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Comprehensive Approach to Modeling and Simulation of Microgrid with Photovoltaic and Wind Resources

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Abstract:- According to the suggested system, there are many power transfer techniques for a grid-connected hybrid generating system with flexible power transfer. This hybrid model maximizes the use of freely accessible sustainable energy sources such as wind and solar energies, allowing for optimum energy efficiency. For such system, an adaptive MPPT algorithm will be employed in conjunction with the traditional perturb and observe technique. Dependent on the power sources' accessibility, this arrangement enables the client sources to serve the load independently or concurrently. As for wind energy, turbines rotor speed is a major factor, whereas the output of solar energy is largely influenced by the voltage of solar cells. In order to convert renewable power, a wind farm and a Permanent Magnet Synchronous Generator must be used together. Unconventional energy is converted into AC power by the inverter, which turns the DC output into usable AC power for the associated load. Assuming standard room temperature for solar, and standard wind speed in a flat location for renewable power, this hybrid system functions under typical conditions. It will be possible to minimize harmonic ripples using a fuzzy-based PWM scheme. In order to demonstrate the working principle, practicality, and dependability of this suggested system, the simulation and experimental results.

Keywords:- *Wind, Solar, Battery, PWM, Fuzzy Logic Controller.*

I. INTRODUCTION

Climate change and depletion of conventional fuel supplies have prompted many to search for renewable energy alternatives in order to protect the world for future generations. Climate change and depletion of conventional fuel supplies have prompted many to search for renewable energy alternatives in order to protect the world for future generations. Wind and solar energy have the best potential to satisfy our energy needs, except from hydro. The sun also emits energy during the day, but its strength and shadows created by storms, birds, trees, etc. cause the irradiance levels to change. Unreliability is a typical disadvantage of wind and solar systems due to their alternative power. It's possible to greatly enhance the system's energy transfer quality and effectiveness by merging these two inconsistent sources of power and integrating MPPT algorithms. One of newest developments in energy technologies is the combination of alternative energy sources with energy storage devices. Because of the rising group of alternative energy sources and dispersed generators, new techniques for their management are needed in order to maintain or maintain the efficiency and quality of the power source. As opposed to a common ac type, the use of numerous energy sources via a dc bus of a voltage regulator has become more popular because of the ease of integrated management and surveillance and uniformity in the architecture of the controllers. Analysis of the dynamic response of a wind and solar energy system A wind farm plant model was created and matched to a genuine system. The simulation was found to be accurate. A variety of approaches to optimal architecture or unit sizing are available. On walk systems, the major control objective is to match loads in a given area. Several grid-connected technologies view the grid as either a back-up option when renewable energy sources are inadequate. With a risk of power outage of a specified time, they were initially developed to fulfil local peak load. When it comes to hybrid systems, which are primarily concerned with supplying electricity to their loads, they don't give a hoot about quality or adaptability. For utilities, nevertheless, it is preferable to have a hybrid model with a less erratic real power or the capacity to regulate its energy. As a result, users will choose a system that offers a variety of alternatives for power transmission, as it will make system administration and maintenance easier and more convenient. As a hybrid model, the control techniques must differ than those of traditional systems.

Utilizing two different approaches, such as a battery charger/modified discharger's latency control scheme and a power aggregating methodology provides a low filter, such functions of management can be achieved. Describes the hybrid model idea and its performance monitoring. PV arrays and wind turbines are both controlled using traditional power tracking systems. In order to model and simulate power-system transients, a programme named PSCAD/EMTDC was utilized.

- *When To Consider a Hybrid Solar-Wind System:*

All on the same day, in very many parts of the globe or at certain times of the year, wind and sun energy patterns are diverse and opposing. Hybrid vehicles might be the greatest solution for power generation because of these diverse trends.

- *The Combination:*

For example, a single 3kW wind farm may provide 120 kWh of power each month (instead of a 6kW one.) an arrangement of module with a lesser number of solar cells.

- *Hybrid wind-solar electricity production system Size and Price*

As a result, a combination wind-solar electric grid will require a greater upfront outlay than a single bigger system. This might happen when solar and wind sources have opposing cycles and intensity on a given day (or during certain seasons), making hybrids the better thing.

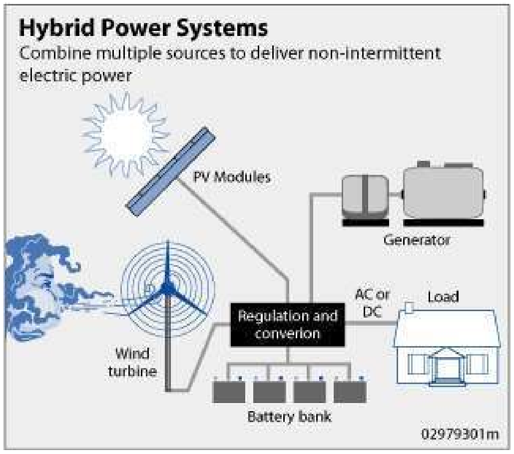

Fig 1.1:- General Hybrid System

- *When Hybrid Solar-Wind Systems Aren't Suitable*

Urbanized surroundings (unless we include new and relatively unproven urban wind turbines) and quasi places are clearly incompatible with smart systems.

Apart from that, hybrid solar-wind systems are mostly used in the production of energy Hybrid systems do not make sense in situations such as heat pumps (where solar is extensively employed).

II. SOLAR AND WIND

When solar energy is converted into dc electricity utilizing materials that show the photoelectric cells, it is known as photovoltaic (PV). Solar panels incorporating photovoltaic cells are used in photovoltaic systems. Monocrystalline silicon, cadmium telluride, polycrystalline silicon, amorphous silicon and copper indium selenide/sulfide are some of the materials now utilized in photovoltaics [1]. Recent advances in the production of photovoltaic arrays and solar cells are due to the rising need for sustainable power.

The solar pv power industry has grown to more than 100 countries, putting it the world's biggest power generating technology, despite the fact that it only accounts for a small proportion of the nation's population 4800 GW electricity producing capacity.

Since 2004, grid-connected Photovoltaic capacity has grown at an average yearly rate of 60 percent, reaching 21 GW in 2009. Building Combined Photovoltaics, or BIPV, is a type of surface photovoltaic system that is occasionally integrated with farming and livestock. An extra 3–4 GW is attributed to off-grid photovoltaics.

In recent years, photovoltaic costs have gradually dropped improvements in information and increased production scale and complexity since the first solar cells were created in the 1970s. There are several nations where solar PV installations have been aided by net meter and based subscription like as favorable flow tariffs.

During exposure to light, a substance generates voltage (or an electric current). Photovoltaics and Photo electrics are closely linked, yet they are distinct and should be differentiated. On doses of radiation of adequate power, particles are expelled from a material's surface. Because of this, electrons produced in a solar panel go from one spectrum of the semiconductor to another (i.e. valence to conductive band), leading in a voltage between two terminals. Almost all photovoltaic technologies use radiation from the sun, which is why these devices are called solar cells. An electricity generator by the depleting area of a p-n junction solar cell when the material is illuminated. It wasn't until 1839 that Alexandre-Edmond Becquerel noticed the photovoltaic effect for the first time.

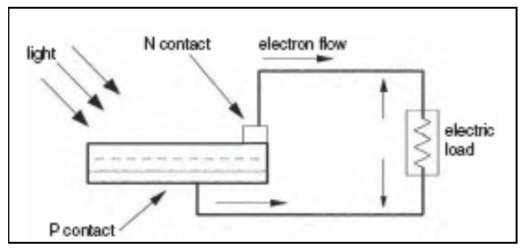

Fig 2.1:- PV effect converts the photon energy into voltage across the pn junction

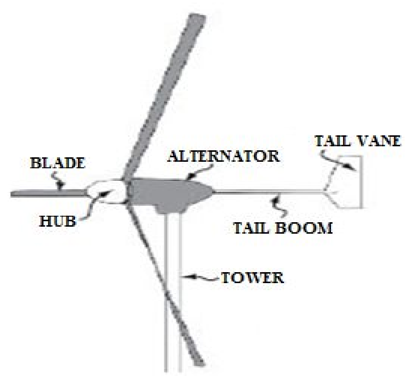

Fig 2.2:- Wind turbine

III. BATTERY STORAGE

When it comes to applications, electricity is more adaptable than other kinds of power since it is a highly organized form of energy that can easily transformed. So, it may be transformed into rotational motion with a near 100% effectiveness or into temperature with 100% effectiveness, for example. That's because heat energy is a disorganized type of energy in the atoms, and it can't be transformed very efficiently into electricity. Therefore, conventional fossil power plants have a superior heat power density of less than 50%.

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Electricity has the disadvantage of being difficult to store on a big scale. Most of the electricity utilized today is used at the same time as it's being produced. When it comes to traditional power plants, where the fuel consumption varies continually with the load need, this is not a problem. It is impossible for intermittent sources of energy, such as wind and solar panels (PVs), to fulfil the demand for power at all times, 24 hours per day and 365 days in a year.

A. Battery control

The battery converter's primary job is to alter the dc-bus voltage, as implied by its name. The battery load current changes rapidly while the grid inverter is operated in dispatching or averaging mode. Controlling the common dc-bus voltage is necessary to maintain a constant voltage regardless of battery current fluctuations. We use a modified hysteresis-control method to achieve this. Hysteresis bands can be used to alter the DC voltage of a shared circuit. A charger/discharger is regulated in such a way that it does not overshoot or undershoot, as shown in figure, the upper and lower limits of the DC bus voltage. It is decided whether to charge or discharge the battery depending on the level of the standard DC-bus voltage. The batteries buck-booster operates as per the following way:

If $V_{dc} > V_{dc_{up}}$, then charging $\rightarrow V_{dc}^{¿} = V_{dc_{up}}$

If $V_{dc} < V_{dc_{up}}$, then discharging $\rightarrow V_{dc}^{¿} = V_{dc_{lw}}$

If $V_{dc_{lw}} \leq V_{dc} \leq V_{dc_{up}}$ then no control (rest)

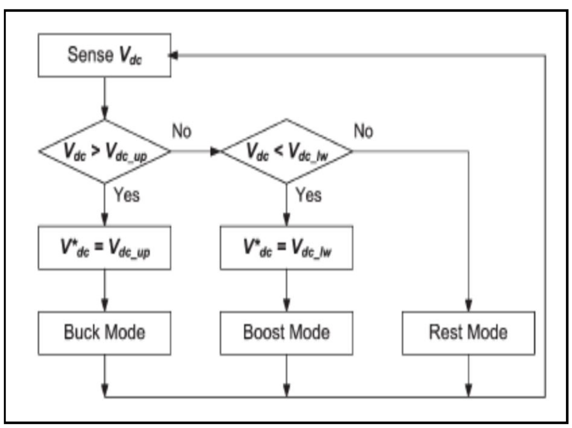

Fig. 3.1:- Battery-mode control block

Vdc is set to the higher limit if the dc voltage Vdc exceeds the upper limit. If Vdc falls below the lower limit, the voltage goal is tied to the lower limit, and the converter switches to boost mode to compensate for the voltage drop.

IV. FUZZY LOGIC CONTROLLER

A. Introduction

Ongoing progress has been made in the core application of Fuzzy control framework based on the empirical principles There are several ways to increase the performance of fuzzy frameworks. To upgrade community traditional optimization frameworks by adding a layer of insight to the current control technique, fuzzy control can be utilized. As part of the Fuzzy Inference System Editor, a Fuzzy Logic Controller is created. In this FIS editorial manager, a sensitive swapping circuit is reenacted. As a result of the fuzzy controller's contributions, VCr and ICR are calculated. As a result, the controller has a fresh value. The FIS Editor, Membership Work Editor, Rule Editor, Rule Viewer, and Surface Viewer are all included in this graphical user interface (GUI).

B. Fuzzy Inference Diagram

In this case, the fuzzy derivation outline is a combination of all of the smaller graphs we've looked at thus far. All of the fuzzy induction process's parts are displayed at the same time in this diagram. The hazy outline is filled with data. To design the mapping from a provided contribution to a yield using fuzzy reasoning, fuzzy estimation is used. At that point, the mapping provides a starting point from which decisions may be taken or designs can be identified. For example, the enrollment capabilities, fuzzy rationale administrators, and if rules are all part of fuzzy induction's process.

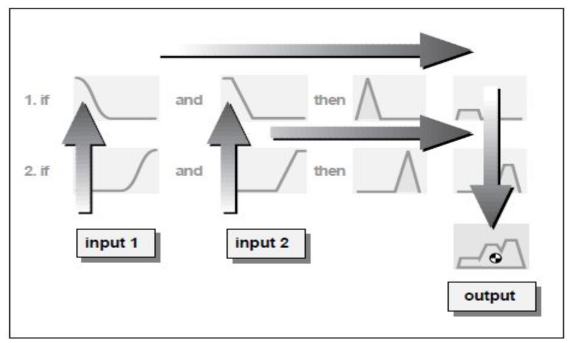

Fig.4.1:- Fuzzy Inference Diagram

There are a number of domains where fuzzy derivation frameworks have been successfully used. This is due to the fact that Fuzzy Deduction Frameworks are used in a variety of disciplines.

V. SIMULATION RESULTS

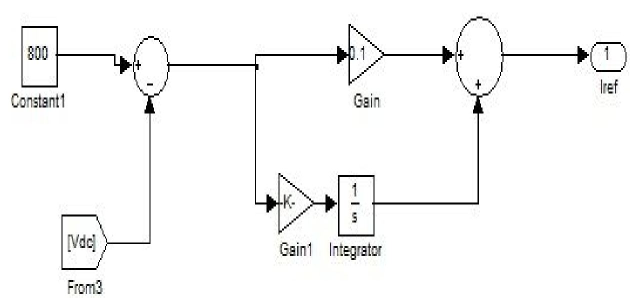

Fig.5.1:- MATLAB Simulink model of PI control

Simulink's panels and views allow us to see the program's signals. MATLAB visualization and GUI software applications allow us to create our own unique displays. For comment, we may additionally log the signals that we receive.

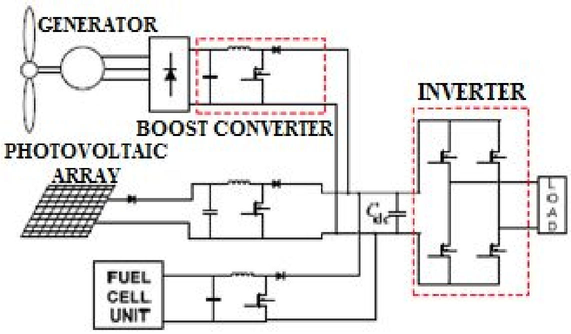

Fig 5.2:- Model of Proposed Hybrid Circuit

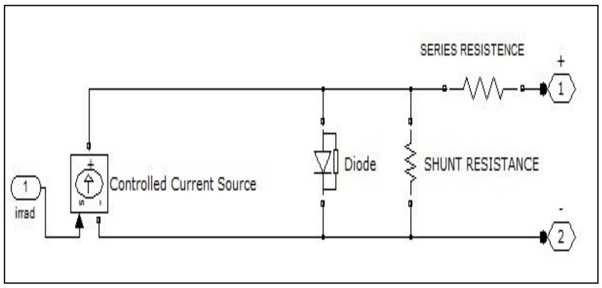

Fig 5.3:- Basic Structure of PV-Cell

Electrical radiation is used to power the fundamental PV cell, which is then fed forward from the help of a diode. Shunt and series resistors have been used to improve the performance of a PV cell.

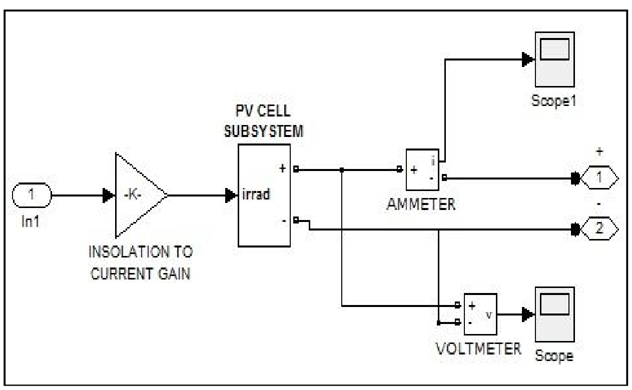

Fig 5.4:- Transition of Insolation into Current Gain

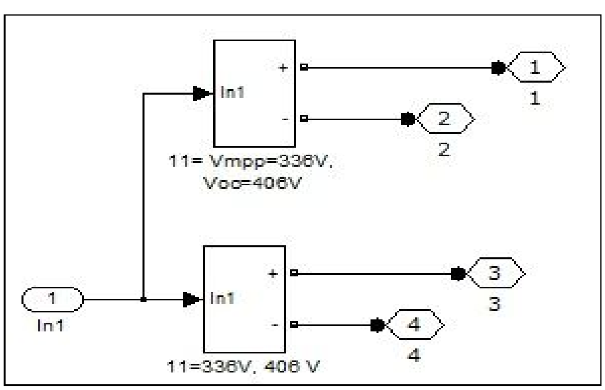

Fig 5.5:- Parallel Connection of Solar Cell

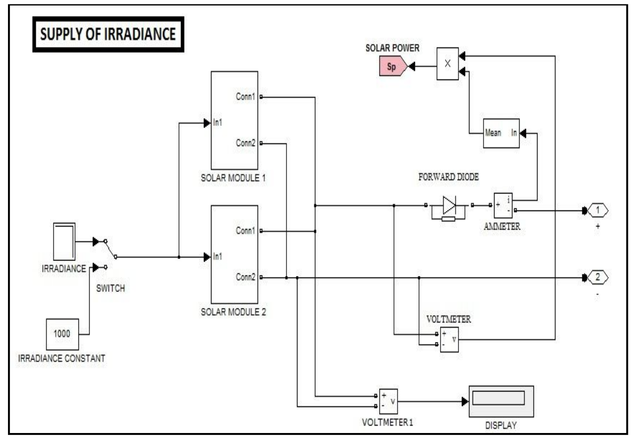

Fig 5.6:- Simulation Model Showing the Utilization of Irradiance and Solar Modules

The PV System has different components of PV cells. Each PV panel contains two rows of 11 cells. Simulink's Show block is used to increase the current generated at the parallel combination between the PV panels.

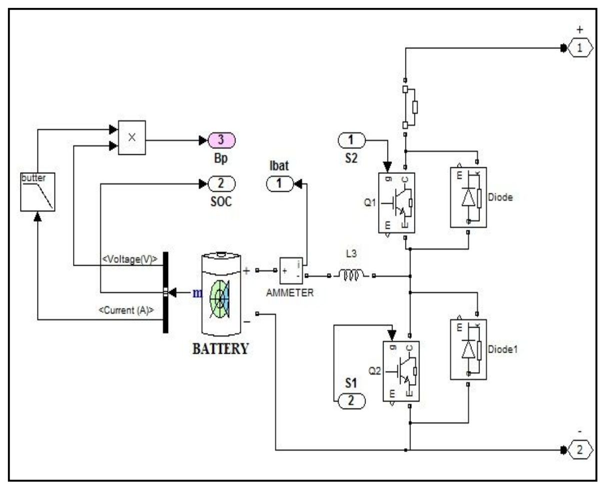

Fig 5.7:- Battery Operation features sufficient supply to load

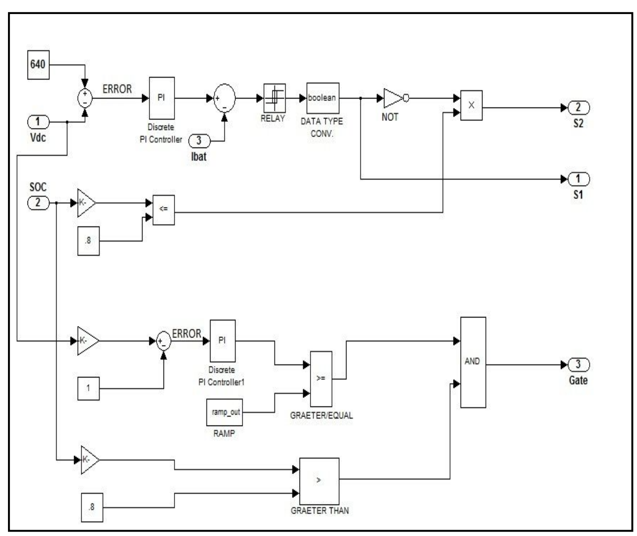

Fig 5.8:- Working Logic of Battery Operation

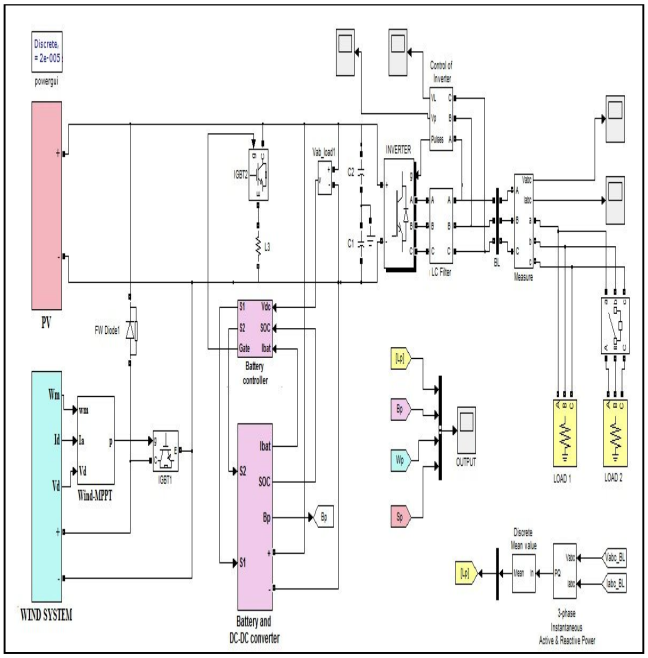

Fig 5.9:- Composite Simulation Model of Proposed Hybrid System

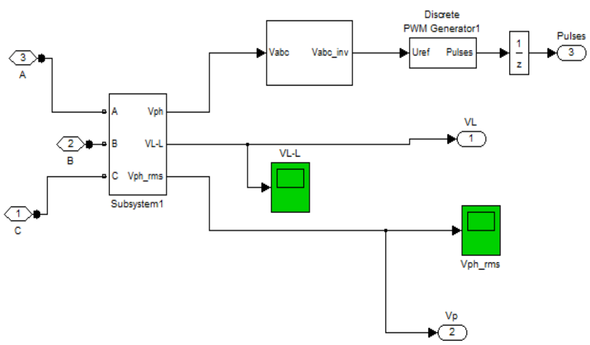

Fig 5.10:- Inverter control using PWM

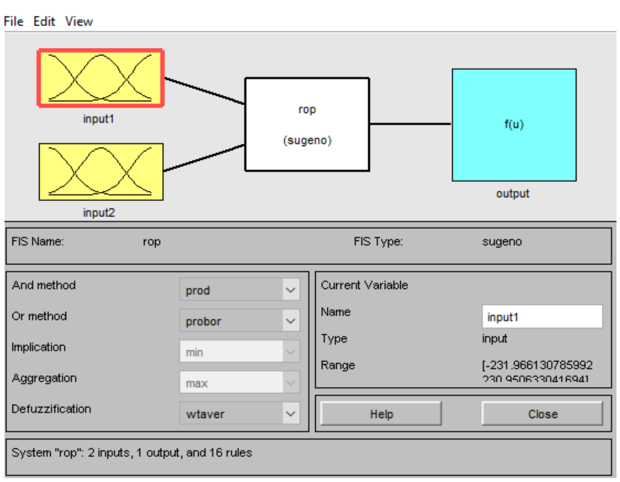

Fig 5.11:- Fuzzy Inference System

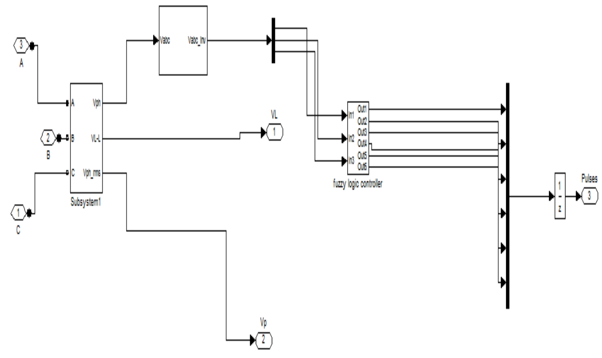

Fig 5.12:- Fuzzy logic controller based PWM controller

Table 5.1:- Life Cycle of Hybrid System

TIME	Characyeristics
0-1s	1) Solar energy with full irradiance 2) Wind Turbine tends towards base speed of 12m/s after 0.5 s 3) Battery gives partial supply to load 4) Load is 10 KW
1-2s	1) Wind achieves 5.6 KW 2) Battery stores 5 KW
2-3s	1) Solar Energy Reduced by 15 % 2) Battery stores 3.5 KW
3-4s	1) Wind speed decreases by 25 % to 9m/s 2) Battery gives partial supply to load
4-5s	1) Load is increased by 40 % 2) Battery is responsible to overcome 40 % load demand
5-6s	Load demand comes to previous point

Simulated Graphs:

- All throughout time scale, the generation capacity is 10 KW, with the exception of 4 to 5 seconds when it jumps to 14 KW.
- Photovoltaic energy's intensity declines from 2 seconds to 15 percent. After 0.5 seconds, a 5m/s wind farm increases to a 12m/s base speed. In this case, the spinning speed has been slowed down to 25% of its rated speed.
- All of these criteria are evident in the graph below.

Approximately 640 V is the maximum voltage of the PV array, according to measurements. As shown in the graph below, changing irradiance is what determines the maximum voltage.

Table 5.2:- Major Landmarks of Proposed Hybrid System

TIME	SOLAR ENERGY	WIND ENERGY	BATTERY	LOAD
0-1		Speed Tends Towards Base Speed		
1-2			Significant Charging	
2-3	Irradiance Drop	Speed falls		
3-4				
4-5			Mainstay Load Sharing	Additional Load Attached
5-6				

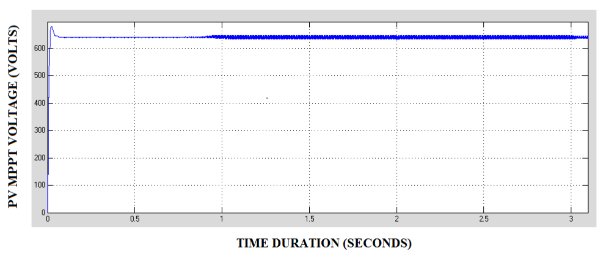

Fig 5.13:- Phase Voltage observed at the PV array

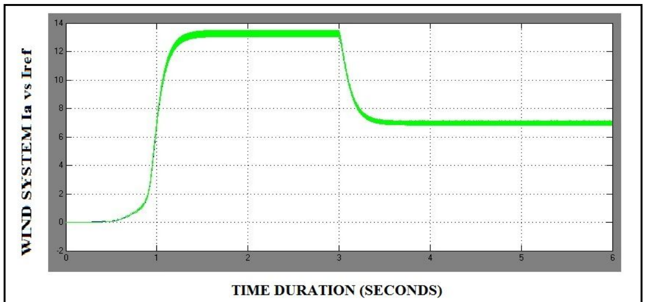

Fig 5.14:- The relative variation curve of Actual Current (Ia) and Reference Current (Iref)

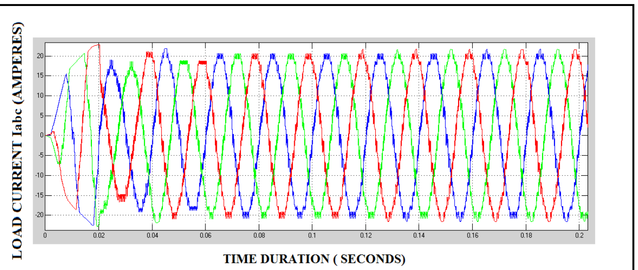

Fig 5.15:- The load current supplied to the load is sinusoidal in nature as depicted in the simulation

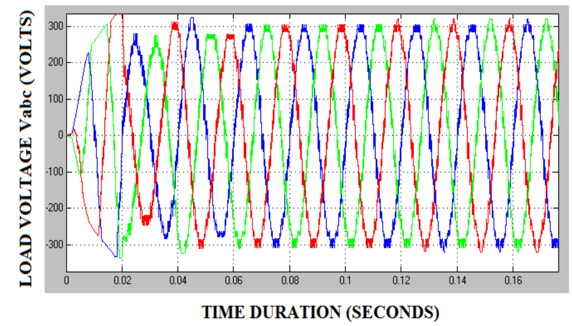

Fig 5.16:- Three Phase Voltage Supplied to The Load By The Inverter

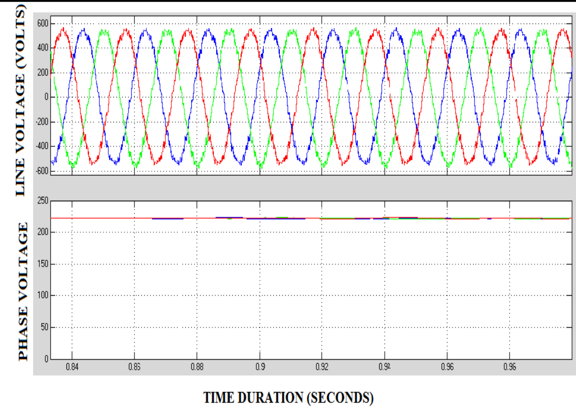

Fig 5.17:- AC Line Voltage and Phase Voltage Given by The Inverter

Table 5.3:- Inverter Output Voltage

TIME	PHASE VOLTAGE
1 s	230
2 s	230
3 s	230
4 s	230
5 s	230
6 s	230

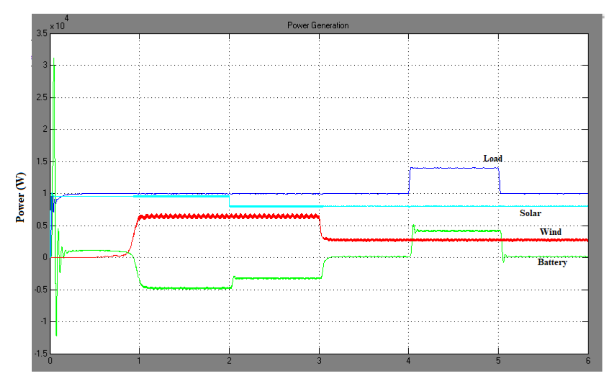

Fig 5.18:- Simulation result with PWM (PI) control

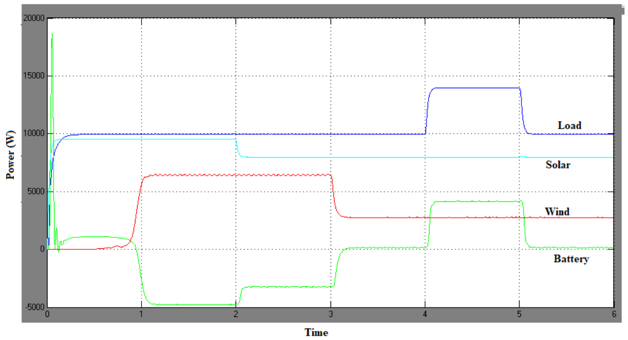

Fig 5.19:- Simulation result with fuzzy logic controller

VI. CONCLUSIONS

In the paper, the wind turbine, PV array and battery work together to meet the load requirement. A solar and wind inverter is used to convert solar and wind energy into AC electricity. It is necessary to utilize a circuit breaker to attach an extra load of 5 KW within the specified time frame. In order to satisfy the demand, this combined system is programmed to provide maximum power output even under operating circumstances to satisfy the load, either a wind or solar system is backed by the battery. Also, batteries for the same load are used to enable the simultaneous operation of wind and solar systems. When compared to a PWM controller, fuzzy control provides superior inverter system stability. The use of fuzzy logic controllers helps decrease the amount of disruption caused by load changes.

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