Renewable Hybrid Power Plant for Eco-Friendly and Economical Power Production

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Abstract: One of the important problems faced by all the countries in the world is the power production and consumption problems. Renewable power sources are the sources through which we can get the direct power from the nature. Renewable energy is the best method for eco-friendly power production. Hybrid energy sources (HES) fulfill the power problem to some extent. Hybrid energy system is formed by the combination of the different energy resources such as solar, wind, biomass, and small hydro with fossil fuel powered diesel generator. This type of system is more cost effective and eco-friendly. This paper proposed a hybrid power generation is suitable for the remote area applications. This paper gives us an detailed information about the hybrid power plant formed by the combination of solar, wind, tidal power plants, along with their load conditions, power production analysis table, and their efficiency curves.

Keywords: Renewable power source, Hybrid, Load conditions, Efficiency curves.

1. INTRODUCTION

Global warming, pollution and sky racketing prices of the conventional energy sources have put the governments and the power industries under increasing pressure to invest in the renewable energy sources. In India power demand is going on increasing every year. In order to face this power demand the implementation of renewable energy resources are becoming more appealing. This research paper consists of complete study of implementation of hybrid power plant using solar, wind and tidal power plant. This also gives detailed description of HES layout, efficiency curves, load conditions, advantages, and implementation process.

Solar power is the conversion of sunlight into electricity, either directly using photovoltaic (PV), or indirectly using concentrated solar power (CSP). Here solar panels are used for efficient performance and high production. Wind power is the conversion of wind energy into a useful form of energy. Wind turbines are used to convert this kinetic energy into mechanical energy which is the coupled with an alternator. By this the mechanical energy is converted into electrical energy. Onshore wind is an inexpensive source of energy. Tidal power is a form of hydropower that converts the energy of tides, into a useful form of power, mainly electricity. The combination of all

the above three renewable energy sources is explained in this paper. Here a lot of discussion about the Maxeon cell technology to obtain maximum output for solar power plant, procedure to increase the efficiency of solar, wind and tidal coupled power plant, selection of implementation area, advanced technologies used in wind turbines, steps to reduce the risk in tidal power production, conditions for maximum output, have also done.

Solar Power Plant: Solar power is the process of conversion of sunlight into electricity. The plant used for this conversion is known as solar power plant.

2. REQUIREMENTS FOR SOLAR POWER PLANT

1). ***Abundant Solar Radiation***: The greater the amount of insolation, the more electricity obtained from the solar cell module. The project site should be selected not only based on insolation but also on the meteorological conditions such as temperature.

2).*Selection of Land & flat area*: For the construction of 1MW solar power plant will require an area of 20,000 m^2 to 30,000 m^2. Another main requirement is that the selected area should be flat.

3).*Transmission line capacity:* Transmission of electricity from a mega power plant requires large interconnected capabilities. For a solar power plant of capacity of 2MW requires a high voltage transmission lines (over 600v).

4).*Selection of Heat collectors:* The main requirement for the efficient power production of a solar power plant is the heat collectors.Here we are using parabolic troughs as heat collectors. The parabolic trough is coated with a polished mirror.

3. CONSTRUCTION OF PARABOLIC TROUGHS AND DEWAR TUBE:

In order to increase the efficiency and the rate of power production, parabolic troughs are used.The trough is straight in one dimension and curved asa parabola in other two. The energy of sunlight which enters the mirror parallel to its plane symmetry is focused along the focal line. For electricity purpose, a tube, frequently a Dewar tube is used. The mirror is oriented so that sunlight which is completely concentrated on the tube, which contains a high boiling point fluid, which is heated to high temperature by the energy of sunlight. The Dewar tube used for the flow of high temperature working fluid is based on improved bellow design. Improved bellow design eliminates throat seal leakage and lubrication. These are designed to eliminate conventional throat seals, providing high reliability for moisture sensitive materials. This improved bellow design increases the aperture length to 96%. The inner layer is formed by durable glass-to-metal contact. This combination is done in order to match the thermal expansion. The outer most layer is fabricated Anti-Reflective

coating especially developed for solar panels. Anti-Reflective coating is very important in increasing the output power module. Solar panels are designed to absorb light, and accordingly reflect only reflect a small amount of the sunlight that falls on them compared to most other objects. Solar panels reflect significantly less than flat water. In order to increase the efficiency glass panels are treated with anti-reflective coating, which could increase the light transmission in glass and reduce the reflection. The glass-metal contact layer and the anti-reflective layer is separated by vacuum insulation. The conduction heat transfer between the inner and outer tubes is the most difficult to control. In such cases the conduction heat losses gets increased. To minimize the heat conduction loss, vacuum layer is provided.

4. LAYOUT OF SOLAR POWER PLANT

The above described construction is implemented and the preferred layout is presented below. A large number of parabolic troughs are installed in a flat area. Each parabolic panel are connected to Dewar tube. The transmittance of the Dewar tube is increased to 99% by providing a strong layer of Anti-Reflective coating as discussed in [1], [2]. A high boiling fluid such as oil or heavy water is allowed to flow increased in tube. The trough is aligned in north-south axis, in order to track the sun. The temperature of the operating fluid is nearly equal to 400 deg. There are various methods used to heat up the fluid substance to the maximum of 1200 deg as described in [5], [4]. The temperature should be enough necessary to convert the fluid into steam with high pressure and temperature. There are necessary steps made for the purpose of cooling of the evacuated tube [6]. A concentrated solar power plant uses steam turbines.

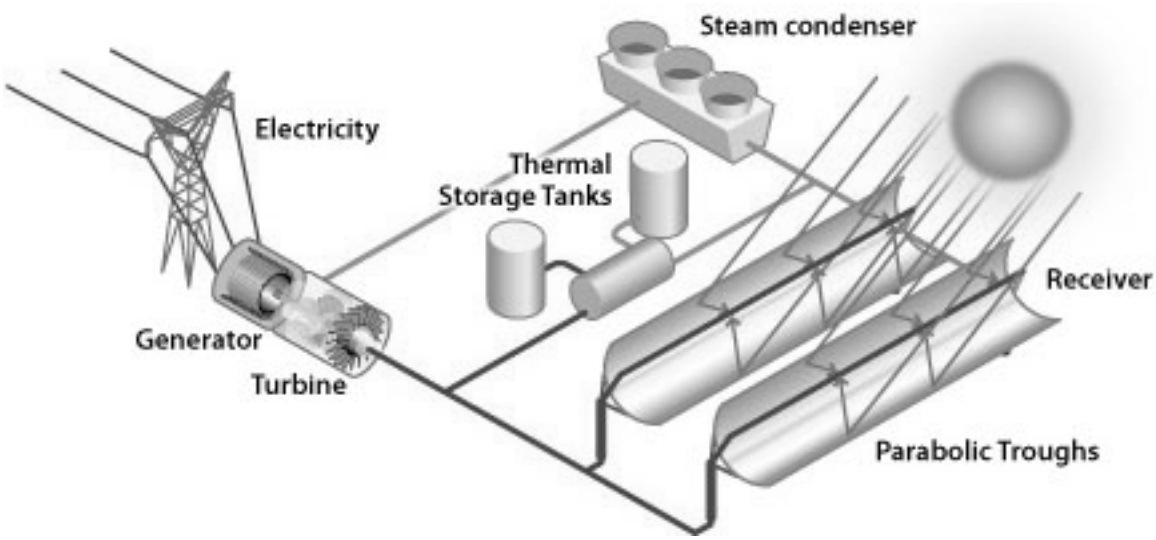

Fig.1. Working of solar coupled steam power plant

The main features of steam Turbine is:

1). High efficiency 3D reaction blading (impulse on small ST)
2). Applicable to reheat and non-reheat cycles, air and water-cooled condensers.
3). Axial and side exhaust arrangements to minimize civil works.
4). Material selection and construction for different CSP technologies.

This high pressure steam is allowed to flow inside the turbine. Here the kinetic and pressure energy of the steam is converted into mechanical energy. The turbine is coupled with an alternator which is then connected to the supply station and then to the transmission lines. The remaining high pressure steam is then passed into the steam condenser where it is then condensed and reused [7]. Along with this thermal storage tanks are employed for the storage of working fluid.

Wind Power Plant:

Wind power is the conversion of wind energy into a useful form of energy, such as using wind turbines to make electrical power, windmills for mechanical power. Wind energy is the kinetic energy of air in motion, also called wind. Total wind energy flowing through an imaginary area A during the time t is:

$$E = \frac{1}{2}mv^2 = \frac{1}{2}At\rho v^3$$

Requirement of Wind power plant:

1) Turbines work at the best when on high, exposed sites. Coastal sites are especially good. Town centers and populated residential areas are usually not suitable.
2) The distance between the turbine and the power requirement station should be very less.
3) The speed of wind should be higher than 70 Km per hour.
4) The wind mill should be installed near the coastal area. The efficiency of turbine should be much enough to withhold and capable of increasing the output power generation.

Selection of wind turbine:

Wind turbines capture the kinetic energy in the wind using propeller like blades mounted on shaft. When the wind makes the blades turn, the shaft spins a generator to produce electricity. There are three blades that are aerodynamically designed to capture the most energy from the wind. Abundant offshore wind resources have the potential to supply immense quantities of renewable energies. Offshore winds tend to blow harder and more uniformly than on land. The potential energy produced from wind is directly proportional to the cube of the wind speed. As a result,

increased wind speeds of only a few miles per hour can produce a significantly larger amount of electricity.

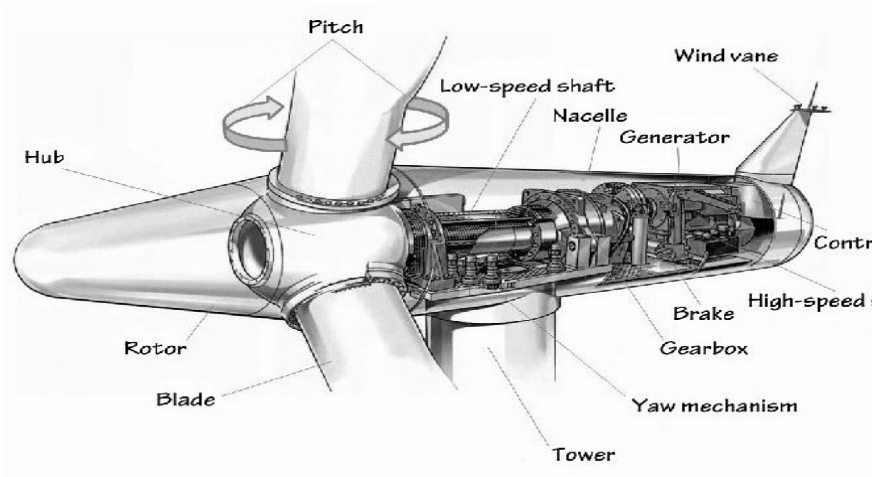

Fig.2. Working of wind turbine in the proposed system

Yaw mechanism: This system is responsible for the orientation of wind turbine rotor towards wind.

Nacelle:A nacelle is the outermost covering of the components in the wind turbine

Generator: It converts the mechanical energy into electrical energy

Controller: Controllers are components that are used to control or limit the power produced.

Tidal Power Plant:

Tidal power which is also called as tidal energy is a form of hydropower that converts the energy of tides into useful forms of power, mainly electricity. Tides are more predictable than solar and wind energy.

Tidal power is the only technology that draws on energy inherent in the orbital characteristics of the earth-moon systems. This is one of the major part of renewable source of energy. Though the initial cost for implementing a tidal power plant is too high, the power produced is very higher than the solar and the wind power plants. The electricity can be produced by using tidal power plant by raising a tidal barrage minimum of about 25-30 Km on seashore area. But the main disadvantage is that the electricity can be only generated only on tides in and out states i.e. Only 10 hours per day [8]. The next thing is that only about 20 sites in the world have been identified as possible tidal power projects. In order to overcome this problem underwater wind farm project idea is proposed here. This project is also called as “swanturbines”.

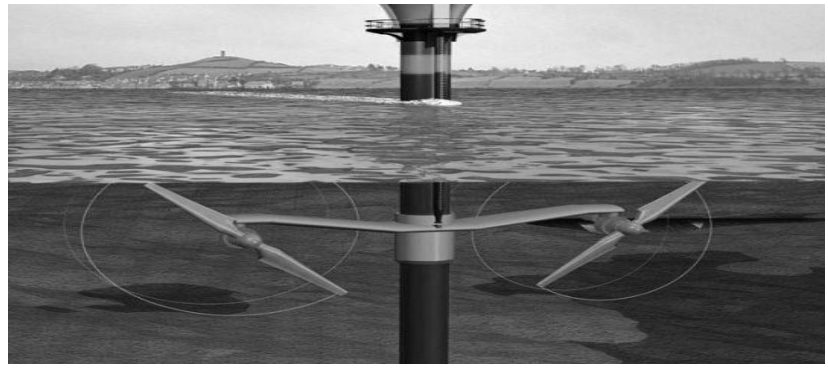

Fig.3. Working of Tidal Power in the proposed system

Operation:

At the primary stage in solar power plant, the heat energy is absorbed by the troughs and the fluid flowing in the vacuum tube which is at the axis of the trough is heated. The heating rate should be around 100^0C to 200^0C. Here the working fluid gets heated. This fluid is then allowed to flow along a tube and is made to allow boiling the water. At this stage the water is converted into high pressure steam. By preheating process the pressure can be increased. This steam is then allowed to run a turbine, which is coupled with an alternator. At the intermediate stage in wind power plant the blades are made up of material-fiber glass. For a wind at a speed of 70Km/hr, the RPM is nearly equal to 10 to 22. These blades are connected to the rotor of an A.C motor, and then due to the change in flux, voltage is developed.

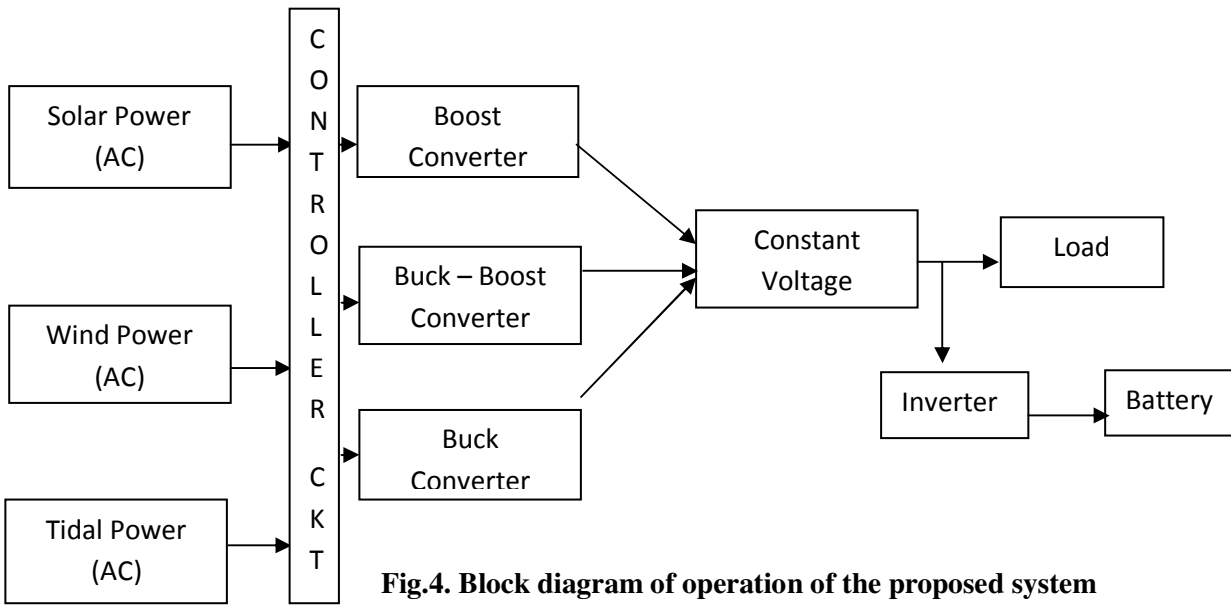

Fig.4. Block diagram of operation of the proposed system

The coupling of solar and wind power is clearly explained in [3]. At the final stage in underwater tidal power plant, the operation is same as that of the wind power plant. But it is planted under the water level. This is because the density of water is higher than the air and main advantage is the elimination of long tidal barrage. The blades are made up of special types of alloy, and the specification is 15rpm. This can be implemented as single or as a pair. The above described three renewable energy sources are coupled together. The generation of electricity from these power plants varies from climate to climate. During sunny days, high efficiency is obtained from the solar and tidal plant. During rainy days, only under water tidal power plant can only produce power. All the powers are coupled together to a constant voltage limit

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