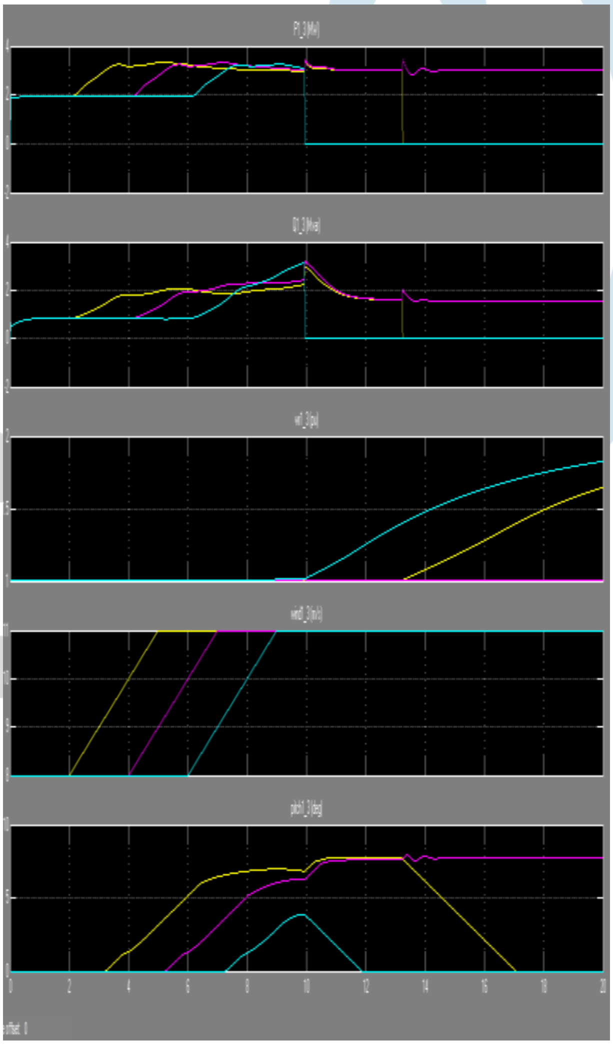

Figure 2 : output power (MW) ,reactive power (MVAR), Wind Speed (pu), Wind Speed (m/sec), and Pitch (degree) of the Wind Turbine.

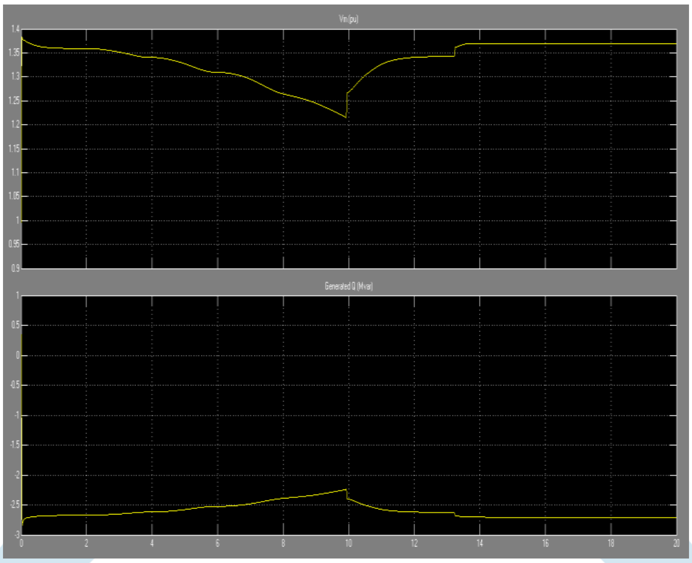

Figure 3: Voltage (pu), and Reactive Power (Mvar) supplied by the STATCOM

In the simulation, the PV plant produces a power output of 100KW at an irradiance of 1000W/$m^2$.

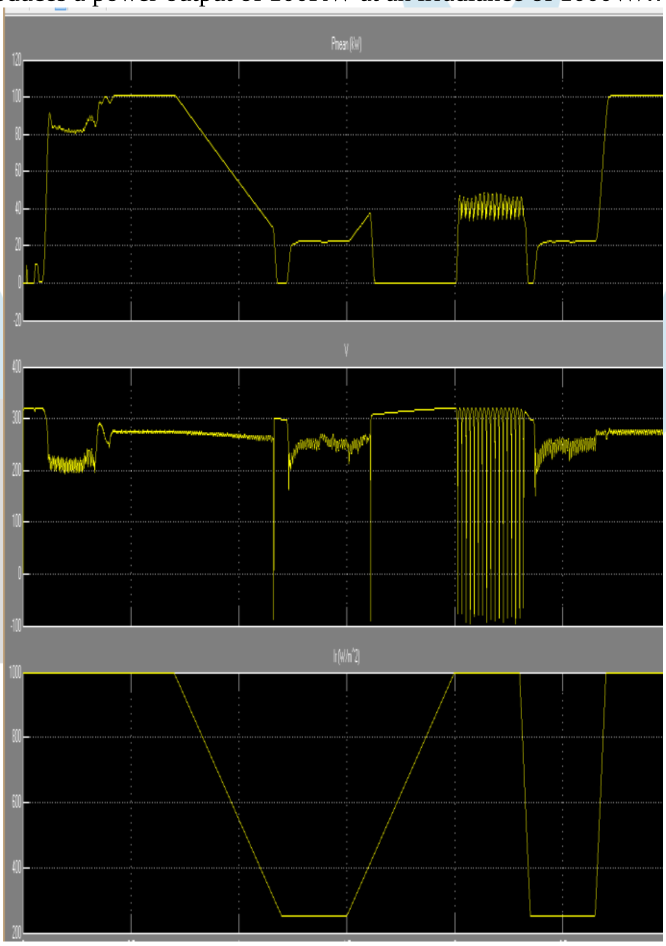

Figure 4 : output power (KW), voltage (V), and Irradiance of the photovoltaic plant

The DC output voltage and DC output current of the photovoltaic array panel is shown as follows:

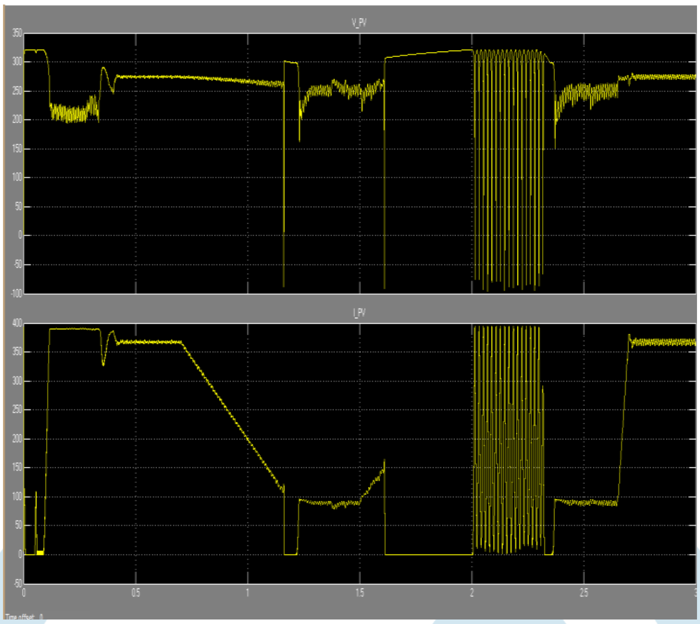


Figure 5: output D.C. voltage(V) and output D.C. current(A) of the photovoltaic array

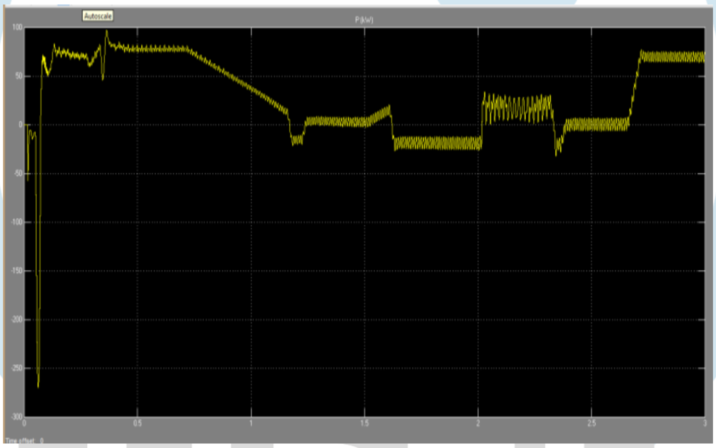


Figure 6 : Output Power of the Photovoltaic Plant.

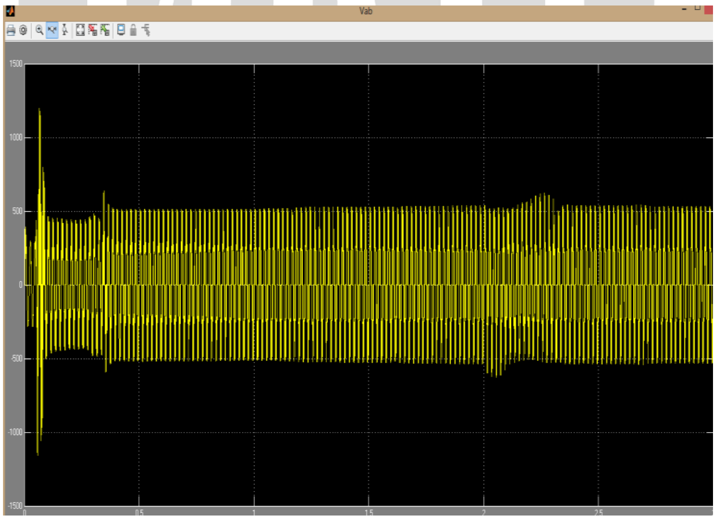


Figure 7 : Line to Line voltage  of the photovoltaic plant.

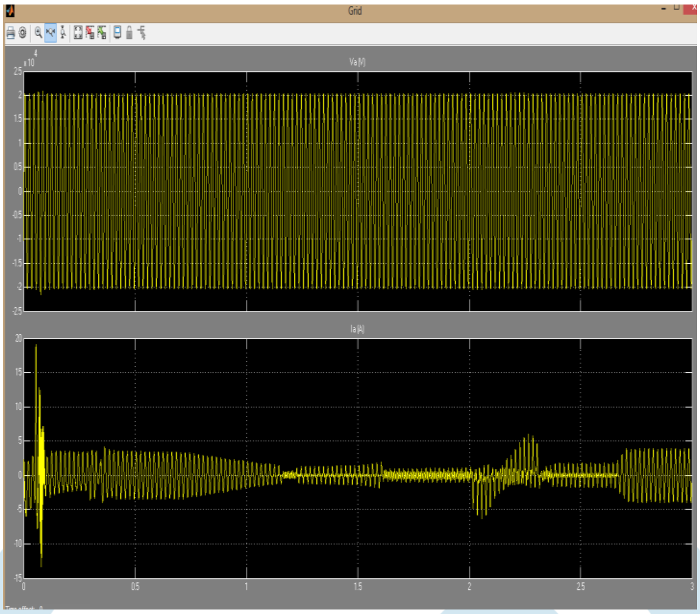

Figure 8 : Output voltage (V) and Output Current (A) of the grid connected to the photovoltaic plant.

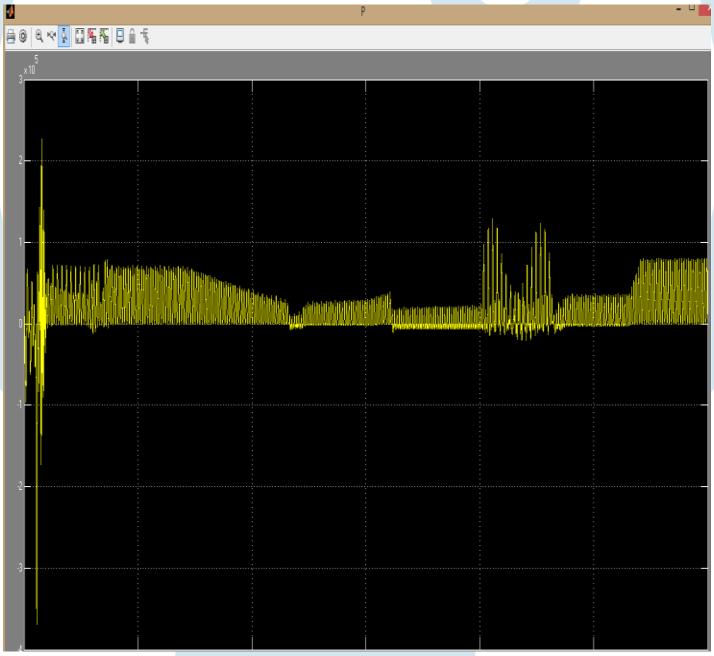

Figure 9: Output Power(W ) of the grid connected to the photovoltaic plant

**BATTERY STORAGE SYSTEM:**

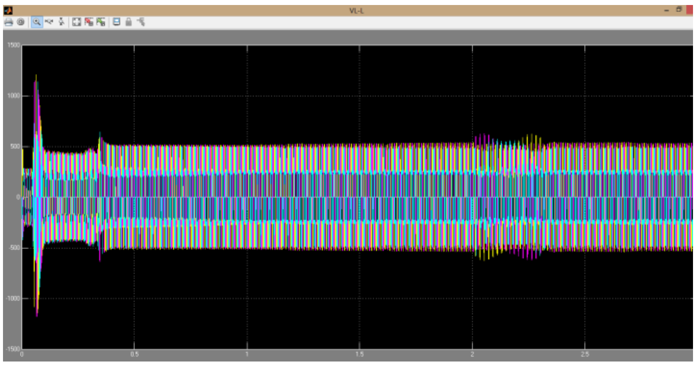

Figure 10: Line to Line voltage of the battery energy storage system.

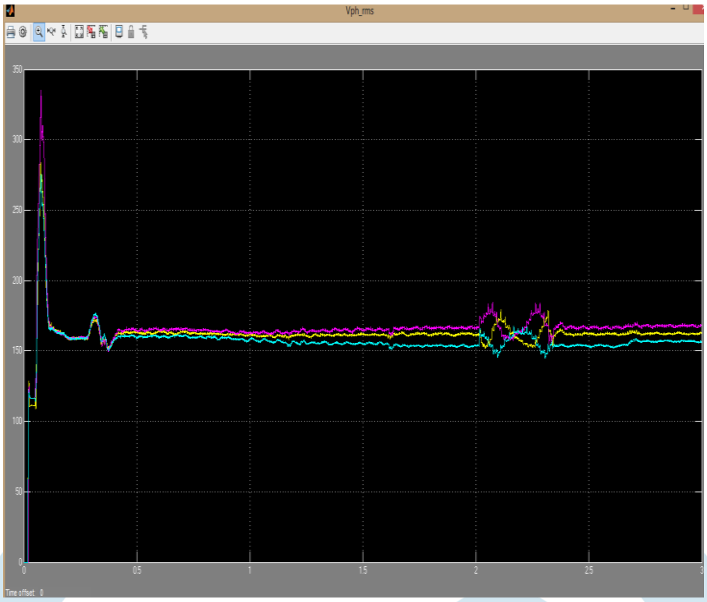


Figure 11: phase voltage of the battery energy storage system.

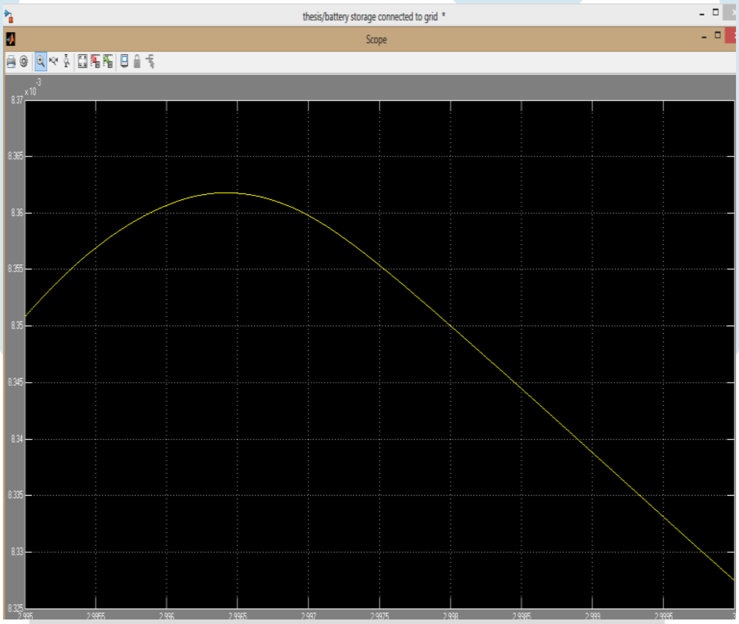


Figure 12: State Of Charge of the Battery in Battery Energy Storage System

CONCLUSION

In this paper an hybrid system model based on PV and wind energy conversion system was proposed. The proposed system was simulated using Simulink block and modalism. The outputs of the PV system and the wind energy conversion system were studied. It was found that the proposed system was recovered from most of the faults as in the case of STATCOM. The transients were very less. Further work needs to be done in the hybrid system model as some controller could be connected in place of the manual change over switch for continuous supply to the loads. Additional work needs to be done in the hybrid model to replace the STATCOM to deliver the continuous supply to the grid even under faulty conditions

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