Restrainment of Renewable Energy Systems and Smart Grids

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ABSTRACT
The worldwide consumption of electrical energy is increasing firmly and there is a huge demand of fulfilling the power generation capacity. An indicative proportion of power generation can be from the renewable energy systems. Energy systems like wind energy, solar energy technologies, etc. will surely play an inimitable role in future energy supplies. However other systems like micro turbines, fuel cell systems can also be serious contributors to power supply. This paper focuses on two forms of energy solar, wind energy. Finally the role of smart grids with the integration of renewable sources is discussed.

Keywords
Power generation, energy systems, wind energy, Smart Grids.

1. INTRODUCTION
The usage of renewable energy systems has greatly increased after the big oil crises in the late seventies. Energy harvesting on a huge amount, undoubtedly, is one of the main challenges for us. To fill up this gap we can invest in alternative energy resources like wind turbines, solar systems and smart grids. Future energy sustainability and controllability is hugely dependent on how it is being addressed in future decades. Though these systems cost less but the main problem with these systems is their availability. These are not always available as daily seasonal conditions affect these systems. Smart grids provide integration over these renewable systems and will provide other benefits as well. Industries must prevail over a number of technical issues to deliver renewable sources in indicative quantities. Control is one of the key factors that enable the technologies for the development of renewable energy systems. Both solar and wind technologies have immense potential in fulfilling the future needs. The early techniques used in wind energy system were a squirrel cage induction which was directly connected to the grid. This transfers the wind power pulses directly into the electrical grid system. Moreover there was no control of active and reactive power, which is the key parameter to measure the frequency and voltage of the electrical grid system. This paper will explain the wind energy system technologies, solar system technologies and then introduction and applications of smart grids.

2. WIND ENERGY SYSTEMS
The purpose of the wind turbine is to convert the linear motion of the wind into rotational energy that can be used to drive a generator, as shown in Fig. 1.

Wind turbines portray the power from the wind by means of aerodynamically designed blades which convert into mechanical power. These blades use airfoils to generate mechanical power. The aerodynamic power of wind energy is given by the formula:

$$P = \frac{1}{2}\rho\pi R^2 v^3 C_p$$

Where ρ is the air density,R is the turbine radius, v is the wind speed, and C_p is the turbine power coefficient which determines the power efficiency of the wind turbine. Charles F. Brush is given credit for the designing and inventing the world's first automatically operating wind turbine. During the late 1970's the modern wind driven generators were used, which generated up to a power of 50 kW with a blade length of 8 m. Nowadays, the output power has increased up to 1.5 to 3.5 MW with a blade length of 40 to 60 m. Due to this the cost of these turbines have reduced and efficiency, reliability, and availability has surely increased. New multi designing tools have led to the advancement and development of more advanced, complex and efficient wind turbines. The arrangement of a fixed-speed wind turbine is based on a gearbox and an asynchronous generator, which is generally a squirrel-cage generator to lower the costs. The gearbox links the wind turbine shaft with rotor of an unchangeable speed generator, providing high rotational speed as required by the wind generator. The generator manufactures electricity through a straight forward grid connection, and a set of capacitors is used to counter balance the reactive power. Due to shortage of frequency convertor, the generator speed is indicated by the grid frequency. One drawback of fixed speed action is poor aerodynamic efficiency, especially at partial load operation. From the electrical system's standpoint, another drawback is that this type of process causes effect on voltage because many generators demand reactive power from the grid.A general power curve for a variable speed controlled wind turbine is given in the Fig.2. Four girdles and two areas are shown in Fig.2. The power P of the wind turbines divides the graph into two main areas. The below rated power of the wind turbine produces less power to its total designed power, and a control planning needs to be performed. Also, for above rated power limitation control planning is performed.

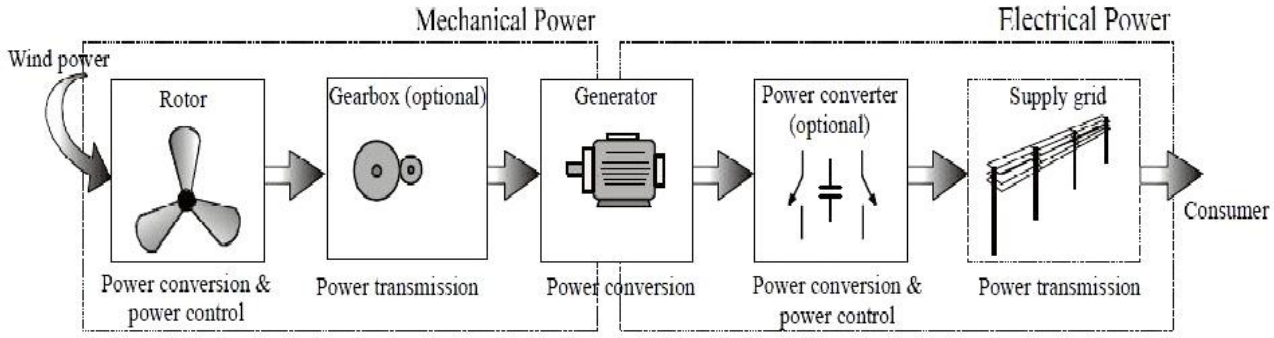


Fig 1 Conversion of Wind Power to Electrical Power in Wind Turbines

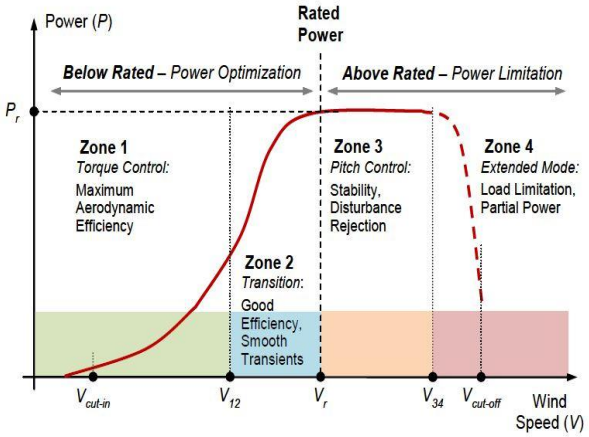


Fig 2A Generator Power Curve for Variable Speed Controlled Wind Turbines

APPLICATIONS

1. Wind energy systems are used for obtaining mechanical energy for grinding, pumping purposes.
2. Wind energy systems are basically used for energy conservation.
3. Wind energy systems are used in transportation purposes.
4. It has its biggest impact on agricultural and rural fields in the form of windmills.
5. Wind turbine generators generate huge amount of electrical power.

3. SOLAR ENERGY SYSTEMS

Solar energy or solar power received by the earth is in very dilute form. It is being utilized by many subsystems like the photovoltaic cells, fuel cells etc. Many thermal solar energy plants have been developed over the last twenty years. The new installations include 10-MW and 20-MW power plants. Solar power plants cannot be restrained with simple control planning's. They require advance processes to calculate the solar reflector positions as well as for self –calibration and prophesy of the reflectors. The sun vector clarity index, concentration ratio needs to be calculated. The clarity index K can be between 0.1 to 0.7 and the concentration ratio is given by:

$$C.R = \frac{\text{solar power per unit area}}{\text{power per unit area}}$$

The new trends in solar concentrator systems are to use open loop controllers that calculate the directivity of the solar vector based on location and time. Parabolic elongated systems concentrate sunlight on a receiver pipe situated along a focal line of the elongated collector. A heat transfer fluid, basically synthetic oil is heated as it flows along receiver pipe. For maximum efficiency, a static supply of hot oil is required at some predefined temperature, despite the variations in temperature and direct solar radiation. The photovoltaic cell is a very useful application of solar energy system. It is basically a all electrical device which produces electrical power when exposed to sunlight and connected to a load. Since wear and tear in photovoltaic cells is very low therefore their life time increases up to 25 years. However its efficiency might reduce due to aging. A typical photovoltaic cell is made up of 36 to 72 solar cells connected in series. The electrical characteristic of photovoltaic cell, exposed to a given amount of sunlight and temperature is depicted in Fig.3.

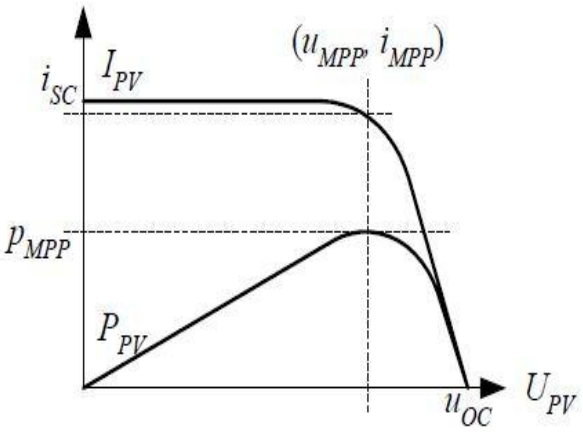
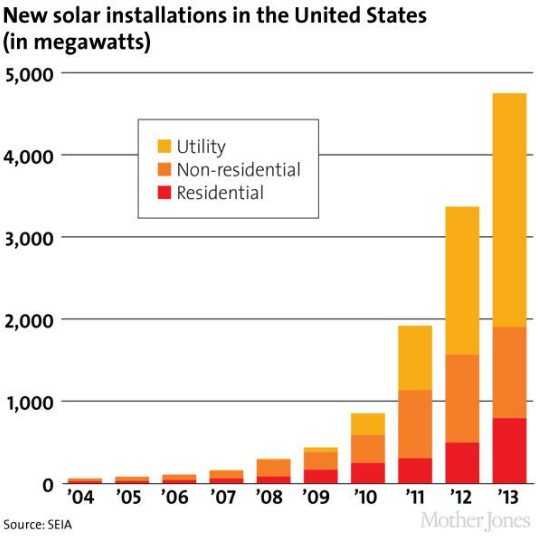


Fig 3 Electrical Characteristics of Photovoltaic Cell

1. Solar energy systems have passive heating applications without any special devices.

2. Solar thermal energy applications of medium temperature and high temperature for producing steam, electrical energy in power plants.
3. Solar to electrical energy direct conversion with the help of photovoltaic cells.
4. Large solar central receiver thermal power plants in MW range.
5. It can be used in preparing solar filter designing.



4. SMART GRIDS

The smart grid can be idealized as an extended cyber physical system that guides and supports indicative controllability and ready response of distributed resources within the electrical power systems. The smart grid technology platform briefly explains the advantages of smart grids which are as follows:

1. It allows the consumers to play a vital part in determining the operation of the system.
2. It provides with great information and options for choosing the supply.
3. Indicatively reduce the environmental impact on the whole electrical supply system.
4. It improves and maintains the existing upper levels of system quality and security supply.
5. Maintain and improve the existing services and fostering the market on a large scale.

The present grid model reflects considered trades between cost and reliability. The response achieved through smart grids concepts will play an important role in achieving high scale integration of new formats of energy generation and demand. Renewable generation techniques will make an increasingly vital contribution to electric energy production for future purposes. Integration of these highly dynamic, widely divided sources will call for new approach towards power system operation and control. New types of load, such as plug-in electric vehicles with their associated vehicle to grid potential will give new challenges and opportunities. A conceptual model of smart grid network is shown in Fig.5.The smart grids promise cost-impressive technology that overcomes the limitations of the energy systems and allows the consumers to reply to power system conditions and hence actively take part in system applications and operations. Smart grid concepts surround a wide range of technologies and their applications.

Traditional grid	Smart grid
Electric machinery	Digital
One-way communication	Two-way communication
Centralized power generation	Distributed power Generation
A small number of sensors	Full grid sensor layout
Manual monitoring	Automatic monitoring
Manual recovery	Automatic recovery
Failures and power outages	Adaptive and Islanded
Few user options	More user options

Table-comparison between traditional and smart grid

5. CONCLUSION

The renewable energy systems are a vital source for the human beings. Their usage, advantages and disadvantages are a matter of concern. The energy systems are used in abundance in many applications, therefore control over them is necessary and smart grids use practical and technical techniques to provide control over these energy systems and try to put a limit over them so that they can be used in a limit for future purposes. The significant challenge with the smart grids is the integration over the renewable energy generation. Wind energy and solar energy systems have a large number of applications by which they are able to provide high amount of energy with the help of wind turbines, photovoltaic cells, fuel cells. Therefore the control over renewable energy systems is possible with the help of smart grids.

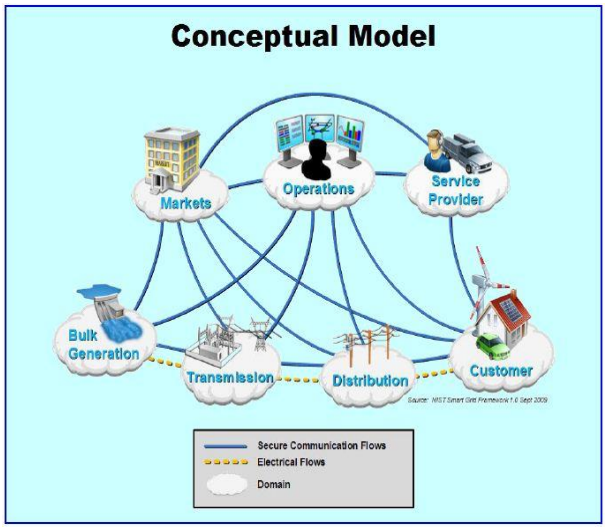


Fig 4 Conceptual Model of the System

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