Wind Energy Integration in Smart Grid

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Abstract— Approaching towards the innovation of smartest technology in the world Smart Grid is being modified day by day for the better efficiency and better performance. One of the ways to improve the efficiency or performance of the smart grid (SG) technology is to integrate the alternative energy sources within it. In this research paper, the possibility of integrating an alternative energy sources in Smart Grid technology have been discussed. And this alternative energy source is Wind Energy. If the alternative energy sources can be integrated with the Smart Grid, the efficiency and performance will increase depending on some factors like geographical location etc. In this research paper all these things have been discussed.

Index Terms— Grid Connectivity, Smart Metering System,Wind Energy,Wind Power Plant, Hybrid System etc

1 INTRODUCTION

THE energy deficiency is one of the greatest problems for the upcoming challenges in future. Energy in the future world is going to be very limited if the dependency on the traditional fuel supply do not change. Thinking of the future generations and to meet the increasing demand for the power and energy in the future world, the world must shift to the alternative energy source and obviously to a new and efficient power and energy transmission and distribution system which is better in terms of efficiency. Smart Grid is such kind of Electricity Transmission and Distribution System which is far better and intelligent system from the traditional Electricity Transmission and Distribution System. Moreover the efficiency of the Smart Grid technology can be increased and enhanced by integrating Alternative Energy Sources. This research paper is focused on integrating alternating energy source specially Wind Energy.

2 SMART GRID

2.1 Smart Grid History

Thinking of cleaner energy, greener energy engineers started to think of such kind of electrical power and transmission system that will deliver the best output. In the year of 2003, the term Smart Grid has been used for the first time [1**].** Basically Smart Grid is the conceptual frame of combining the whole power system in a particular system which can be controlled centrally. Traditionally, the existing power system consists of three parts which includes generations, transmissions and distributions. **[2].** Smart Grid is an interactive network which ensures the connectivity between the consumer end and supplier end. Communicating through the interconnectivity network smart grid works like internet connectivity to keep the total infrastructure reliable, communicable, secure and transparent. Advanced Metering System (AMS) is enabling the smart grid to become more user friendly for the users to manage their demand (i.e. Demand Side Management (DMS)) through Smart Meter(SM)**[3].** In a single word Smart Grid is the system where power generation, transmission and distribution is controlled and monitor in a central system.

2.2 Smart Grid Motivations

Smart Grid is the Smartest technology in the world in the field of Electricity Transmission and Distribution System (ETDS). Loses in the traditional electricity transmission and distribution system is one of the drivers for changing the infrastructure of Electricity Transmission and Distribution System (ETDS). It is observed that the ETDS loses has become nearly doubled in the year 1970 to 2001[4]. Another driving factor for changing the infrastructure to the Smart Grid is Carbon Emission. Carbon Emission is one of the significant factor for changing global climate. The rapidly increasing Carbon Di Oxide is an alarming sign for the future world. So, the future world must be built on such kind of base that is carbon emission free or evolved with less carbon emission. In a survey it has been proved that the power stations had the largest fraction with 21.3% of anthropogenic annual green house gas emissions in the year of 2000 [5]. So, thinking of the future Smart Grid technology has been set up to reduce the carbon emission to save the world environment. Last but not the least, aging factor is also responsible for shifting to the rigid infrastructure of modern electricity transmission and distribution system. All these driving factors motivated the modern engineers to think of the smartest technology in the world and hence invented the Smart Grid Power System (SGPS).

2.3 Distributed Generations

Distributed generations can be defined as the electricity generated by several small power plants and then feeding the electricity to a common bus for a distribution zone. Distributed generations generally refers to small scale capacity generators usually ranges from 1KW to 50 MW[6].

3 WIND ENERGY

3.1 History of the Wind Energy

The first simple wind energy devices which was vertical axis wind mills was found thousands of years ago at the Persian-Afghan borders around 200BC and the horizontal axis wind mills was found at the Netherlands and the Mediterranean at much later(1300-1875 AD). During the 19Th century further evolutions were made by the Scientists and Engineers in USA **[7]**.Moreover different types of wind energy based instruments (i.e. Musical, Working etc) were used back in time.

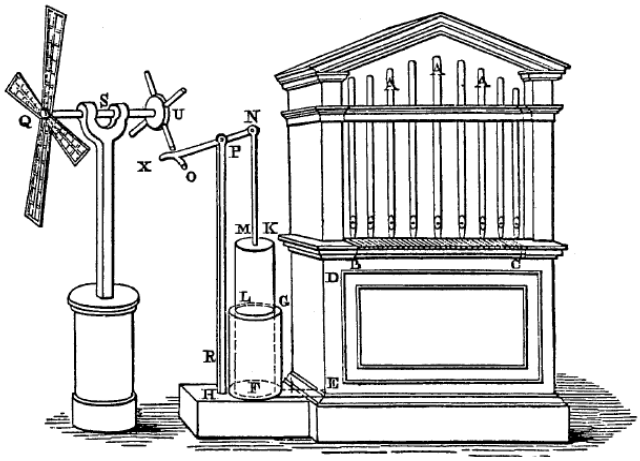

Figure: Figure: Ancient wind energy based musical instrument used in first century (AD)**[8]**

3.2 Components of Wind Power System

The wind power system consists of some mechanical units and operates electrically in parallel.

In general wind power system consists of:

1. The Tower
2. The wind turbines with three or three blades.
3. The yaw mechanism such as the tail vane.
4. The mechanical gear.
5. The electrical generator.
6. The speed sensors and control.

The Modern Wind Power System has the following components:

1. The Power Electronics
2. The Control Scheme, usually involving a computer.
3. The battery for improving the load availability in stand-alone mode.

The transmission line connecting to the area grid.[9]

3.3 Wind Power Generation

The Power of Wind can be defined as,

$$P_{Wind} = \frac{1}{2}\rho A V^3$$

Where,
ρ = Air Density
A = Area
V= Velocity of Wind

The third power of the wind velocity can be expressed in terms of the stated equation below:

$$E = \frac{1}{2}mV^2$$

m is the air mass which is passing through the area A in a given time[10].

So the power of Wind Energy can be described as,

$$P_{Wind} = \frac{1}{2}\rho A V^3 = \frac{1}{2}mV^2 = E$$

3.4 Benefits of Using Wind Power:

Wind energy plants around the world produced 273 TWh of electricity in 2009, from an estimated installed capacity of 159 GW [Grid integration of large-capacity Renewable Energy sources and use of large-capacity Electrical Energy Storage].

There are several benefits we can achieve from wind energy. They are stated below:

[1]. Wind Energy is cost competitive with other fuel sources.

[2]. Wind Energy Creates Job opportunities for the unemployed citizens.

[3]. Wind Energy is an indigenous and natural source that helps to enrich the energy portfolio of the nation's energy department.

[4]. Wind energy is an inexhaustible renewable energy source.

[5]. Wind Turbine requires less maintenance and operating cost.

[6]. Wind Energy is Clean Energy.[11]

4 Wind Energy Integration

Integration of wind energy to the grid in terms of increasing efficiency can enhance the power output of the Smart Grid Technology. There is a block diagram of integrating wind to the grid has been given in the figure. We can divide the whole system into three major parts. Beside the wind turbine, there are:

1. Turbine & Speed Control Box
2. Wind Interfacing Box and
3. Grid Connectivity & Transmission to the AC Grid

Turbine and Speed Control Box consists of Power and Speed Control devices such as gear boxes etc, generator, turbine control unit and network switches.

Wind Interfacing Box consists of AC to DC rectifier as the electricity generated from the wind turbine is AC. This rectified DC electricity is transmitted through the DC transmission line and then feed into Battery Bank as the reserve system for further use of electricity. Then the DC transmission line is directed to the DC to AC inverter for the transformation of AC electricity. There is communication control that is done for the purpose of controlling the battery charging and preventing the overcharging problem of battery which affects the battery life span and also the charging limit from the very first time of getting overcharged. These types of communication are done by the optical fibers.

The Grid Connectivity unit is mainly serving the inverted AC electricity directing to the three phase power line and filters. This is how the AC electricity generated from wind turbine is connected to the grid.

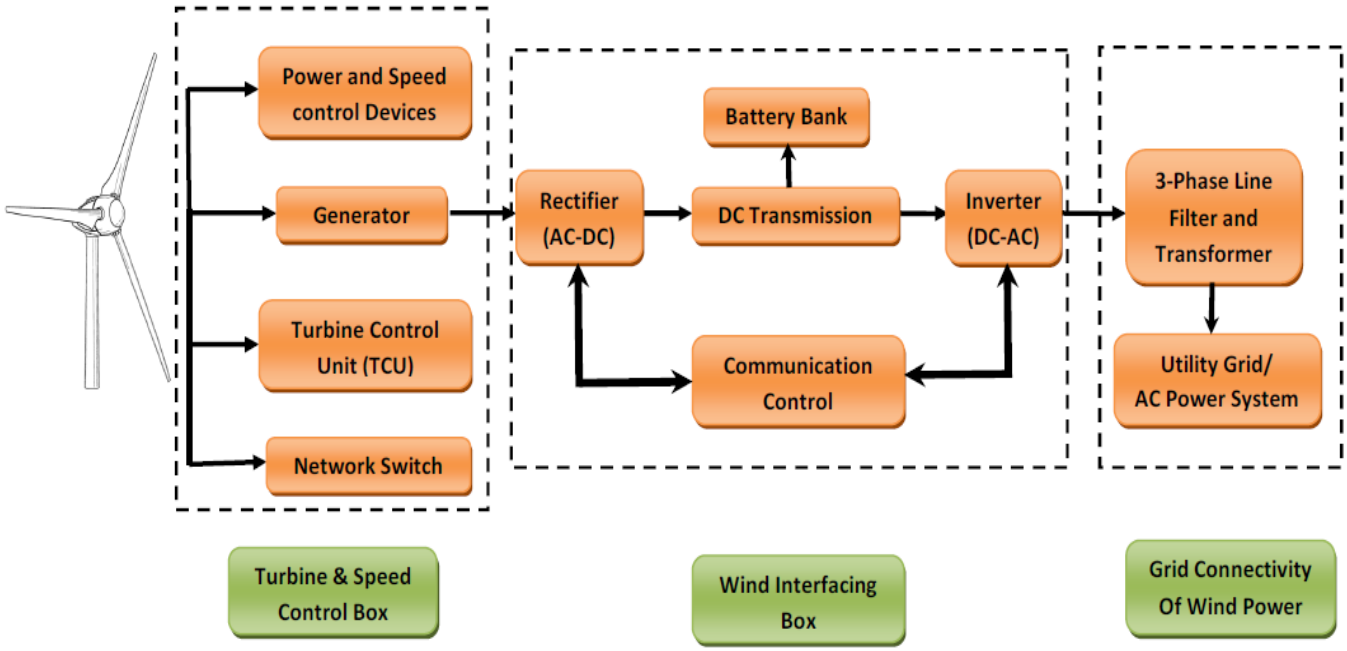

Figure: Wind Power Generation, control & Grid Connectivity

5 Wind Power Plant As Distributed Generation

As distributed generation power plant wind power plant can play a vital role. Wind Power plant can be selected as distributed generation plant evaluating some factors. There are some challenges integrating the wind power to the grid. They can be described as below:

1. Non Controllable Variability:

Non Controllable variability is the irregularity of the generation of power of wind turbines. Because of variable wind speed there must be fluctuation of the peak voltage of generated electricity. And depending on the weather condition and the air density of the locality where the wind power plant i.e. the wind turbine has been installed, the generated electricity must be varied. So there must be synchronization unit of the generated electricity.

2. Location Dependence:

Just like the solar power, wind power also has the location dependency. Solar Radiation depends on the position of the location in accordance with the position of the solar. In the same manner wind power depends on the availability of the wind density which varies from region to region. Usually the locality which is closer to the shore is having the availability of the wind. This is how the wind power integration to the gird depends on the location.

6 Benefits of Integrating Wind Energy to the Grid

The benefit of integrating the wind energy to the grid can not be denied. As the wind energy is an alternative energy source there is no fuel needed to generate the wind power. There are some other benefits of integrating the wind energy to the smart grid:

1. Enhancing the efficiency of the Smart Grid
2. Enriching the power output by adding to the generated electricity and transmitted electricity.
3. No fuel consumption while generating electricity.
4. Low maintenance cost
5. Efficient in terms of longer payback period.

7 Discussions and Limitations

Wind Energy integration in terms of integrating Renewable Energy sources can play a very important role in enhancing the efficiency and out of the power transmitted. Though there are some limitations of using wind energy as the distributed generation plants, despite of the limitations wind energy is welcomed with huge acceptance as it is clean energy and not harmful to the environment.

8 Future Works

Development of Wind energy integrator module to the smart grid is one of the future tasks. The next task can be developed by integrating multiple sources like solar, wind, hydro and biomass electricity to a hybrid module of electricity and feeding it to the Smart Grid Power Transmission & Distribution System. Developing an efficient mathematical model for the integration of hybridized electricity module to the grid is the ultimate future goal.

9 Conclusion

Considering all the situations and conditions in this research paper it is clear that the wind energy integration is obviously beneficial for the smart grid technology. Further work must be

continued to make the system more and more efficient.

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