Design and Implementation of Wind-Solar Hybrid Power System with Power Converters

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Abstract— The electrification world map shows that the rural areas are in great need of affordable & reliable electricity to achieve development. According to the World Bank's 2017 State of Electricity Access Report, 1.06 billion people still do not have access to electricity and 3.04 billion people still rely on solid fuels and kerosene for cooking and heating. The Renewable Energy Sources (RES) are one of the most suitable and environmental friendly solution to provide electricity in the rural areas. Wind and solar PV costs were lower and long-term contracts in some countries were in the range $60-80 for onshore wind and $80-100 for utility scale solar PV. The merit of renewable energy technologies are flexible, modular and can be used in various configurations, ranging from those that are grid-connected to those that are off-grid. This paper describes the implementation of Wind – Solar Hybrid system with power converters.

Key words: Wind-Solar Hybrid Power System

I. INTRODUCTION

Hybrid power system can be used to reduce energy storage requirements. The power electronics scheme proposed here involves a multi-level inverter for obtaining a constant voltage and constant frequency AC power supply for utility or commercial applications. A portable solar PV system is used which effectively eliminates rapid fluctuations. This system is capable of simultaneously maximizing the power generated by every PV cell in the PV panel. The proposed configuration consists of an array of parallel-connected PV cells, a low input voltage step up power converter. This system also reduces power conversion losses by employing multi-level inverter. To enhance efficiency a tracking wind direction system is implemented, to sense the speed of the wind and the rotor tends to rotate according to the changes in wind direction. This is achieved by providing a wind vane.

II. ENERGY SCENARIO

India with production of 1,278.91 TWh in 2015, India was the 3rd largest producer & 4th largest consumer of electricity in the world, with the installed power capacity reaching 305.55GW by September 2016. The country also has the 5th largest installed capacity in the world. Wind energy is estimated to contribute 60GW, followed by solar power at 100 GW by 2022.The target for renewable energy has been increased to 175 GW.

A. Installed Capacity – Wind

The table shows the India's year on year installed wind power, annual wind power generation and annual growth in wind power generation since 2014.

Financial Year	2014-	2015-	2016-
	2015	2016	2017
Installed Capacity(MW)	23,447	26,777	32,280
Generation (GWh)	28,214	28,604	46,011

Table 1: Installed Wind Power Capacity and Generation in India Since 2014

Tamil Nadu's wind power capacity is around 29% of India's total. The Muppandal windfarm in Kanyakumari, Tamil Nadu with the total capacity is 1500 MW is the largest wind power plant in India. The total wind installed capacity in Tamil Nadu is 7633 MW. During the fiscal year 2014-15, the electricity generation is 9.521 GWh, with about a 15% capacity utilization factor.

B. Installed Capacity – Solar

As of September 2017 the country's solar grid had a cumulative capacity of 14.77 GW. Tamil Nadu was the state with the highest installed solar-power capacity in India on 21 September 2016, when the 648-MW Kamuthi Solar Power Project was dedicated. With this plant, the total installed capacity in Tamil Nadu is 1,697 MW as on 31 July 2017. This is 21 percent of the installed renewable energy in the state; the other 79 percent is wind power.

III. HYBRID POWER SYSTEM

Hybrid systems using renewable energy sources together with batteries or a diesel generator can be used to address the problems of intermittency. Wind energy is the largest renewable energy source in India. Projects like the Jawaharlal Nehru National Solar Mission (aims to generate 20,000 MW of solar power by 2022) are creating a positive environment among investors keen to exploit India's potential.

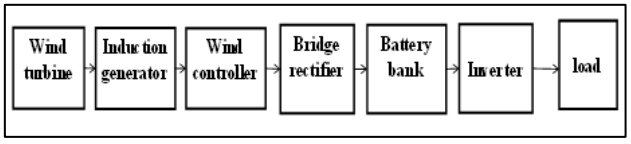

Fig. 1: Block Diagram of Wind Power System

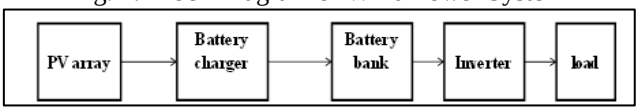

Fig. 2: Block Diagram of Solar Power System

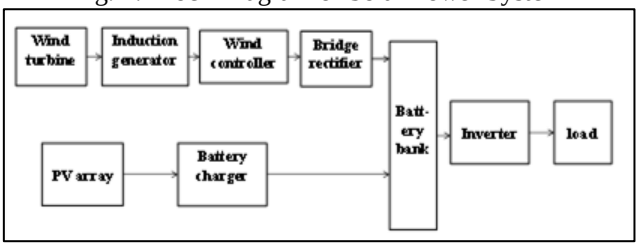

Fig. 3: General Block Diagram of Wind-Solar Hybrid Power System

1) Solar Panel

Solar panel / PV panel are used to convert the renewable power coming from the sun into electrical energy. The principle of working solar panel is with semiconductors. Solar panels are photovoltaic which generates electrical energy using sun light radiations. Depending on the position and intensity of the sun radiations, the amount of electrical DC energy will be produced. For the proposed project specifications and design, a 12V, 150 Watt off grid solar panel is required.

a) Design Specifications

- PV panel rating - 200W
- Peak power/module - 100W
- No. of cell/module - 12
- No. of cell/panel - 36
- No. of module/panel - 3
- Operating temperature - 40 to 85 degree Celsius
- Module Dimension - 1026*671*40 mm
- Solar cell type - mono crystalline cell
- Solar Cell size - 60(10*6) inch
- Battery rating - 12V/100 Ah
- Type of PV module - Silicon
- Type of battery - lead acid
- Inverter rating - 500W

2) Wind Turbine

The wind is available 24 hours in earth's eco system. Wind turbine having large blades which are joined to rotor of generator leading to produce electrical energy. Wind Turbine is a mechanical system/machine which generates electrical energy from renewable wind energy source.

Depending on the speed of the wind the amount of electrical AC energy will produced. For the project, a 500 watt, having 3 blades of 1 meter radius, wind turbine generator will be needed. The height of the wind turbine should be 18 meters. For foundation of it a 2 x 2 x 4 m space required.

a) Foundation

The foundation has to be strong enough to withstand the wind forces. Hence, it is designed with a good factor of safety and in consideration of the following factors.

- Weight of the tower and nacelle
- Height of the tower
- Maximum wind speed
- Soil bearing capacity

It is constructed with large quantities of cement and steel reinforcements.

Fig. 4 : Wind Mill Foundation

Fig. 5: Wind Mill Erection

Fig. 6: Wind Mill Installation

3) Battery

The electrical energy produced by the system is needed to be either utilized completely or stored. Complete utilization of all the energy produced by the system for all the time is not possible. So, it should be stored rather than wasting it. Electrical batteries are the most relevant, low cost, efficient storage of electrical energy in the form of chemical reaction. Hence, batteries are preferred. The energy generated from the proposed project is needed to be stored. So, two batteries are needed. One is attached to wind turbine for which a 120AmpH battery will be required, which will be fair enough full fill the storage capacity for targeted value. The second battery is 80AmpH is preferred for storing solar energy.

4) Inverter

Inverter is an electronic system, which converts direct current into alternating current, i.e. DC into AC. The stored electrical energy in the batteries is DC in nature. And it cannot be utilized for various kinds of load. So, for delivering AC supply to the load inverter system is required. The proposed project uses the inverter which is analog in nature. The input energy is in DC (12V) form stored in the batteries. It will convert it into AC with ~230V, 500W (the maximum value of load to be attached), ~50Hz specification matching with the house hold mains supply. At output, AC loads is attached.

IV. ESTIMATION OF THE PROJECT

The design and implementation of wind-solar hybrid power system for producing 500 W with the estimated cost of Rs.86600 is given below

S.No.	NAME OF THE EQUIPEMENT	COST(Rs)
1.	Battery	11,000
2.	Charge controller	8,600
3.	Inverter	4,700
4	Solar PV module	21,500
5.	Lattice tower	7,000
6.	Tubular tower	3,800
7.	Generator	9,000
8.	Blades	10,000
9.	Nacelle	11,000
	TOTAL	86600

Table 2: Cost Estimation

V. LOAD

The inverter is used in the system to convert DC into AC and the ac loads are connected to the system. The power produced in the system are given to light loads such as tube light, fan etc., In our implemented system we are providing supply to 3 rooms, each with the lightning load of 2 tube lights and a fan.

Time in hours	Load in Watts
0-2 AM	282 W
2-4 AM	270 W
4-6 AM	252 W
6-8 AM	243 W
8-10 AM	202.5 W
10-12 AM	181 W
12-2 PM	162 W
2-4 PM	143 W
4-6 PM	177 W
6-8 PM	192 W
8-10 PM	209 W
10-12 PM	238 W

Table 3: Output

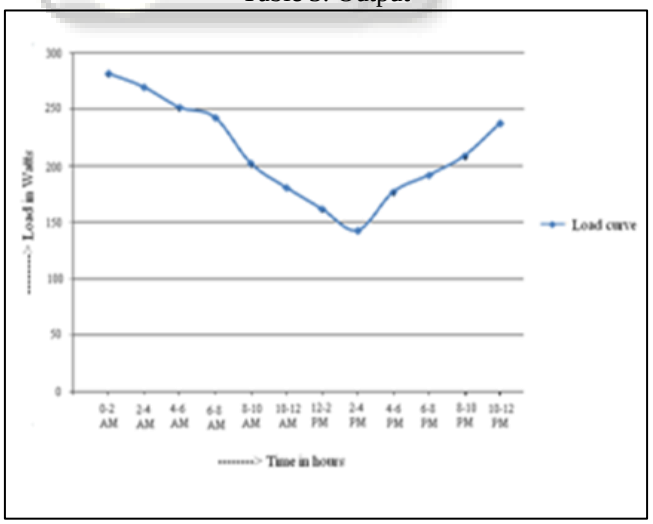

Fig. 7: Load Curve

VI. CONCLUSION

The continued growth of renewable energy and energy efficiency despite the tumbling prices of fossil fuels is a clear indication that there is a global shift towards the adoption of clean energy. The hybrid system proposed in this project is suitable for small houses. In this system electrical energy is produced from both solar panels and wind turbines. Then it is directly given to the load. The excess energy is given to the battery groups to charge them. The desired voltage and frequency is obtained from the Solar and Wind Energy Conversion Systems for Remote localities. The power conversion losses are reduced by employing multilevel inverter.

For real power conversions from DC to AC, the cascaded inverters need separate DC sources. The structure of separate DC sources is well suited for various renewable energy sources such as photovoltaic and wind. Least number of components is required to achieve the same number of voltage levels. Considering the implementation cost of MLI, we have provided the normal inverter. In future expansions multilevel inverter and solar tracking system using stepper motor will increase the power output from the system. The output obtained from the inverter is fed to the ac loads.

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