Grid Integration of Hybrid Power Generation System: A Review

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Abstract — To limit the carbon emission in a manner to save the earth from the consequences of global warming, penetration of renewable energy resources into the power system are increasing. Hybrid power generation is one such system with almost zero carbon traces. Indian subcontinent has favorable geographical conditions for hybrid generation system such as solar, wind, hydro etc. This paper presents a review on various technologies available to harness the electricity from renewable power generation system. A lot of research has been done on hybrid power generation system including small, mini, micro generation. A topological survey is presented in this paper for combine generation of power from such a hybrid system. The most popular hybrid resources such as wind, PV and small-hydro plant are discussed in brief.

Keywords: Hydal Power, Solar Photovoltaic (SPV), Nanogrid, Point of Common Coupling (PCC), Wind Generation System.

I. INTRODUCTION

In India, energy utilization in the advancement of the residential, horticulture, mechanical social orders and for other essential needs is expanding step by step to an abnormal state with a specific end goal to accomplish an impeccable living. Because of increment in the utilization of electricity in different power frameworks demand is expanding, this in turn increasing the discharge of the green-house gas which is contaminating the environment and atmosphere [1]. Since there are distinctive kinds of energy frameworks which are being utilized for supplying electrical energy, however hybrid power frameworks are the best methodologies for energizing the rustic territories and small scattered demand [2].

These diverse power frameworks are sunlight based photovoltaic cells, wind vitality, hydroelectric power, geo-thermal power, atomic power, wave and tidal vitality and so forth, yet this paper is speaking to the examination about the wind with small hydroelectric power plants. So when at least two or more than two power generation systems are joined than they are called hybrid control frameworks. At the point when at least two or more than two power networks are interconnected for the utilization of electrical vitality and request at the peak stack can be accomplished, this guarantees the better quality of electrical energy. Utilization of hybrid power network also reduces the carbon emission and dependency on fossil fuels for conventional power generation system [3, 4].

The utilization of sustainable power source innovations, both substantial and small scale, is to a great extent reliant on the geology in the territory of use [5]. To rearrange improvement, the undertaking is coordinated towards a little scale execution. Normally this will include a provincial property or way of life piece, where the land proprietor approaches a wellspring of streaming water, and consistent breeze. In light of a normal family unit control utilization of 8000 kWh every year, this framework will mean to produce around 1 kW on average [6, 7]. Small scale sustainable power source applications are naturally particular to the site they are executed on. This makes it extremely hard to research and outline a framework that can be by and large connected. Thus, a reasonable site has to be chosen. This paper presents a brief survey on popularly adopted hybrid generation sources with their schematic arrangement.

II. HYBRID POWER GENERATION SYSTEM

The Traditionally Electricity Network (EN) is the biggest physical structure on earth. It is almost one and a half century old affecting all type of life on the planet. Since the early stage of EN, power production is confined through fossil fuel, hydral generation also holds a large share where water is available in abundance and few decades ago nuclear power plant generates a huge share of electricity [8-10]. All these are the Conventional resources. In conventional sources like coal carbon traces are high which has very adverse effect in global warming. Many policies are made to reduce the carbon traces including fine on industries and energy entitites locally and globally. Hence it is the need of the time to switch to such generation with zero carbon emission.

Hybrid Power Generation System (HPGS) is defined as a power generation system that combines two or more plants with different energy sources [11, 12]. They are deployed in conjunction with grid or in micro/nano grid structure generating power for the remote or rural electrification where transmission of power is either not feasible or have high transmission losses. The advantages for deploying hybrid generation are that it compliments the limitation of one-another for example in this work hybrid generation for Solar, wind and hydro power generation system [13] is presented. A hybrid power system is developed by combining various conventional and non-conventional power sources, for reducing greenhouse emission from the consumption of fossil fuels and to increase the stability of the power system so that a reliable operation of electricity is gained. Indian subcontinent has potential for lots of wind power generation system but intermittent nature is a limitation to completely rely on it. Hence a hybrid system has to be opted to over- come this limitation. This paper presents a review on integrated PV, small hydro and wind power generation. In literature lots of topologies are available for power production from wind energy and hydal energy this section presents a short review on these topologies. The general structure of HPGS is shown in figure1.

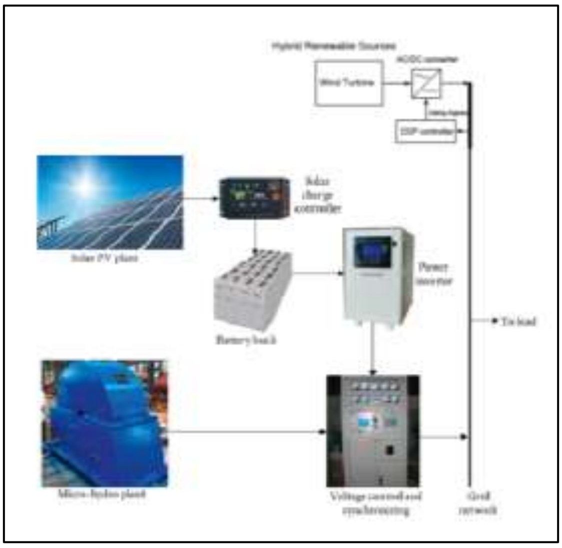

Fig. 1: Classification of Stability

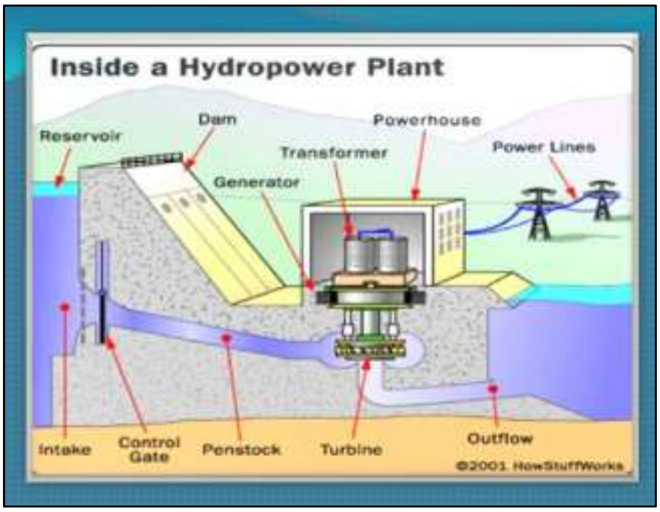

Fig. 2: hydro power plant layout.

III. HYDRO GENERATION

Hydroelectric power station the active power is created because of gravity in falling water from higher to bring down head is used to turn a turbine to deliver power. The potential energy put away in the water at upper water level will discharge as dynamic energy when it tumbles to the lower water level [14]. This turbine turns when the accompanying water strikes the turbine sharp edges. To accomplish a head contrast of water hydroelectric electric power station are for the most part built in uneven zones. In the method for the waterway in uneven zones, a manufactured dam is built to make required water head. From this dam water is permitted to fall toward downstream controllably to turbine sharp edges. Therefore, the turbine pivots because of the water constrain connected to its edges and thus the alternator turns since the turbine shaft is combined with alternator shaft. The structural diagram of hydro power plant is shown in Fig-2 [15]. The primary preferred standpoint of an electric power plant is that it doesn't require any fuel. It just requires water head which is normally accessible after the development of the required dam. A hydal plant generating power in a range of 1-20 MW for supplying local community or industry or as apart of distributed energy generation system for grid integration can be termed as small hydro power plant. This rating may vary application to application and nation to nation, the classification is shown in Fig-3. Impoundment is a type of hydro plant in which a dam is built to store water. In diversion type flow of river through a penstock is utilized to rotate turbine, no dam is built in this type of plant. Another type of hydropower called pumped storage works like a battery, storing the electricity generated by other power sources like solar, wind, and nuclear for later use. In a region where cost of power transmission could be high or where utility system can't be reached small hydro power plant can be installed [16].

IV. WIND POWER GENERATION

In A wind turbine changes over the kinetic energy in the breeze to electrical energy by means of a generator. Generators with more dependable, proficient, and minimal plans ought to be utilized as a part of wind turbines to augment the breeze control catch and create a higher quality yield control [17-20]. To decide the fitting generator outlines for onshore and offshore wind turbines, diverse kinds of wind turbine generators that have been examined in the writing are talked about in this paper, with the criteria in light of the speed extend, cost, weight, size, and power quality of the integrated system. The wind turbine generators are analyzed, and points of interest and drawbacks of various outlines are condensed with more broad criteria. In general wind turbines are classified as horizontal axis and vertical axis wind turbine (HAWT and VAWT). The choice depends upon the application, efficiency and cost. The role of generator is to convert the rotating energy of turbine into electrical energy. Wind generation system can be equipped with any three phase generation classified as;

A. *Asynchronous (induction) generator:*

1) Squirrel cage induction generator (SCIG) [15, 16];
2) Wound rotor induction generator (WRIG) [14, 17, 18];

B. *Synchronous generator:*

1) Permanent magnet synchronous generator (PMSG) [19];
2) Wound rotor synchronous generator (WRSG) [20];

C. *Other types of potential interest:*

1) High-voltage generator (HVG) [21, 22],
2) Switch reluctance generator (SRG) [23, 24],
3) Transverse flux generator (TFG) [25, 26].

Wind turbine is a complex mechatronic system and consists of a variety of components. For modern wind turbine systems with more than 1MW output power the schematic diagram of wind energy system is shown in Fig-3;

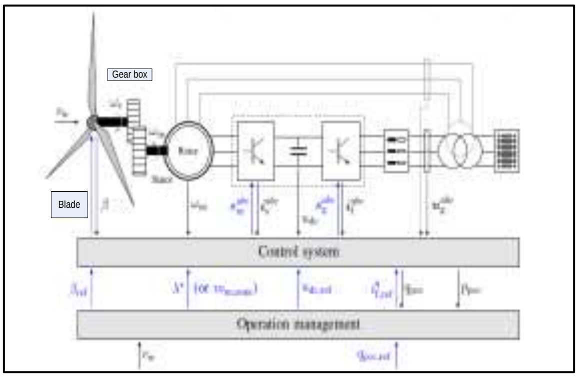

Fig. 3: Schematic diagram of wind energy system

V. Solar Generation

To Energy from solar radiation is available in abundant and costless too; hence it can be easily accessible for further use legitimately. For the purpose of producing electricity from sun based vitality; it can't be easily accessed, a conversion mechanism is required which can convert solar energy into electricity. This is called as solar cell. Though solar radiation are freely available but the cost of converting solar energy into electricity is very high which always been a research field to meet the cost efficiency [27, 28].

The photovoltaic effect was discovered as early as 1839 by the French scientist Edmund Becquerel. When sunlight falls on the PV cell, it absorbs a part of this light through the semiconductor material [29]. Photons with the energy greater than the band gap energy of the semiconductor are absorbed and dislodge the electrons from the atoms of the cell and create an electron-hole pair. These carriers are swept apart under the influence of internal electric fields of the p-n junction and create a current proportional to the incident radiation. The physical process in which a PV cell converts sunlight into electricity is known as the photovoltaic effect as shown in figure 4.

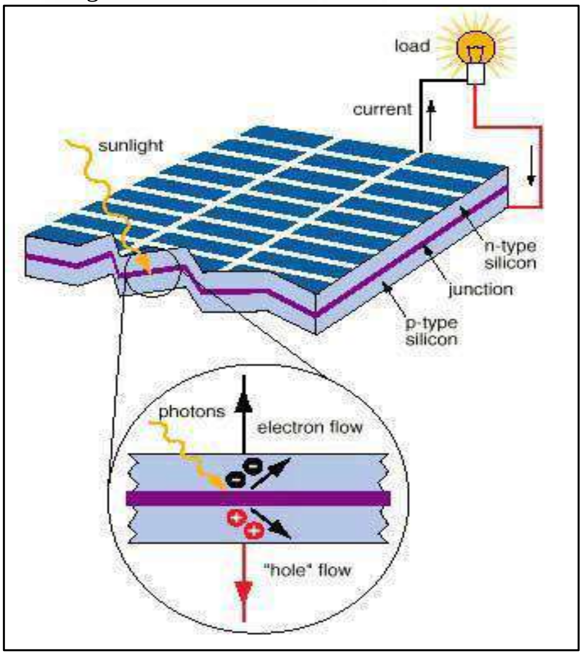

Fig. 4: Basic structure of solar PV cell

The power transformation components have been enormously decreased in measure in the previous couple of years. The advancement in control hardware and material science has helped designers to come up little yet intense frameworks to withstand the powerful request. However, the hindrance of these frameworks is the expanded power thickness. Pattern has set in for the utilization of multi-input converter units that can viably deal with the voltage changes. In any case, because of high creation cost and the low proficiency of these frameworks they can barely contend in the focused markets as a prime power era source.

The environmental dependency of the solar output has been a biggest limitation of its mass production. This can be avoided by employing power tracking control mechanism. The utilization of the most up to date control systems called the Maximum Power Point Tracking (MPPT) calculations has prompted the expansion in the proficiency of operation of the sun based modules and in this manner is successful in the field of use of inexhaustible wellsprings of vitality [30-33].

VI. Conclusion

For the populations live in rural areas access is almost negligible. A possible reason is that these areas are far away from the national grid. But there are accessible resources such as small hydro (mini, micro and Pico) and solar at remote area. These sources need short transmission line and can be installed at load sites. The power generated by Micro hydroelectric can be an answer to remote rural electrification, but the constructed power plant from hydro is not enough for the local load. So, other additional power source like solar is required to fulfill all loads (basic electric needs for local community) and to make the site reliable system. The specific objective is to assess hydro and solar resources potential for power generation project, to Local load with minimum component requirement which can be operated either in standalone system or in grid connected operation. For the installation of small hydro power Project River or canal is the first requirement and at such location availability of energy is for sure. The selection of generators, system integration and control algorithm are the major issues for such a hybrid system. Tremendous literature are available for the selection of generator for such a microgrid system. Permanent magnet synchronous generator (PMSG) is considered as a very good option for the wind generator because of its high power density and hence small size, low maintenance. Indian subcontinent has high potential for solar. Solar are popularly adopted both as stand-alone as well as grid connected system. Hence integrating as a hybrid generation is the best choice.

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