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AN OVERVIEW ON HYBRID SOLAR-WIND GENERATION SYSTEM

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Abstract: This paper presents study of hybrid power system.A solar-wind hybrid system is a reliable alternative energy source because it uses solar energy combined with wind energy to create a stand-alone energy source that is both dependable and consistent. Solar power or wind power alone can fluctuate, when used together they provide a reliable source of energy. The perfect solution is to combine these two forms of energy sources to create a constant energy flow. Main objective of this paper is to study of stand-alone solar-wind hybrid power system and to maximize use of renewable energy generation system while minimizing the total system cost.

I. INTRODUCTION

Rapid depletion of fossil fuel resources on a worldwide basis has necessitated an urgent search for alternative energy sources to cater to the present days' demand. . Therefore, it is imperative to find alternative energy sources to cover the continuously increasing demand of energy while minimise the negative environmental impacts Recent research and development of alternative energy sources have shown excellent potential as a form of contribution to conventional power generation systems. There is a huge potential for utilizing renewable energy sources, for example solar energy, wind energy, or micro-hydropower to provide a quality power supply to remote areas. The abundant energy available in nature can be harnessed and converted to electricity in a sustainable way to supply the necessary power demand and thus to elevate the living standards of the people without access to the electricity grid. The advantages of using renewable energy sources for generating power in remote islands are obvious such as the cost of transported fuel are often prohibitive fossil fuel and that there is increasing concern on the issues of climate change and global warming. The electric power generation system, which consists of renewable energy and fossil fuel generators together with an energy storage system and power conditioning system, is known as a hybrid power system. A hybrid power system has the ability to provide 24 hour grid quality electricity to the load. This system offers a better efficiency, flexibility of planning and environmental benefits compared to the diesel generator stand-alone system. The maintenance costs of the diesel generator can be decreased as a consequence of improving the efficiency of operation and reducing the operational time which also means less fuel usage. The system also gives the opportunity for expanding its capacity in order to cope with the increasing demand in the future. This can be done by increasing either the rated power of diesel generator, renewable generator or both of them.

The disadvantage of standalone power systems using renewable energy is that the availability of renewable energy sources has daily and seasonal patterns which results in difficulties of regulating the output power to cope with the load demand. Also, a very high initial capital investment cost is required. Combining the renewable energy generation with conventional diesel power generation will enable the power generated from a renewable energy sources to be more reliable, affordable and used more efficiently. Solar and wind energy systems are being considered as promising power generating sources due to their availability and topological advantages for local power generations in remote areas. Utilization of solar and wind energy has become increasingly significant, attractive and cost-effective, since the oil crises of early 1970s. This Paper focuses on the combination of solar wind systems for sustainable power generation. The solar energy also varies with the hourly, daily and seasonal variation of solar irradiation. The wind turbine output power varies with the wind speed at different conditions. However, a drawback, common to solar irradiation and wind speed options, is their unpredictable nature and dependence on weather and climatic changes, and the variations of solar and wind energy may not match with the time distribution of load demand. This shortcoming not only affects the system's energy performance, but also results in batteries being discarded too early. Generally, the independent use of both energy resources may result in considerable over-sizing, which in turn makes the design costly. It is prudent that neither a stand-alone solar energy system nor a wind energy system can provide a continuous power supply due to seasonal and periodical variations for stand-alone systems.Thus wind system is hybridized with solar sytem to maximize use of renewable energy generation system while minimizing the total system cost.

II. CLASSIFICATION OF ENERGY RESOURCES

Energy resources are classified into non-renewable and renewable resources

A. Non-renewable Energy Resources

Non-renewable energy resources are the ones which are limited and become extinct with the time , such as oil, coal and coal derivatives, natural gas, wood and radioactive material (uranium, plutonium) and also produces a lot of harmful waste.

B. Renewable Energy Resources

Renewable energy resources are the ones that are continuously available and renewing itself with the time.

Industrialization and ever increasing world population need the use of renewable energy resources. Solar energy, wind energy, biomass, tidal energy, wave energy, geothermal power is popular.

1) Solar power

Solar panel is a device that converts solar energy directly into electrical energy. Solar panel is made up off photovoltaic cells which are made by semiconductor. When sun beam is fall on the PV cell they absorb the heat and electron are emitted from the atom. Due to the movement of the electron current is generated. With this process solar panel, convert solar energy directly into the electric energy. Photovoltaic is known as the process between radiation absorbed and the electricity induced. Solar power is converted into the electric power by a common principle called photoelectric effect. The basic unit of a photovoltaic power system is the PV cell, where cells may be grouped to form panels or modules. The panels then can be grouped to form large photovoltaic array that connected in series or parallel. Panels connected in parallel increase the current and connected in series provide a greater output voltage.

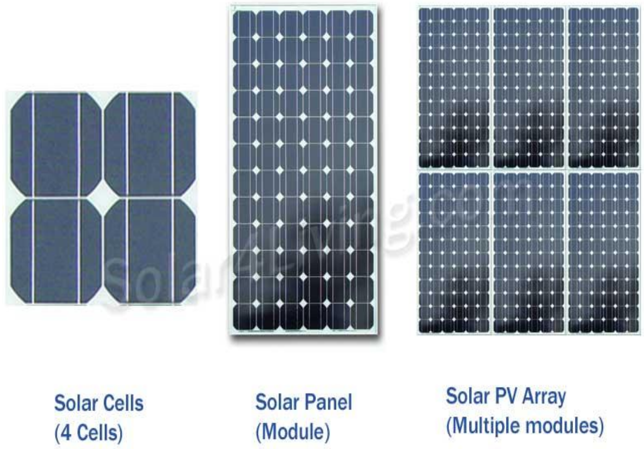


Fig 1. PV Cell, PV Module, PV Array

Fig 2. Solar PV System

The energy generated by the sun radiation is calculated bythe formulae:

P = A·x2 + B·x + C (in Watts)

Where,

X = Solar radiation

P= Power Formation

And A,B,C are constant

By the above formula, we can calculate the amount of power generated by the Sun.

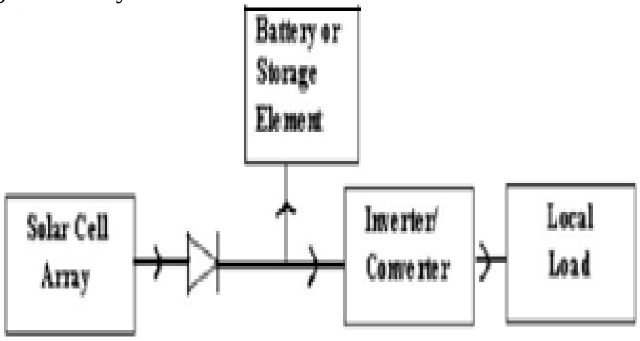


Fig 3. Basic PV System

Storage batteries as shown in Fig. provide the backup power during cloudy weather to store the excess power or some portion of power from the solar arrays. This solar power generating system is used for domestic power consumption, meteorological stations and entertainment places like theatre, hotel, restaurant etc.

2) Wind Power

The wind energy is a renewable source of energy. Wind power involves converting wind energy into electricity by using wind turbines. A wind turbine is a machine that converts the kinetic energy in wind into mechanical energy. The energy production by wind turbines depends on the wind velocity acting on the turbine. Wind power is able to feed both energy production and demand in the rural areas. The main drawback of this system is that as the wind speed or velocity is not constant with respect to time i.e. fluctuating, hence the electric power thus obtained is also does not have a fixed value i.e. varying nature. Thus, it is better to feed the wind electricity to the battery or any power storage device, which supply the load consecutively, rather than directly supply to the load as shown

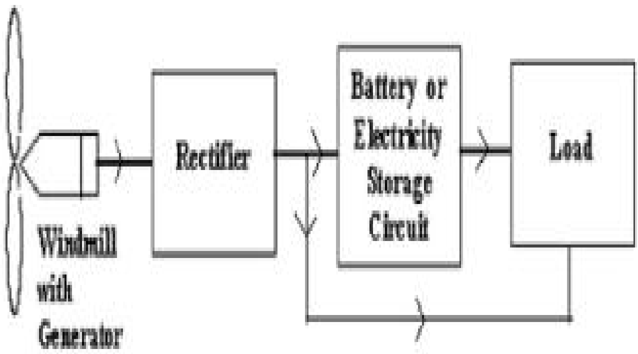


Fig 4. Basic Wind Power System

The power output of a turbine is a function of the cube of the wind speed, so as wind speed increases, power output increases dramatically. Areas where winds are stronger and more constant, such as offshore and high altitude sites are preferred locations for wind farms. We cannot convert all the wind energy into electricity: we can convert only 59%, according to Betz limit. The output equation for a wind generator is given by:

$P = (1/2) \times \rho \times A \times v3$(in Watts)

Where, A=area perpendicular to the direction of flow (in m2), v=wind velocity (ms-1), ρ =density of air (in Kgm-3) and P=power generation.

In wind power system, the power generation increases in proportion to the cube of the wind speed. Thus it is highly affected in rainy and stormy season when the wind speed is too less to produce electricity. This power generation system is pollution free and ecologically balanced. A general characteristic curve that describes the wind turbine output power variation with steady wind speed is shown in Figure

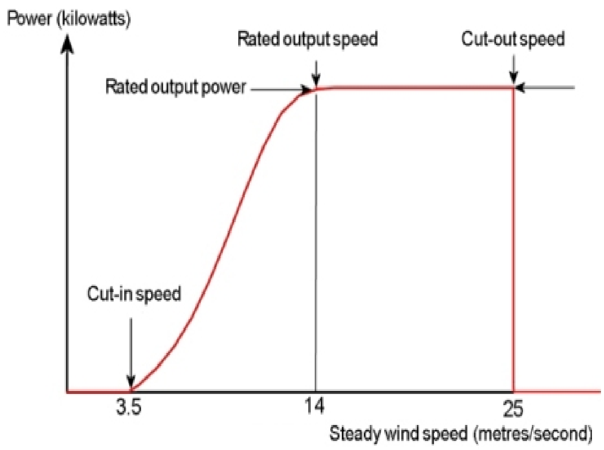


Fig 5. Wind Turbine Power Output Verses Steady Wind Speed Characteristics

From the above characteristic curve, there are three important points at which much attention is paid for the speeds and the corresponding turbine output powers for every wind turbine. These are the cut-in speed, rated output speed and cut-out speed.

Cut-in speed

A very low wind normally exerts insufficient torque on the wind turbine blades to make them rotate. When the speed increases, the wind turbine starts rotating and generating electrical power. The speed at which the turbine first starts to rotate is called the cut-in speed and is typically between 3 and 4 m/s.

Rated output wind speed

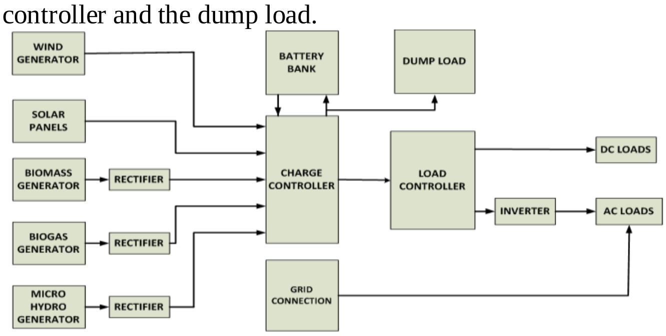
When the wind speed increases beyond the cut-in speed, the wind turbine generates electrical power and this increases rapidly as it is cubic function to speed and this can be seen in Figure. However, depending on the type of turbines, the wind turbine reaches a point where its capability of generating the maximum output power limit is attained at some speed. This limit to the generator output is called the rated power output and the wind speed at which it is reached is called the rated output wind speed. At higher wind speeds, the design of the turbine is arranged to limit the power to this maximum level and there is no further rise in the output power. How this is done varies from design to design but typically with large turbines, it is done by adjusting the blade angles so as to keep the power at the constant level.

Cut-out speed

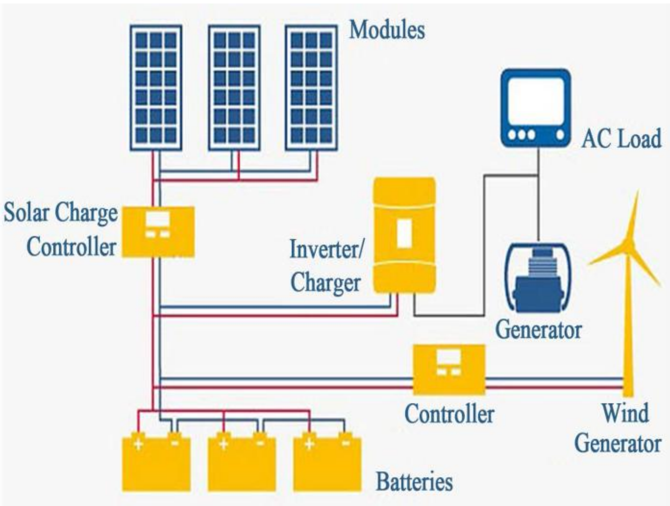
As the speed increases above the rate output wind speed, the forces on the turbine structure continue to rise and, at some point, there is a risk of damage to the rotor. As a result, a braking system is employed to bring the rotor to a standstill. This is called the cut-out speed and is usually around 25 m/s. In general, if wind speed is between the rated speed and the furling (cut-out) speed of the wind turbine, the power output will be equal to the rated power of the turbine and if the wind speed is either less than the cut-in speed or greater than the furling speed of the wind turbine, then the output power will be zero.

III. HYBRID POWER GENERATION SYSTEM

A typical hybrid system combines two or more energy sources, from renewable energy technologies such as PV-panels, wind or small hydro turbines; and from conventional technologies usually diesel Gensets. In addition, it includes power electronics and electricity storage bank. Our proposed hybrid system is designed for both on grid and off grid operation to reduce dependency on the national grid for electrical supply. The “fig.” shows the block diagram of a typical hybrid grid connected power system. The system consists of PV generators, wind generator, biogas, biomass (rice husk), micro-hydro, battery bank, battery charge controller and the dump load.



In this paper, a hybrid system of solar-wind is considered. Here, we have different power generating units. Some of them generate AC and others DC power directly.



Grid Tie PV/ Wind Hybrid System

These systems can be classified in terms of their connection to the power system grid into the following:

A. Centralized AC-bus architecture

In this architecture, the generators and the battery are all installed in one place and are connected to a main AC bus bar before being connected to the grid .This system is centralized in the sense that the power delivered by all the energy conversion systems and the battery is fed to the grid through a single point. In this case, the power produced by the PV system and the battery is inverted into AC before being connected to the main AC bus.

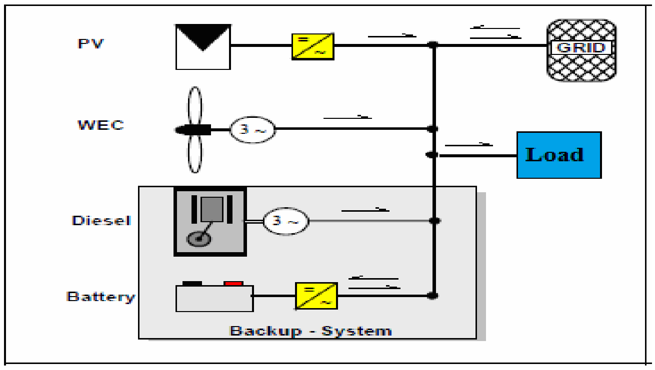


Fig 6. Centralized AC-bus architecture

B. Centralized DC-bus architecture

The second architecture utilizes a main centralized DC bus bar as in figure. The wind turbine and the diesel generator, firstly deliver their power to rectifiers to be converted into DC before it is being delivered to the main DC bus bar. A main inverter takes the responsibility of feeding the AC grid from this main DC bus.

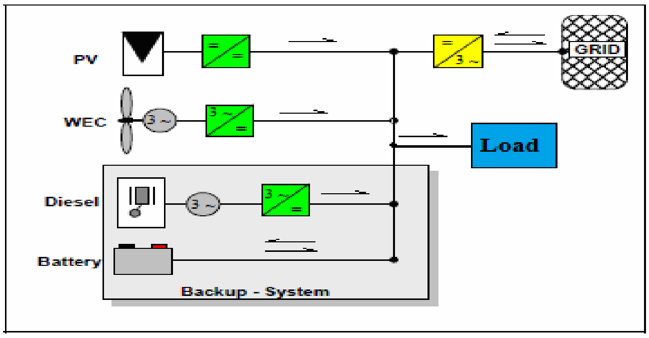


Fig 7. Centralized DC-bus architecture

C. Distributed AC-bus architecture

The power sources in this architecture do not need to be installed close to each other as in figures, and they do not need to be connected to one main bus bar. Otherwise, the sources are distributed in different geographical locations as appropriate and each source is connected to the grid separately. The power produced by each source is conditioned separately to be identical with the form required by the grid. The main disadvantage of this architecture is the difficulty of controlling the system.

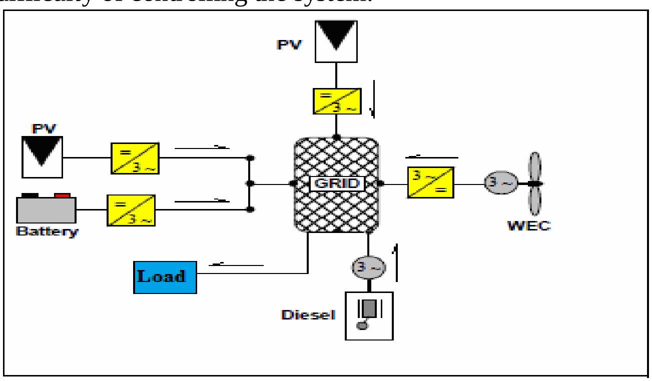


Fig 8. Distributed AC-bus architecture

D. Modified Distributed Ac Bus Architecture

The following architecture is the one upon which the submitted thesis is based. It is an improved version of the distributed AC-bus architecture shown in above figure. The improvement exists mainly in the addition of a DC/DC converter for each energy conversion system and the remove of storage battery. By this addition of the DC/DC converters, the state values of the energy conversion sources become completely decoupled from each other and from the state values of the grid the power production of the different sources becomes now freely controllable without affecting the state values of the grid. Decoupling the state values means that the variations of the renewable resources like the velocity of the wind and the intensity of the solar radiation will not influence the state values of the electrical grid. The main disadvantage of this architecture is the difficulty of controlling the system, but this problem is not effective since the improvement of wireless communications.

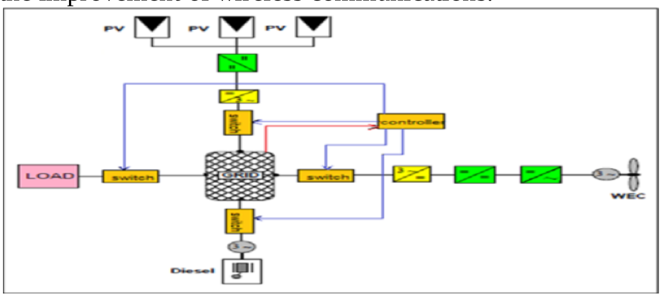


Fig 9. The modified distributed Ac bus architecture.

Energy scenario in India

Global energy scenario:

Energy, a word everybody is well acquainted with, mathematically means power consumption in a certain span of time. From the first hour of the day till the last hour the daily needs of a man start consuming energy in one form or the other. Nowadays people can't even imagine their lives without energy. A man without a major body part is called to be handicapped; likewise a world without energy is like a crippled world. Mankind is getting developed year by year and the total population of the world is also increasing as years are passing. As a result, the total energy requirement is also increasing rapidly to keep pace with the rapid modernization of mankind and with the rapid increase in population. According to a survey the primary energy demand is increasing by 1.5% per year and by 2030 the total energy demand will be 16,800Mtoe, with an overall increase of 40%. According to BP Statistical Review of World Energy, world energy consumption got increased by 2.5% in 2011, less than 5.1% in 2010 but well in coordination with the historical average till date.

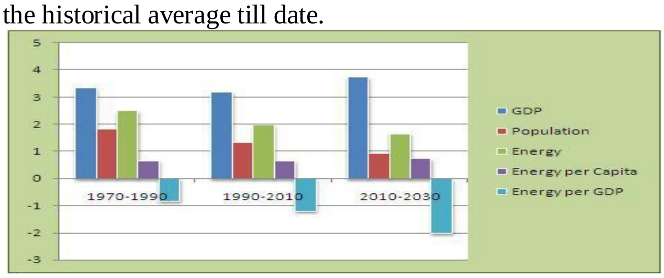


Fig 10. Global growth rate from 1970 to 2030.

In the above figure, it is seen that the GDP (Gross Domestic Product) has increased to a higher value from 1970 till 2010 and will be even more in 2030. But population is decreasing and is estimated to decrease more in the coming years. It can be observed that energy is decreasing but energy per capita in increasing by a marginal value. Lastly energy per GDP is estimated to decrease more and more up to 2030.

Indian energy scenario:

India, a developing country, nowadays is enlisted as one of the strong economy countries. In 2011, India's 121 crores population comprises of 17% of the world's total population. From2001 to 2011 there has been a percentage growth of 17.64% in the population of India. With this continuous increase in population, the electricity consumption of India will grow at an average rate of 3.3% per year through 2035 and to meet this increasing demand the total generation capacity of India should be increased by 235 MW. Presently India's per capitaelectricity consumption is 531.34 kWh, which is presumed to increase day by day with more and more modernization. The imbalance between the demand and supply of electricity in India needs major attention now.

It can be observed that the maximum power generated in India comes from coal-based thermal power plant. 57% of the total power developed is dependent on coal as a fuel, whereas 1% and 9% are generated from oil and gas. Renewable energy sources generate very less power in India, about 12% only, and rest 19% and 2% are developed from hydro-power and nuclear power. The actual values of the installed capacity of power generation in India on coal for power generation whereas the usage of renewable technologies for power generation is minimal with respect to that of coal. Here, the major power comes from coal, which is a non-renewable resource. According to Ministry of Power of the Government of India, the total power generation of India is 209276.04MW as on the end of October, 2012, comprising of 120103.38MW (57%) coal based, 18903.05MW (9%) gas based, 1199.75MW (1%) diesel generation, 39291.40MW. (19%) hydro, 4780.00MW (2%) nuclear and 24998.46MW (12%) from renewable energy sources.

IV. RENEWABLES 2014 GLOBAL STATUS REPORT MARKET AND INDUSTRY TRENDS

A. SOLAR PHOTOVOLTAICS (PV).

The solar PV market had a record year, adding more than 39 GW in 2013 for a total exceeding 139 GW. China saw spectacular growth, accounting for nearly one-third of global capacity added, followed by Japan and the United States. Solar PV is starting to play a substantial role in electricity generation in some countries, particularly in Europe, while lower prices are opening new markets from Africa and the Middle East to Asia and Latin America. Interest continued to grow in corporate- and community-owned systems, while the number and size of utility-scale systems continued to increase. Although it was a challenging year for many companies, predominantly in Europe, the industry began to recover during 2013. Module prices stabilized, while production costs continued to fall and solar cell efficiencies increased steadily. Many manufacturers began expanding production capacity to meet expected further growth in demand.

B. WIND POWER.

More than 35 GW of wind power capacity was added in 2013, for a total above 318 GW. However, following several record years, the market was down nearly 10 GW compared to 2012, reflecting primarily a steep drop in the U.S. market. While the European Union remained the top region for cumulative wind capacity, Asia was nipping at its heels and is set to take the lead in 2014. New markets continued to emerge in all regions, and, for the first time, Latin America represented a significant share of new installations. Offshore wind had a record year, with 1.6 GW added, almost all of it in the EU. However, the record level hides delays due to policy uncertainty and project cancellations or downsizing.

V. CONCLUSION

This paper presents an hybrid wind/PV energy system for standalone system. The standalone hybrid system is better than a single energy source. The wind energy systems may not be technically viable at all sites because of low wind speeds and being more unpredictable than solar energy. The combined utilization of these renewable energy sources are therefore becoming increasingly attractive. This Paper also highlights the future developments, which have the potential to increase the economic attractiveness of such systems and their acceptance by the user.

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