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Distributed Generation using hybrid model of Solar, Wind and Small Hydro Plant: A Review

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ABSTRACT: This paper proposes a e distributed hybrid power system which consists of solar power, wind power, small hydro power, battery storage and the load. To meet the electricity demand where the grid is unavailable, a distributed power generation strategy has been discussed. Different from the conventional solutions where the diesel is the sole source, the proposed approach utilizes the wind, solar and small hydro as the main sources .With a reasonable capacity configuration, this proposed design highly increases the service time and reduces the dependence on traditional sources.

Index Terms: Renewable Energy, Solar Plant, Wind Plant, Small Hydro Plant, Hybrid Model.

I. INTRODUCTION

The contemporary non-conventional sources of energy like wind, tidal, solar etc. were the conventional sources until James Watt invented the steam engine in the eighteenth century. In fact, the New World was explored by man using wind-powered ships only. The nonconventional sources are available free of cost, are pollution-free and inexhaustible. Man has used these sources for many centuries in propelling ships, driving windmills for grinding corn and pumping water, etc. Because of the poor technologies then existing, the cost of harnessing energy from these sources was quite high. Also because of uncertainty of period of availability and the difficulty of transporting this form of energy, to the place of its use are some of the factors which came in the way of its adoption or development. The use of fossil fuels and nuclear energy replaced totally the non-conventional methods because of inherent advantages of transportation and certainty of availability; however these have polluted the atmosphere to a great extent. In fact, it is feared that nuclear energy may prove to be quite hazardous in case it is not properly controlled. India is a large and spread over a wide area so it's quite difficult to access electricity each and every part of the country using Traditional Generation, distributed generation in which electricity is produced at consumer end serves a better end. In Traditional Generation sometimes the grid failure leads to the blackouts while in Distributed Generation this case will not occur. Traditional Generation consist of long transmission lines which makes it costly in case of Distributed Generation there is no need of long transmission line which ,makes its cost effective. Traditional generation system are quite complex as there are very big system consisting of many parts while distributed generation is quite simple in its construction. Traditional generation is an effective method but there are some rural areas are in India which is still inaccessible so the Distributed Generation will play a significant role in remote nd inaccessible regions.

II. DISTRIBUTED GENERATION

Distributed generation (DG) refers to power generation at the point of consumption. Generating power on-site, rather than centrally, eliminates the cost, complexity, interdependencies, and inefficiencies associated with transmission and distribution. Like distributed computing (i.e. the PC) and distributed telephony (i.e. the mobile phone), distributed generation shifts control to the consumer. Distributed Generation is gaining worldwide acceptance due to its number of benefits. It eliminates the cost and complexity and reduces the chances of inefficiency which occur in the transmission and distributed network. Basically electricity produced is generated at large generating stations which is then send at high voltages through the transmission lines to the load centers and then through local distribution network distributed to the customers at distribution level voltage. In present scenario there is an increase in demand which is creating gap between demand and supply to fulfill this gap distributed generation can plays the significant role. The main reason for the need of distributed generation is it is clean and continuous. Distributed generation means generating power on site or at a near-by location not centrally. Distributed generation is the best way for rural electrification.

Benefits of Distributed Generation:

The basic benefits of Distributed Generation are given below:

- Reduces the cost as there is no use of long transmission line
- Reduces the complexity
- Environment friendly
- Avoid the impact of massive grid failure.
- Easy to maintain and easy to operate as it consist of simple construction.
- Better power quality and reliability.
- The factor of high peak load shortage eliminates.
- Improves the efficiency of providing electric power.

Of, course operation cost varies on the basis of various distributed technologies are used. Distributed Generation eliminates a number of problems which occurs in traditional generation.

As in distributed generation power is generated at the consumer end so the on-site power equipment can provide consumer with affordable power at a higher level of quality.

III. REVIEW OF LITERATURE

Nazih [1]: In the context of renewable energy, this study treats the functioning of a hybrid system containing two sources: solar panels and wind turbine. In fact, the conversion of solar energy and of wind energy to electrical one is non-pollutant. The studied system is connected to a lead acid battery.

K.R. AJao [2]: HOMER power optimization software for evaluation of design and performance of both off-grid and grid connected power systems has been applied for cost-benefit analysis of a wind-solar hybrid power generation system. Comparison was also made with the cost per kilowatt of grid power supply.

Yuehua Huang [3]: With the complementary characteristics between wind and photovoltaic, wind-solar hybrid generating system take advantage of the intervals wind and photovoltaic to make the stable technology output by the control strategy of transformation, charging and storage and so on. For making maximum use of the wind and solar energy, this paper apply the Maximum Power Point Tracking control method to the global power of the wind-solar hybrid generating system according to the basic principle of the variable step perturbation tracking maximum power point algorithm.

Ren Yan [4]: The aim of hybrid wind-solar-pumped -storage power system is to solve the electro-problem of remote and undeveloped areas short of power. Aim to the special physical geography condition of some island, hybrid wind-solar-pumped-storage power system is brought forward which is based on traditional hybrid wind-solar power system, and which storages energy by using pumped-storage.

Ankur [5]: Power generation is the harbinger of economic growth and industrial development of any country. India has a large verity of renewable and non-renewable energy resources still it suffers lack of generation, Transmission and distribution of electricity due to its poor policies and week planning strategy.

Jing Li,Wei Wei and Ji Xiang et al. [6]: In this paper, we develop a simple algorithm to determine the required number of generating units of wind-turbine generator and photovoltaic array, and the associated storage capacity for stand-alone hybrid micro grid. The algorithm is based on the observation that the state of charge of battery should be periodically invariant.

Maamar Laidi1 [7]: This paper shows an experimental investigation that uses a combination of solar and wind energy as hybrid system (HPS) for electrical generation under the Algerian Sahara area. The generated electricity has been utilized mainly for cooling and freezing. The system has also integrated a gasoline generator to be more reliable.

Yuksel [8]: In this research, an isolated wind-photovoltaic hybrid power system with battery storage will be presented that can supply electricity to two laboratories with a capacity of 1072 W peak electrical power depending on the need at the laboratory illuminating where used. An 1170W hybrid power generation system consists of a 190W 24V 3 pieces mono crystal solar panel and 600W 3-phase permanent magnet synchronized generator (PMSG) wind power generation system, rotating 3600 according to direction of wind, was installed.

Ankur Omer [9] - This paper discusses Issues, challenges and opportunities particular to India and suggests strategies which contribute to plan the electricity network in order to meet the growing electricity demand for the development of country.

Ajla Merzic [10]: In this research, the complementary nature of wind and solar energy has been considered, especially by analyzing output power variations from a photovoltaic power plant (PVPP), a wind power plant (WPP) and their combination in a hybrid system. For these purposes, an own model has been made, with calculations based on real wind and solar energy potential data.

Md. Habib Ullah [11] - This system incorporates a combination of solar PV, wind turbine, battery and diesel generator. HOMER, software for optimization of renewable based hybrid systems, has been used to find out the best technically viable renewable based energy efficient system for 100 households and 10 shops.

Dr Pallikonda Ravi Babu [12]: Electrical energy is most vital source for growth of any nation, which keeps the progress on wheels. The growth of any nation depends on per capita consumption of electrical energy.

Unfortunately the resources of electrical energy are depleting day by day hence, the gap between demand and generation is increasing. To bridge this gap alternative non-conventional methods have to be adopted. Prasanna [13]: With the continuous exhaustion of fuel in today's modern world it becomes a necessity for us to use the available fuel in more efficient way. In this paper technique where loads are regulated with the help of fuzzy logic has been designed.

Raj Kamal [14]: In the realms of today's high technology growth, energy in the form of fuel and power has become one of human's basic needs. Even though the conventional sources of fuel are available for energy generation, the entire world depends on the renewable and nonpolluting resources such as wind power, tidal, geothermal and solar as a clean source of energy. However recent world's interest for power generation is the concept of producing electricity from waste.

Dr Rachana Garg [15]: Technological innovation along with abundance of solar energy in ecosystem has led to its emergence as an alternate, clean and sustainable energy solution. Rising cost and depleting reserves of conventional non-renewable sources has further urged the need to explore and optimize cost of non-conventional energy sources. Intermittent nature of solar energy along with low conversion efficiency of PV (photovoltaic) generators is one of the biggest challenges to its economical and sustainable deployment in power system.

Sushaban [16]: This research presents an optimal load flow model in conventional thermal power system to minimize the generation cost, active power losses and reactive power losses by introducing an additional wind generator in the existing system. The electrical power demand of the growing concerns totally depends upon the conventional power plants.

Yubin Jia [17]: Distributed model predictive control for a hybrid system that comprises wind and photovoltaic generation subsystems, a battery bank and an AC load is developed in this paper. Consider that the wind subsystem and the solar subsystem are two spatial distributed energy generation systems, so we design a distributed MPC for optimal management and operation of distributed wind and solar energy generation system.

IV. SOLAR ENERGY

Solar energy is the most readily available source of energy. It is free. It is also the most important of the non-conventional sources of energy because it is non-polluting. Fuel cells, magneto hydrodynamic systems, and devices based on thermoelectric, thermo ionic and solar-electric conversion are all potentially useful nonconventional electricity sources. Earth surface receives 1.2x10^17 W of power from sun. Energy supplied by the sun in one hour is almost equal to the amount of energy required by the human population in one year.

Renewable energy sources play an important role in electricity generation. Various renewable energy sources like wind, solar, geothermal, ocean thermal, and biomass can be used for generation of electricity and for meeting our daily energy needs. Energy from the sun is the best option for electricity generation as it is available everywhere and is free to harness. On an average the sunshine hour in India is about 6hrs annually also the sun shine shines in India for about 9 months in a year. Electricity from the sun can be generated through the solar photovoltaic modules (SPV). Solar Energy is a good choice for electric power generation. The solar energy is directly converted into electrical energy by solar photovoltaic module.

The photovoltaic modules are made up of silicon cells. The silicon solar cells which give output voltage of around 0.7V under open circuit condition. When many such cells are connected in series we get a solar PV module. Normally in a module there are 36 cells which amount for a open circuit voltage of about 20V. The current rating of the modules depends on the area of the individual cells. Higher the cell area high is the current output of the cell. For obtaining higher power output the solar PV modules are connected in series and parallel combinations forming solar PV arrays.

V. WIND ENERGY

Wind power systems convert the kinetic energy of the wind into other forms of energy such as electricity. Although wind energy conversion is relatively simple in concept, turbine design can be quite complex. Most commercially available wind turbine uses a horizontal – axis configuration with two or three blades, a drive train including a gearbox and a generator and a tower to support the rotor. Typical sizes for a wind turbine range from 200-750 KW, and electricity produce within a specific range of wind speed. Capital costs have declined from about $ 2.2/w in early 1980 to less than $ 1/w today. Cooperative research between department of energy and manufacturing companies is aimed at increasing the aerodynamics efficiency and structural strength of wind turbine blades, developing variable speed generation and electronic power controls and using taller tower that allow access to the stronger wind found at greater height. Usable speeds of wind are between 5 m/s and 15 m/s. Wind energy is free and does not produce any pollution [29]. However, to benefit from this energy, the following constraints must be considered:

- The wind speed can fluctuate about 25% over a period of few minutes,
- The direction of the wind is not constant; therefore, the direction of the turbine must be changed frequently so that it remains facing the wind in order to optimize the available power.
- The best direction of wind depends also on the site. To select this site, summaries on speed and direction of wind over a period of at least one year for several regions must be recorded.

• When wind power exceeds the nominal value, the mechanical power of the turbine must be limited and therefore the electric generated power.
• At high wind speed, the speed of the turbine must be reduced or even stopped completely to avoid damage of the turbine and that of the tower supporting it.
• Because of their height, the blades of the turbine constitute a natural target for thunderbolts.
• During winter, the accumulation of snow and ice must be monitored.
• To use the power generated by wind farm, it must be connected to an electric network with the same voltage and frequency as that generated by the turbines.

VI. SMALL HYDRO ENERGY

Small scale hydropower systems capture the energy in flowing water and convert it to usable energy. Although the potential for small hydro-electric systems depends on the availability of suitable water flow, where the resource exists it can provide cheap clean reliable electricity. A well designed small hydropower system can blend with its surroundings and have minimal negative environmental impacts.

Moreover, small hydropower has a huge, as yet untapped potential in most areas of the world and can make a significant contribution to future energy needs. It depends largely on already proven and developed technology, yet there is considerable scope for development and optimization of this technology. The amount of power that can be obtained from a stream depends on:

- the amount of water flow
- the height which the water falls (head)
- the efficiency of the plant to convert mechanical energy to electrical energy.

The basic components of small hydro scheme can be broadly classified as (i) civil works and (ii) electro-mechanical equipment.

(i) Civil Works: In SHP projects the major components of civil works are diversion channel, spillway and power house building. Spilling arrangement is generally carried out through existing canal. It is easier and economical to build small hydropower plant while new irrigation channels being planned or built, civil works of small hydro should be taken up side by side to make works economical.

(ii) Electro-Mechanical Equipment: The Electromechanical equipment is considered to be the equipment and system required to develop the energy available in impound or flowing water to convert it into electric al energy, to control it and to transmit it to the power grid. The major Electro-mechanical component of power plant is the inlet valve, turbine, draft tube, gates, generator, control and protection equipment and substation for transformation of power to the transmission line. In terms of space requirement and cost the major items are the turbine and generator.

VII. CONCLUSION

In this paper, several research works proposed by different authors have been studies and reached up to a conclusion that energy generation from non-conventional energy sources can be very beneficial for everyone. Nazih [1] proposed a hybrid system containing the solar and wind turbine which is connected to a battery for the backup. This system is capable of generating the electricity without polluting the environment. K.R. AJao [2] has applied the cost-benefit analysis of solar-wind hybrid power generation cost and has computed the pay-back period of 30 years. Different comparisons have been made to find out the cost per kilowatt of grid power supply. Yuehua Huang [3] has applied the MPPT (Maximum power point tracking control method) technique to control the power of wind-solar hybrid generation system. Ren Yan [4] has proposed the hybrid wind-solar pump storage power system to solve the electro-problem of remote area. Effective usage of wind and solar resources with advanced stability of the system with reduced investment has been proposed. Ankur [5] discusses issues, challenges and opportunities to plan the electricity network in order to meet the growing electricity demand of India. Jing Li [6] has developed a simple algorithm to find out the units generated by the wind turbine and photovoltaic array. A case study to show the efficiency of the system has been carried out. The hybrid system of solar and wind energy proposed by Maamar Laidi1 [7] has been utilized mainly for cooling and freezing in Algerian Sahara desert. Yuksel [8] has proposed a hybrid system of solar and wind that is providing the electricity to the laboratory. Several authors have focused on the different configurations of wind turbine and solar panel and MPPT control methods for a combined wind-solar-battery power generation system. Models of a horizontal axis wind turbine and a PV array and their MPPT power tracking controllers and adaptive voltage controllers and supervisory controller were built and their cost analysis models have also been proposed. A supervisory control strategy was proposed to generate the maximum power from these renewable energy sources and battery while connected to a common coupling point. By employing the renewable sources, the rural area electrification system is suitable for the long-term fieldwork applications with a longer service time and less dependent on diesel oils. India's growing economy has forced the country to increase installed power capacity to 200 GW this year. Despite this growth in supply, the country is still facing major challenges in providing electricity access to all the households and also improving reliability and quality of power supply. Its power systems are struggling to overcome power shortages and poor power quality. The major constraint in achieving the target is shortage of capital resources. Shortages are exacerbated by inefficiencies in power generation, distribution and end-use systems.

There is an immediate need for change in planning strategies from the traditional approach of increasing generation to meet in disciplined consumption to need, resource and conservation based approach for economic and environmental benefits. Considering the scale of the target, multipronged strategies are envisaged. Some of these are partial solution for power shortages, yet these are important measures in context of resource crunch since these would enable reducing the requirement for new generating capacity. These include removing obsolescence, optimum utilization of existing assets, reducing transmission and distribution losses, demand side management through greater conservation of electrical energy, policy changes in pricing mechanism, shift and emphasis on renewable energy sources for power generation, total energy systems, new energy storage systems like Superconducting Magnetic Storage Systems as spinning reserve to meet peak demand and energy efficiency promotions in accordance with national and socioeconomic and environmental priorities. Steps which may help large scale integration of renewable power with conventional power generation are also enumerated.

This paper presents a power generation station driven by wind, solar and small hydro. By employing the renewable sources, the proposed system is suitable for the long-term field work applications with a longer service time and less dependent on fossil oils thereby increasing the reliability of the overall hybrid system.

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