International Journal on Recent and Innovation Trends in Computing and Communication
Volume: 3 Issue: 7
ISSN: 2321-8169
4885 - 4888

Development Trends in Wind Energy Conversion System: A Review

G.C.Biswal,
Department of Electrical Engineering,
BIT,Durg(India)
Gouranga97@rediffmail.com

S.P.Shukla
Department of Electrical Engineering,
BIT,Durg(India),
sps_bit@rediffmail.com

Abstract:- Wind energy for electricity production today is a mature, competitive and virtually pollution-free technology widely used in many areas of the world. Wind energy conversion systems have become a focal point in the research of renewable energy sources. This is not only due to the rapid advances in the size of wind generators but also for the improvement of energy electronics and their applicability in wind energy extraction. This paper deals with the recent developments in wind energy conversion systems, their classifications, choice of generators and their social, economic and environmental advantages and disadvantages, a review of the interconnection issues of distributed resources including wind power with electric power systems.

Keywords: *Induction generators, Wind energy, Off-Grid, Pitching, sitting, Shadow-Flicker.*

*****

I. INTRODUCTION

The major components of a typical wind energy conversion system include a wind turbine, generator, interconnection apparatus and control systems. Wind turbines can be classified into the vertical axis type and the horizontal axis type. Most modern wind turbines use a horizontal axis configuration with two or three blades, operating either down-wind or up-wind. A wind turbine can be designed for a constant speed or variable speed operation. Wind electric systems have siting problems involving their aesthetics, and some wind machines have problems with killing raptor birds that fly into the blades.

Variable speed wind turbines can produce 8% to 15% more energy output as compared to their constant speed counterparts, however, they necessitate power electronic converters to provide a fixed frequency and fixed voltage power to their loads. Most turbine manufacturers have opted for reduction gears between the low speed turbine rotor and the high speed three-phase generators. Direct drive configuration, where a generator is coupled to the rotor of a wind turbine directly, offers high reliability, low maintenance, and possibly low cost for certain turbines.

Wind energy has significant potential to reduce GHG emissions, together with the emissions of other air pollutants, by displacing fossil fuel-based electricity generation. Because of the commercial readiness and cost) of the technology, wind energy can be immediately deployed on a large scale As with other industrial activities, however, wind energy also has the potential to produce some detrimental impacts on the environment and on human activities and well-being, and many local and national governments have established planning, permitting and sitting requirements to reduce those impacts [7], [8].

Wind Turbine Generators:

There are different wind turbine configurations. They can have or not gearbox, the generator can be synchronous or asynchronous. Different modes of operation can be used depending on the wind turbine configuration. They are classified in variable-speed and fixed-speed. For fixed-speed operation, the system is very simple and thus the cost is usually low. As a drawback, the conversion efficiency is far from optimal. Normally an asynchronous generator is used and it is directly connected to the grid [3].

(i) Squirrel Cage Induction Generator (SCIG):

The first concept consists of a rotor coupled to a SCIG (figure 1a) through a gearbox. The gearbox is required as the optimal rotor and generator speed ranges are different. The generator is directly coupled to the grid. Therefore, rotor speed variations are very small as the only speed variations that can occur are changes in the rotor slip.

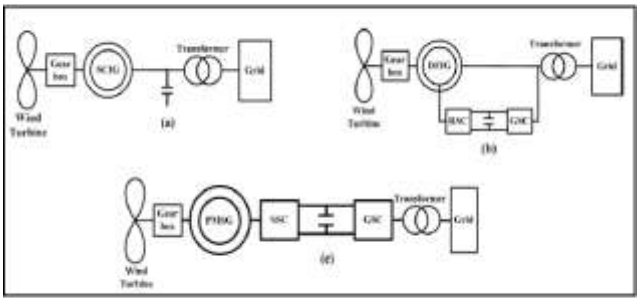


Figure 1. General structures of three different types of wind turbines

ISSN: 2321-8169
4885 - 4888

(ii) Doubly Fed Induction Generator (DFIG):

The second concept is a wind turbine with DFIG in which a back-to-back voltage source converter feeds the rotor winding (Figure 1b). A gearbox is necessary to couple the rotor to the generator like the previous case, because of the difference in the rotor and generator speed ranges. The stator winding of the DFIG is coupled to the grid, the rotor winding is coupled to rotor-side converter (RSC).
Meanwhile the other side of back-to-back voltage source converter namely grid-side converter (GSC) that feeds the rotor winding is coupled to the grid. Moreover, a DC-link is added to decoupled RSC and GSC. To limit the rotor speed, the blades are pitched.

(iii) Permanent Magnet Synchronous Generator (PMSG):

In order to operate with low speeds, a high number of poles are used in PMSG wind turbines. Instead of electrical DC excitation the magnetic rotor field is provided by permanent magnets. Because the multiple poles PMSG is a converter connected low speed application, no damper winding is necessary. The use of permanent magnets eliminates the DC excitation system, which means a reduction of losses and the omission of slip rings and thus maintenance requirements.
This configuration may respond to a variable speed wind turbine with a permanent- magnet synchronous generator connected to the grid through a full-scale power converter (Figure 1c).

Choice of the Generator type:

The choice for a particular generator type depends mainly on wind condition at a particular site, size of the generator, desired electrical energy from the generator, power quality and stability barriers and the most important one is economics associated with the installation, operation and maintenance. Figure 2 below depicts the world market trends towards wind generator types [5].

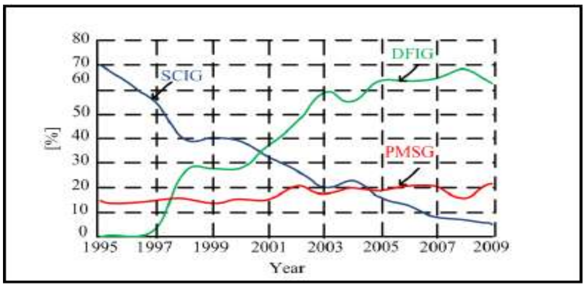


Figure 2 Annual development of wind generator types.

The Wind Energy Conversion Systems:

There are three types of machines used in wind energy conversion systems that are mentioned in previous section. The WECS consists of three major aspects; aerodynamic, mechanical and electrical as shown in figure 3 The electrical aspect of WECS can further be divided into three main components, which are wind turbine generators (WTGs), power electronic converters (PECs)and the utility grid.

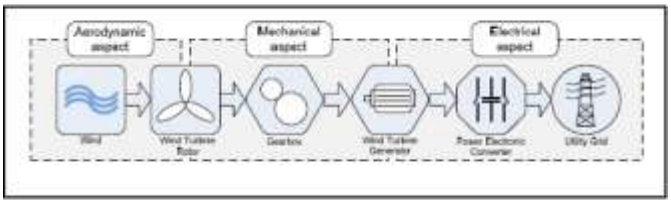


Figure 3 Wind energy conversion system

The captured aerodynamic power by the wind turbine is given by:

$$P_{wt} = \frac{1}{2} \rho \pi R^2 V^3 \qquad (1)$$

Where P_{wt} is the power, ρ is the air density [kg/m3], R is the blade radius [m] and V is the wind speed [m/s]. The turbine mechanical power which a wind turbine can extract depends on the power coefficient C_p is given by:

$$P_{mec} = C_p P_{wt} = \frac{1}{2} C_p \rho \pi R^2 V^3 \qquad (2)$$

From equation (1) and (2) it is evident that the power generated increases with wind velocity, radius of the turbine blades the power coefficient factor and the air density [6] .

Pitch Control mechanism:

Recent economic and technical developments such as the pressure to reduce the overall cost of electricity generated by wind turbines, the necessity to reduce Operation and Maintenance costs as well as increased emphasis on reliability and predictability of power production. Load reduction is a key element of the solution. The pitch controller (figure 4) plays a key role in compensating loads.

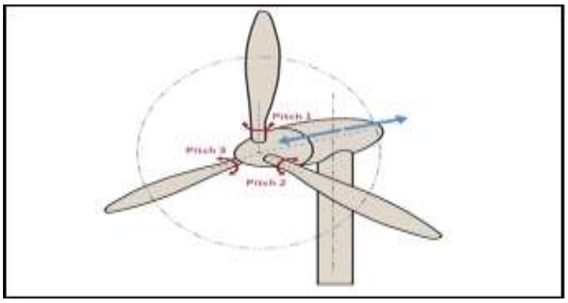


Figure 4 Pitch Angle Controllers

It allows control of the turbine speed and consequently the power output. It also acts as a brake, stopping the rotor by turning the blades. At increasing wind speeds the pitch of the blades is controlled in order to limit the power output of the turbine to its nominal value. When wind speeds reach a predefined threshold, the turbine stops power production by turning the blades to a 90°position.

PROS and CONS OF WIND ENERGY[1]

(I) Economic Advantages:

(1) Revitalizes Rural Economies
(2) Fewer subsidies
(3) Free Fuel
(4) Price Stability
(5) Promotes Cost-Effective Energy Production
(6) Creates Jobs

(II) SOCIAL ADVANTAGES:

(1) National Security/Energy Independence
(2) Supports Agriculture
(3) Local Ownership

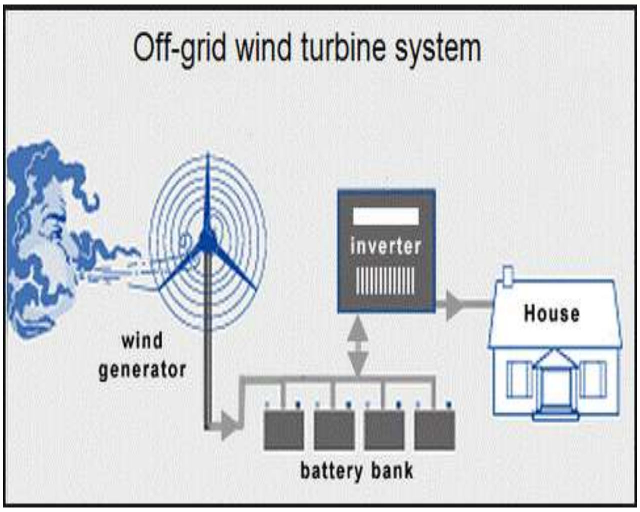
(III) Environmental Advantages:

(1) Conserves and Keeps Water Clean
(2) Clean Air
(3) Negligible Greenhouse Gases
(4) Mining & Transportation
(5) Land Preservation

(IV) DISADVANTAGES:

(1)A Variable Resource
(2) Aesthetics
(3)Shadow Flicker
(4) Sound
(5) Biological Resource Impacts
(6) Construction
(7) Radar

Wind Grid Interconnection Issues:



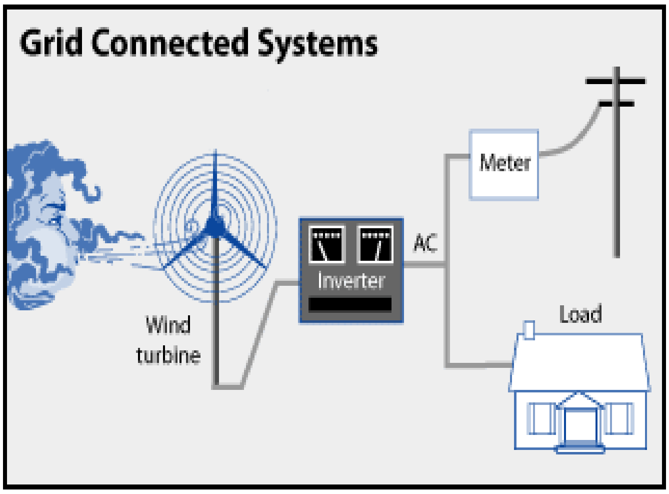


Figure 5 Comparison of Off-grid and Grid connected system

Figure 5 above depicts the comparison on the basis of interconnection to the utility grid. The grid connected systems have more reliability and flexibility [2], [4].

Typical requirements for wind power plants in transmission grids:

- Wind turbines should be able to remain connected to the grid without power reduction, even if considerable voltage and frequency deviations occur.
- If voltage dips occur due to grid problems, wind turbines should remain connected to the grid for a defined period.
- Short circuit current feeding may be demanded during a grid failure.
- After a fault has been remedied, a wind farm should resume power feed as quickly as possible within a specified maximum time range.
- Wind farms should be able to operate with reduced power output.
- For coordinated load distribution in the grid, the case of power gradient, e.g. time of wind farm started up, should be able to follow the grid operator's specifications.
- Wind farms should be able to contribute reserve energy within the grid.
- If necessary, wind farms should be able to contribute to maintaining voltage stability in the grid by supplying or accepting reactive power.
- Wind farms should be able to be integrated in the grid control system for remote monitoring and control of all wind turbines in the grid.

ISSN: 2321-8169
4885 - 4888

CONCLUSIONS

An attempt has been made in this paper to discusses number of issues related to the power generation from WECs, i.e. factors affecting wind power, their classification, choice of generators, main design considerations in wind turbine design, problems related with grid connections, grid-wind interconnection system, environmental aspects of power generation, latest trend of wind power generation from off shore sites. Today wind power accounts for about 0.4% of world's electricity demand. And there is a target estimated by EWEA to reach wind power generation nearly 12% of the world's electricity supply by 2020, which needs global exploitation of available wind potential and to generate power from off shore sites.

REFERENCES

[1] PROS & CONS OF WIND ENERGY. www.windustry.org/pros_cons_wind_energy.

[2] Grid Integration - Wind World India www.windworldindia.com/grid-integration.jsp.

[3] R. Mittal, K.S. Sandhu and D.K. Jain ,"Sustainable Growth Through Wind Energy for Distributed Generation", Proceddings of National conference on Current Trends in Electrical Engineering-08, Bhatinda, 2008,pp-35-38.

[4] Archer, C. L.; Jacobson, M. Z. (2007), "Supplying Base load Power and Reducing Transmission Requirements by Interconnecting Wind Farms", Journal of Applied Meteorology and Climatology (American Meteorological Society) 46(11):1701–1717,

[5] Vries, E.D. (2002) 'On a grand scale: the world's largest commercial wind prototype' Renewable Energy World, Vol. 5, No. 5, pp. 70-75.

[6] Bansal, R.C., Bhatti, T.S., and Kothari, D.P. (2002) 'On some of the design aspects of wind energy conversion systems", Int. Journal of Energy Conversion and Management, Nov. Vol. 43, No. 16, pp. 2175- 2187.

[7] Blanco, M. (**2009)** I., The economics of wind energy. Renewable and Sustainable Energy Reviews**,** 13, (6-7), 1372-1382. [9] Ding Z., Guo, Y. Wu, D. and Fang, Y, (2013). "A market based scheme to integrate distributed wind energy," IEEE Transactions on Smart Grid, vol. 4, no. 2, pp. 976–984. Ding Z.

[8] G. C. Biswal, S. P. Shukla (2014). "Social Aspects of Wind Power Generation- A Review" Journal of Electrical and Electronics Engineering (IOSR-JEEE) e-ISSN: 2278-1676,p-ISSN: 2320-3331, Volume 9, Issue 4 Ver. IV (Jul – Aug. 2014), PP 22-28.