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# Integrated Hybrid Renewable, Diesel System with Improved Power Quality

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***Abstract*- Electricity is the most preferred form of energy used in industries, homes, business, and transportation. In the present situation, meeting the electric power is not the major issue. Global issues are increasing nowadays. So an alternative energy source is required for power generation. Renewable energy sources are widespread throughout the country. Renewable energy sources such as Photovoltaic, Fuel cell and wind energy has many advantages and can be used as an alternative energy source. In order to meet sustained load demand during varying natural conditions these sources are integrated to form a hybrid system. Hybrid systems used for power generation. Hybrid system designed with conventional methods introduces various power quality issues in the system. So in the proposed model a hybrid system designed with motor generator set improves the power quality issues. Diesel engine is also coupled to ensure that overall system performs under conditions when the renewable energy source is insufficient to meet the load.**

***Keywords—Hybrid system, PhotoVoltaic, fuel cell, wind energy, diesel engine, power quality***

## I.INTRODUCTION

Electricity networks are complex systems that cannot be efficiently and securely operated without an appropriate energy management and control system. Electrical energy is fundamental for social and economic development. One third of population lives in developing countries and has no access to electricity. There is a need for increased energy to meet the increasing energy demand. On the other hand global environmental concerns such as greenhouse effect and global warming are increasing. The solution for these issues can be met with the use of an alternative energy source which has excellent potential. India has sustained one of the most comprehensive renewable energy sectors for a long time. The renewable energy sources have excellent potential as a form of energy. The definition of renewable energy includes any type of energy generated from natural resources that is infinite or constantly renewed. Renewable energy, due to its free availability and its clean and renewable character, ranks as the most promising renewable energy resources that could play a key role in solving the worldwide energy crisis.

One of the biggest challenges of integrating renewable generation in any power grid is intermittent generation .This occurrence can destabilize the grid and cause an response known as hunting, even when wind flow is low, which leads to unnecessarily high consumption of backup fossil fuels, engine damage, and expensive blackouts. Power fluctuation is common in isolated networks, but the problem also exists in large networks at the end of transmission lines, or at the interconnection point of wind farms and other critical nodes.

Various renewable energy sources can be combined to obtain modular, expandable and task oriented systems called Hybrid Power Systems (HPS).Unbalance occurs when a single phase load is connected to the micro grid. Different methods can be used to resolve the power quality problem like the filters, inverters and other devices. These methods along with hybrid renewable system can solve power quality issues like total harmonic distortion, voltage unbalances only to some extent. Here in the modified method with the dc motor generator set in place of inverters as in conventional system voltage, speed, frequency variations at the output or grid is obtained in the acceptable range. The Total Harmonic Distortion (THD) is also obtained. This system can tolerate the rapid changes in load and environmental conditions, and suppress the effects of these fluctuations and provides optimum utilization of available resources.

To meet the sustained load demand during varying natural conditions and the effective production of electrical energy renewable sources can be used. Several power quality issues arise when a single energy source is considered for

energy management. In order to meet this sustained load demands during varying natural conditions, and to reduce power quality disturbances, different renewable energy sources and converters are need to be integrated with each other. Hybrid system provides an alternative for this intermittent nature of the renewable energy sources. Aim is to study different configurations of hybrid system and to select the system that provides improved power quality. The Hybrid system designed with motor generator set, in place of inverters as in conventional system provides energy management with all power quality variables within limits.

## II.LITERATURE REVIEW

### *A.Over -View*

The major power quality issues that occur in power system are due to long time voltage variations (overvoltage, under voltage, and sustained interruptions), short time voltage variations (interruption, sag, swell, voltage imbalance, waveform distortion (DC offset, harmonics, inter harmonics, notching and noise), voltage fluctuation (voltage flicker) and power frequency variations. Different methods for power quality improvement are given.

### *B.Filter*

The compensation of voltage unbalances is usually done by using series active power filter (APF) through the injection of negative sequence voltage in series with the power distribution line. While connecting inverter to the grid without an APF the THD value is 32.8%. [1] By using APF in a Distribution Generator (DG) unit the THD is reduced to 10.2% in non linear loads. By using series APF, the Total Harmonic Distortion (THD) value reduced to 9.5%.

### *C.Custom Devices*

Active Power Conditioner (APC) acts as to interface between renewable energy sources and the AC bus of micro grid. Extended indirect control strategy is capable to achieve better values for the following power quality indicators: THD, Power factor, current and voltage balancing. [3] Storage devices can be used as a means of removing the problems. Adding batteries for storage is expensive and the cost will rise as the size of batteries increases, while increasing the size of the hydrogen storage container has a nearly flat nonlinear cost curve. Batteries are not discharged beyond a minimum level, but hydrogen storage can go to zero**.**Electrolyser based approach when used compensate the system real power unbalance Certain devices when used improve the voltage and current in nonlinear loads and reduce voltage sag and swell. For example unified power quality conditioner when used reduced the supply current THD to 0.96%.Statcom device can be used to reduce the harmonics. Scheme is superior compared to the other conventional controller technique in terms of energy saving and dynamic performance.It reduces the total harmonic distortion to 3.21%.

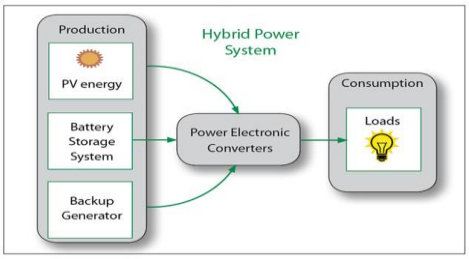
### *D.Inverters*

The shunt inverter is responsible for keeping a set of balanced distortion-free voltages within the micro grid, while the series inverter is controlled to inject unbalanced voltages in series along the feeder to balance the line currents and to see no real and reactive powers are generated. The Hybrid Power System (HPS) topologies use inverters to interface the renewable sources to the load with an offering of low quality power. They are:a)Stand alone system-AC bus layout, dc bus layout, ac to dc bus layout. B) Grid connected system.

All these architectures lag in terms of power quality, which limits the system to connect to the central utility grid. Also, they lack in effective energy management between energy sources and loads to increase the utilization, reliability, and stability of the supply

## III.HYBRID RENEWABLE SYSTEM

A Hybrid energy system is used to meet the increasing energy demand and a DC motor generator set i used for improving power quality they are used in range of 1 to 100 KW.




. Fig. 1.Hybrid Renewable System

### *A. Description of the system*

A Hybrid Power System (HPS) contain alternating current (AC) diesel generators, an AC distribution system, a Direct current (DC) distribution system, loads, renewable power sources, energy storage, power converters, rotary converters, coupled diesel system, dump loads, load management options.. The output of the renewable sources cannot feed the load directly as the voltage fluctuations due to environmental variations are large to damage the concerned load .The DC to AC or the AC to DC converters are used to condition these voltages. Thus, the varying voltage can be brought to the specified variations limits by varying the duty ratio of the converters, and then connected to DC bus. The DC bus voltage is used to drive the DC motor, coupled to the synchronous generator. The Wind turbine output power varies with the wind speed, the PV cell output power varies with both the temperature and irradiance and the FC output power varies with input fuel. So diesel engine is coupled to synchronous generator as a stand by prime mover to avoid shortage of power. The DC motor, alternator and diesel engine are mechanically connected using a clutch. The DC bus integrates all the energy sources and storage batteries. A micro grid connected which ensures stable operation during faults and network disturbances. [5]

### *B. Unit sizing of the system*

In order to efficiently and economically utilize the renewable energy resources optimum sizing method is necessary with full use of the PV array, wind turbine and battery bank, so that the hybrid system can work at the optimumconditions and get optimum system power reliability. Loss of Power Supply Probability (LPSP) technique is used to size the components.

### *C. Algorithm*

- EMCU checks for the conditions whether $P_G \geq P_L$ or $P_{G<}P_L$.According to these conditions, some of the available energy sources will be switched on to meet the demand exactly while some sources may be in rest.
- Initially, PV and WP systems are switched on since there is no input fuel cost for them and EMCU compares the power and load.
- If $P_G$ is more than $P_L$, that indicates the generation of excess power, this excess power is used to charge the batteries or in the process of hydrogen production in electrolyser. If the EMCU finds still excess power, it will switch on the grid synchronizing unit in export mode so that excess power is exported to the grid.

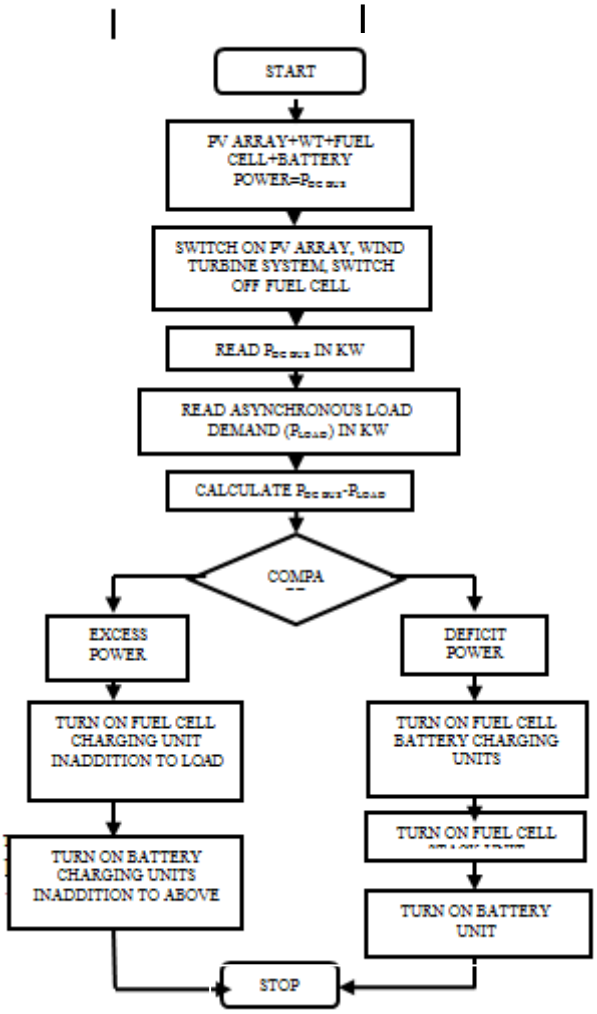



Fig. 3 Algorithm of Hybrid system [4]

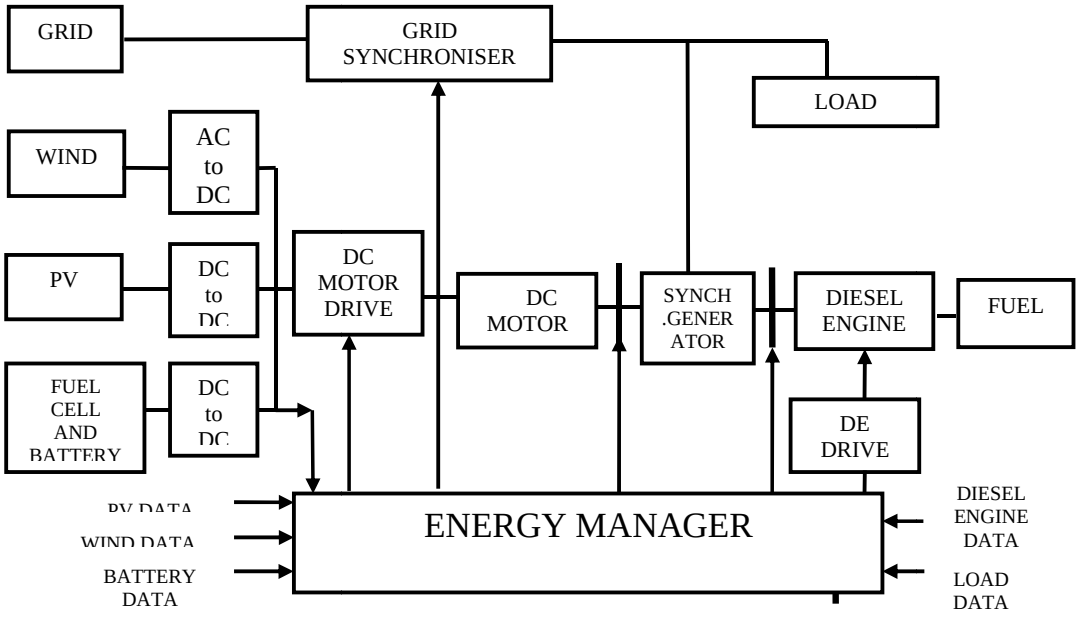



Fig. 4 Block diagram of Hybrid system

- Batteries are switched on if required depending on load, and if still it is found as deficit, the remaining power demand is supplied by central grid, i.e. the EMCU switches the synchronizing unit to grid import mode.
- The process of switching between the resources continues by depending upon the load demands and environmental conditions.
- In any fault or emergency conditions where there will be loss of synchronism, EMCU opens the grid synchronizing unit to isolate HPS with utility grid. The Hybrid Power System is based on the multi-agent theory where the control subsystem is regarded as an agent .Each agent will act as a local controller for that area and connected to the central EMCU to perform the role of data acquisition and communication. The agent takes the control signals from the EMCU and manages the operation of the local micro grid and energy sources like wind generation, solar etc. [10]

### *D. Simulation results*

The power quality problem causes the deterioration of performance of various sensitive electronic and electric equipments. In order to compare the effectiveness of the proposed HPS architecture with the exiting inverter

Table 1 Comparison of conventional and hybrid system

| Sl No. | Specification | Inverter based HPS | MG set based HPS |
|---|---|---|---|
| 1 | THD | 4.87% | 4.61%,0% at steady state |
| 2 | Energy conversion efficiency | 97% | 91.78% |
| 3 | Electrical efficiency | 25%load=85.5%<br>50%load=884%<br>75% load=90.2%<br>100%load=91.2% | 25%load=86%<br>50%load=89%<br>75%load=90.8%<br>100%load=91.3% |
| 4 | Variation in voltage for reactive power variations | Noisy and high | Noisy and high |
| 5 | Variation in voltage for grid exchanges | Noisy | Smooth |
| 6 | Voltage sag | 42% | 21.6% |
| 7 | Voltage swell | 40% | 28% |
| 8 | Voltage imbalance | 13.3% | 3% |
| 9 | Frequency deviation | ±0.4% | ±0.22% |

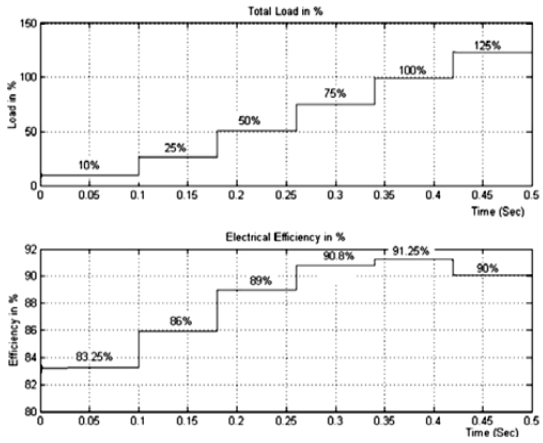



Fig. 5 Electrical efficiency at different loads [10]

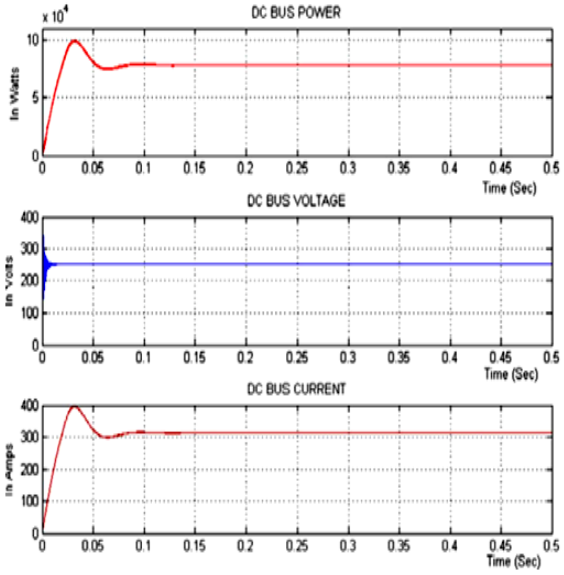



Fig.6 DC bus power, voltage and current [12]

Hence hybrid renewable system with dc motor generator set is the suitable system with improved power quality .Frequency-±0.4%, speed-±0.2%, THD-0%, terminal voltage of system- 0% is obtained with the system. With all the above merits the hybrid system with the motor generator is best suited for power quality improvement and also in the economic perspective. In the next chapter conclusion is given highlighting the merits of the sys**tem.**

## IV.CONCLUSION

The stand-alone hybrid solar–wind power generation system is an alternative to grid supply or conventional fuel-based remote area power supplies all over the world. It is more suitable than systems that only have one energy source. Improving power quality in Hybrid Power Systems ensures continuous and reliable supply to loads. Conventional architectures of the renewable energy based Hybrid power systems are majorly associated with power quality issues. The

method developed here is based on the use of DC Motor-Synchronous generator set instead of using inverters to convert DC to AC Voltages feeding to central utility power grid. It has many advantages

- The main control tasks (voltage/frequency control) are done by the central micro grid controller. This facilitates the application of HPS for grid connected mode.
- The proposed control algorithm manages the switching between available resources according to the load fluctuations.
- Voltage, Speed, Frequency variations at the output/grid is found to be within the acceptable range. The Total Harmonic Distortion (THD) obtained.
- This system can tolerate the rapid changes in load and environmental conditions, and suppress the effects of these fluctuations and provides optimum utilization of available resources.
- This system allows the facilities to export, import, generate, and use power without violating any regulations and tolerate the rapid changes in load and environment.
- This system also ensures continuous, stable and reliable supply to loads by providing optimum utilization of energy resources for economic and quality power generation.

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