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Controllable Hybrid Power System:A Generation Towards Sustainable Development

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Abstract—

Theglobal warming, air pollution and climate change are danger signals that all is not too well with environment. The main causes of these adverse effects are conventional energy generation. Renewable energy has great capacity to usher in universal energy access. Today, about 400 million people in India have no access to commercial electricity. Energy generations from renewable sources are the best solution for this type of problem. PV and wind energy has received overwhelming attention world wide. The purpose of this report is an operation and control strategy for renewable hybrid power system for an off grid operation We are analyzing the data of wind and solar system and estimate the average energy by using hybrid power system with small storage system. In future we will be installing large solar and wind plant which are cheaper as compared to small plants.

Keywords—Battery Storage, Converter, Hybrid System, PV, Wind.

I. INTRODUCTION

In India, out of 593,732 villages there are 21,318 villages listed under the category of un-electrified villages as per ministry of new and Renewable energy Sources, Government of India. Electrification of the un-electrified villages is a great challenge facing the developing countries including India. The Government of India has taken essential steps towards the implementation and promotion of decentralized electricity generation through Renewable Energy Technology (RET) systems.At present in most of the unelectrified villages in India that are located far away from the central electricity grid and have small loads are supplied traditionally by diesel generators which have high reliability, high running cost, high maintenance and low efficiency. However, setting up of new power plants is dependent on highly volatile fossil fuels. The increasing consumption of conventional fuels is leading to degradation of environment. It motivates us to establish an ecofriendly renewable energy sources. Renewable Energy is an emerging sector. This is an area where we are addressing issues of meeting our energy needs from perennial natural resources like solar, wind, hydro, biomass etc. The Ministry of New and Renewable Energy (MNRE) is aiming towards accelerated exploitation of renewable energy potential in the country. Renewable energy is optional today but will be an essential requirement of the future. Today, the investment in these technologies will secure our future to meet energy requirements in a sustainable manner. The total estimated potential of renewable energy is about 2, 45,880 MW. The sources wise potential is shown in Table1. The major disadvantage of renewable energy is they are variable in nature and unpredictable. The hybridization is used to control the variability of renewable energy input. The use of storage system and suitable energy management system allow controllability and the captured energy is delivered when needed. Hybrid power systems are combination of renewable energy sources as solar (PV), wind generators, small hydro plant, biomass etc. with chargeable batteries. Hybrid power system provides power to meet the peak demand. The hybrid systems have become precise solution for a clean and distributed energy production. This paper presents, operational and control strategy for off-grid hybrid power system based renewable energy resources. The control strategy based on digital logic and PI controller. The proposed control strategies give very efficient results to get low power fluctuation and meet given load.

Sr.No.	Resources	Estimated Potential (In Mega Watt)
1.	Wind Power	(at80 m hub height) ~100,000
2.	Solar Energy	>100,000 30-50 MW/sq.km.
3.	Small Hydro	(up to 25 MW) 20,000
4.	Bio-Power	
	Agro-Residues	17,000
	Cogeneration- Bagasse	5,000
	Waste to Energy (Municipal Solid Waste to Energy-Industry Waste to Energy)	2,600-1,280
	Total	>2,45,880

Table.1. Potential of Renewable Energy in India

II. SOLAR WIND HYBRID POWER SYSTEM

Hybrid energy system is made up of combination of two or more energy resources such as sources at a time like wind, solar, biomass, etc. Wind and solar hybrid combination is concerned to be best module because it is abundant and environmental friendly. Also the stand alone system of this combination has disadvantages that wind cannot flow continuously and solar radiation is present approx. 8to10hours a day. Thus this combination is hybridized with energy storing batteries. Wind speed are low in the summer when the sun shines brightest and longest. The wind is strong in the winter when less sunlight is available. Because the peak operating time for wind and solar system occur at different times of the day and year, hybrid

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system are more likely to produce power when you need it.They also offer power supply solutions for remote areas, not accessible by the grid supply. Today, around 30,000 wind turbines and more than 1,00,000off-grid Solar PV systems are installed all over the world.

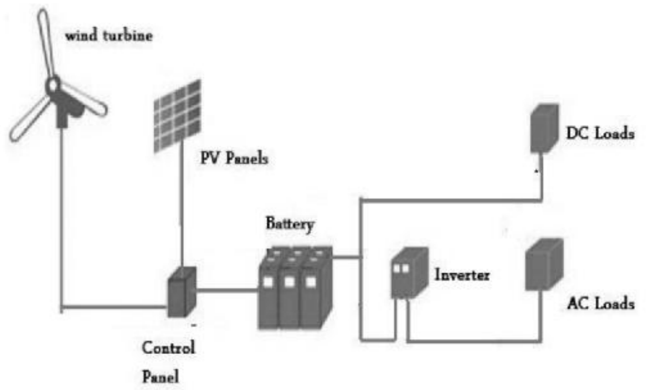

Fig.1. Solar-Wind Hybrid System

III. SYSTEM DESCRIPTION AND CONTROL STRATEGY

The architecture of hybrid system is presented in Fig.2.The system is made of two renewable resources which are wind, solar and a storage unit. The elements mentioned above are connected to each other through a DC bus. The control of the power is acquired by DC-DC converters. A central monitoring system which is known as Energy Management and Power Regulation System (EMPRS) attains the specific voltage and current which is required to access the working parameter of different elements. It provides control strategy for converter. The individual control algorithms define the converter control signal initiate with EMPRS, which is shown Fig.4. The supervisor synchronizes all converters for required operational objectives i.e. predefined power, energy, period and their individual constraints. To maximize the economic yield of the system, the sources should constantly operate their maximum extent by utilizing all the accessible renewable energy.

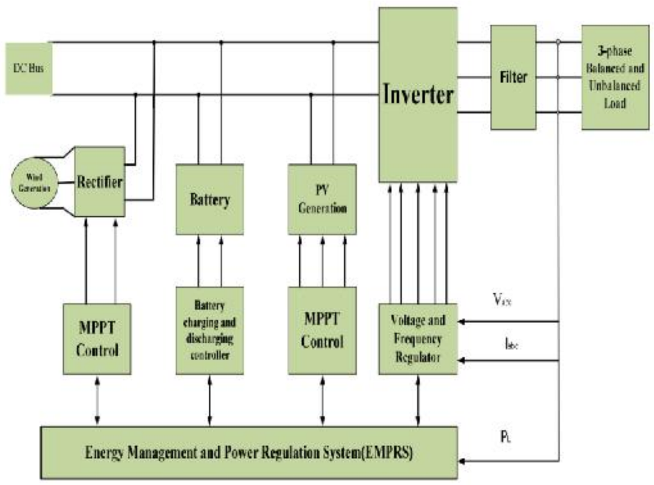

Fig. 2.The proposed architecture of hybrid system

3.1.RENEWABLE ENERGY SOURCES

The system model consists of three main elements i.e. Wind turbine model, PV panel model and the battery model. The hybrid system architecture is presented in Fig.1 and it consists of wind and photovoltaic and storage unit. These elements are connected through DC bus which produces dc power. This power is converted into AC through inverter to maintain required parameter i.e. frequency, voltage etc. These parameters are controlled by EMPRS. The EMPRS controls individual MPPT for different resources of energy.

3.1.1.SOLAR (PV) SYSTEM

A PV system is a combination of series-parallel connected array of solar cells. Solar cells are photoconducted device which covert solar energy into electrical energy. These solar cells are made of silicon which is known as semiconductor materials. The developed model for PV is based on incremental conductance with integral regulator algorithm which provides maximum possible power from solar PV array. The converter is varying duty cycle due to which converter change the PV voltage such a way that operate the PV array towards its maximum power point.

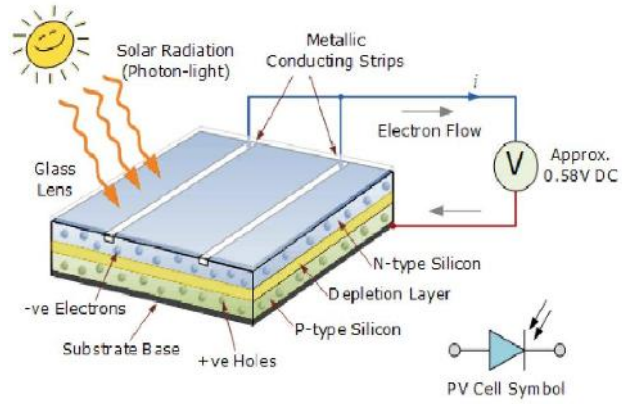

Fig.3. Solar Cell

The power generated by solar cell is calculated as,

$$PS=Ins(t)\times AS\times Eff(pv)$$

Where

Ins(t)=isolation at time t (kw/m2)

AS=area of single PV panel (m2)

Effpv=overall efficiency of the PV panels and dc/dc converters.

The overall efficiency is given by,

$$Eff(pv)=H\times PR$$

Where,

H=Annual average solar radiation on tilted panels.

PR=Performance ratio, coefficient for losses.

3.1.2.WIND ENERGY SYSTEM

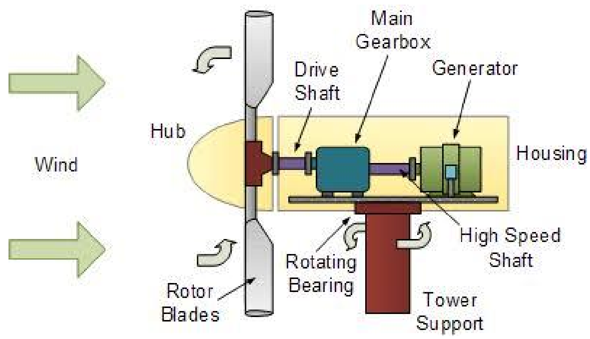

Fig.3. Wind Turbine Model

The flow of air is a type of kinetic energy. This kinetic energy is generated from the air movement of the difference of speed and pressure. This kinetic energy is used to obtain electric power. The power coefficient of the turbine CP is the relationship between the mechanical power and the wind power C_P=P/P1. The mechanical power of the turbine,
therefore,

$$P=0.5\times \rho \times A\times C_P\times V^3$$

C_P is called the power coefficient of the rotor. The maximum theoretical value of 0.59.For practical application the maximum Cp is achieved between 0.4 and 0.5 for high-speed turbine. The power coefficient CP is a function of the ratio between the speed of the blade tip and the wind speed,

$$\lambda = \frac{\omega R}{V}$$

where R is the radius of the rotor and V is the rotational speed of the rotor. The parameter λ is called "tip-speed-ratio" (TSR).

3.1.3.CALCULATION OF TOTAL POWER

The total power generated by this system may be given as the addition of the power generated by the solar PV panel and power generated the wind turbine.
Mathematically it can be represented as,

$$PT=N_W\times Pw+Ns\times PS$$

Where,

PT is the total power generated.
P_W is the power generated by wind turbine.
P_S is the power generated by solar panels.
N_W is the no of wind turbine.
Ns is the no of solar panels used.

3.2. STORAGE DEVICE

In power system, the batteries are acted as spinning serve. A storage battery receives electrical energy as direct current and stores it in the form of chemical energy by a reversible electrochemical reaction. The Thevnin's equivalent battery model is shown in Fig.4. Based on this model, a battery

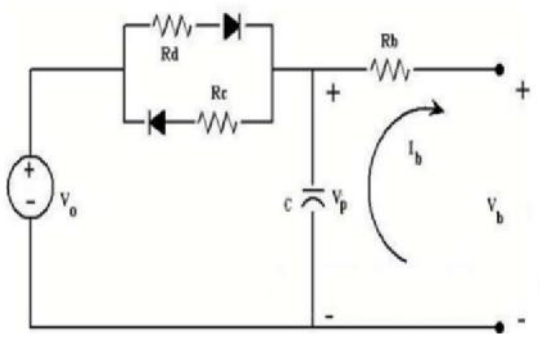

Fig. 4. Thevenin's Equivalent Battery Model

3.3. THE LOAD MODEL

The load model is built using measured data or estimated data for multiple load sand multiple seasons of the year.

3.4.EMPRS UNIT

The EMPRS works on four different modes which coordinates with battery algorithm. It is based on three different modes. These modes are based on SOC (state of charge) of battery bank. It controls all the switching operations according to control algorithm given below,

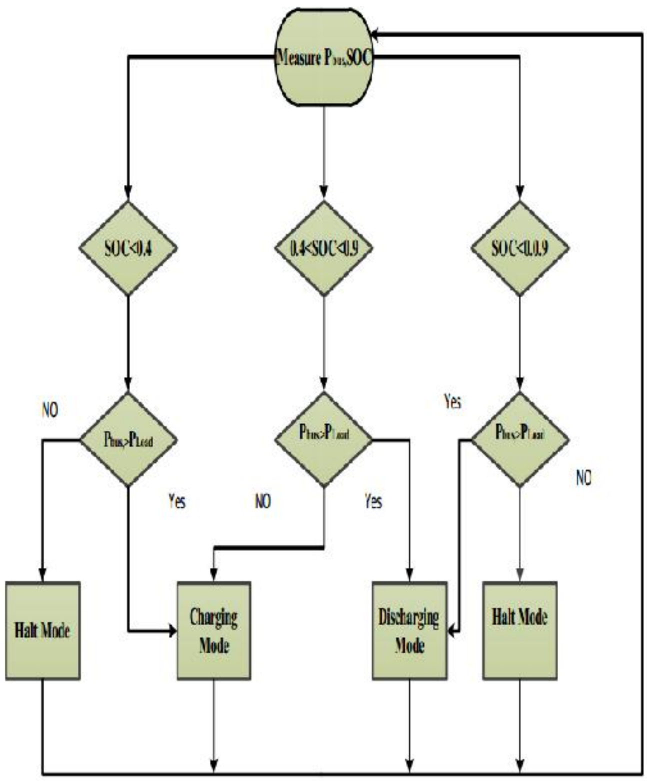

Fig.5. Battery Control Algorithm

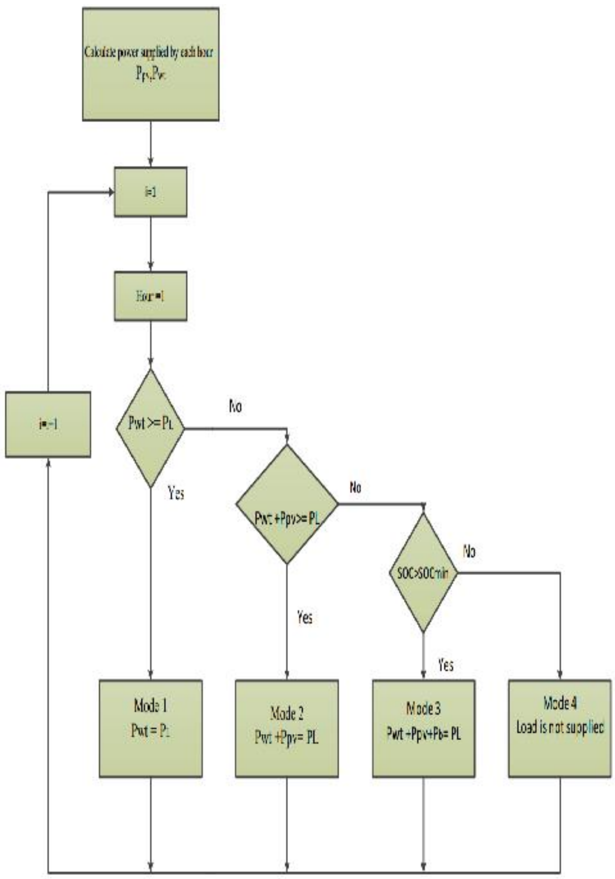

Fig.6.Control algorithm

3.5. CONVERSION BLOCK

The convertors used to convert the powers from AC to DC, DC to AC and from DC to DC.This block is connected to the output of the PV panel and the wind turbine and depends on the converter efficiency and the connection topology of the hybrid power system.

IV. RESULTS AND DISCUSSION

According to Dr, ArunAshfaq's report we can conclude that the data of different resources are used helps to analyze the active and reactive power variation of hybrid system. The variation of different parameter are shown in figures 7. Hybrid based control strategy on optimization technique for wind/solar PV of 1 MW power plant. Power generation fluctuation rate in range of 10%. Using proposed EMPRS for power generation fluctuation get 10% as comparable with simulation result at 2.1 to 2.5 sec. Power fluctuation rate is minimize up to 10% which is 27 kW as compare to maximum generated power of 30 kW.

V.CONCLUSION

An operation and control strategy for a hybrid power system with energy storage for off-grid is proposed. The performance of the proposed control strategy is analyzed under different wind, solar and load conditions. The use and hybridization of available energy resources will promote environmental sustainability by reducing the demand for fossil fuels and wood, and by contributing to green energy. The advantage of the EMPRS ensures the reliable operation with variable intensity of sources. The main goal is achieved a responsive hybrid system which meets the electrical load demand. . The proposed control strategies give very efficient results to get low power fluctuation and meet given load.

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