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Integration of Renewable Energy Sources in Smart Grid

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Abstract: ***Smart grid technology is the key for an efficient use of distributed energy resources. The smart grid is the future conversion for the techniques and strategies of production and the interaction of all the components of power grid. Noting the climate change becomes an important topic of concern, the whole world is currently facing the ever increasing price of petroleum products, coal etc and also the reduction in cost of renewable energy power systems, giving opportunities for renewable energy systems to address electricity generation. However, to achieve this task, an efficient energy management system needs to be addressed. In this context, the concept of smart grid plays a crucial role and can be successfully applied to the power systems. This paper presents the study of integrating renewable energy in smart grid system. The introductory part provide the role of renewable energy and distributed generation in smart grid system The concept of smart grid renewable energy system and its applications along with the PV smart grid system are also been discussed and studied.***

Keywords: Smart grid**,** Renewable energy resources, PV, distributed generation (DG)**.**

1. Introduction

In recent years, the utilization of renewable energy sources in smart grid system has been increasing [1]. The quest for cleaner, green and more reliable energy sources has considerable implications to the existing power transmission and distribution system. Traditionally the power is generated in bulk and distributed to the large load centers via the transmission lines. The transfer of power was always one way, which is from the utilities to the consumers. Now in the immediate future, renewable energy sources cannot support the entire grid by themselves [1]. So they have to be connected to the main grid acting as auxiliary power sources thus reducing the overall burden on the primary power generation units. They could also be employed to serve load units totally isolated from the main grid. A power system having wind powered turbines, micro generators, fuel cell based system and PV systems augmenting the main power lines will constitute a distributed power generation (DG) system. In a DG system end users need not only be passive consumers, but they can be active suppliers to the grid. Distributed generation (DG) is an alternative which is not only gathering momentum but can also playing an important role in meeting the ever increasing power demands by using an alternative source of energy such as photovoltaic, wind, fuel cells, etc.. The need of integrating the renewable energy into power system is to minimize the environmental impact on conventional plant [2]. Smart grid plays a major role here. The basic objective of smart grid is to promote active customer participation and decision making as well as to create the operation environment in which both utilities and consumers can interact with each other. In smart grids, users can influence utilities by providing DG sources such as photovoltaic modules or energy storage devices at the point of use, and reacting pricing signals. Additionally, utilities can improve reliability through the demand response programs, adding DG or energy storage at substations, and providing control automation to the grid [3].

2. General features of smart grid

Smart grid has different aspects and can be characterized as follows:-

- Interactive with users and markets
- Adaptive and scalable to varying situations
- optimized to make the best use of resources and equipment
- Pro-active instead of reactive to prevent emergencies
- Self-healing grids with advanced automation
- Integrated, merging monitoring, control, protection,
- maintenance, EMS, DMS, AMI, etc.
- Having plug-and-play –features for network equipment
- and ICT solutions
- Secure & reliable
- Cost efficient
- Provides real time data and monitoring

Traditional grid includes centralized power generation, and at the distribution level unidirectional power flow and weak market integration. Smart grids include centralized and distributed power generation produced considerably by renewable energy sources. They integrate distributed and active resources (i.e. generation, loads, storages and electricity vehicles) into energy markets and power systems. Smart grid is nothing but the electricity network that smartly integrates producers and consumers to efficiently deliver electricity which is sufficiently capable and coverage area accessible, safe, economic, reliable, efficient, and sustainable [4]. Smart grid development tends to be driven by one of the two principal visions for enhancing electric power interactions for both utilities and end use customers.

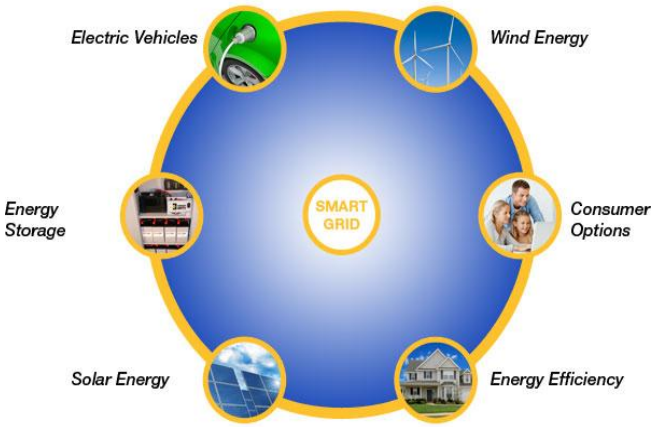

Figure 1: Smart grid features

The rapidly growing installations of non-conventional energy resources require a coordinated and joint effort from the planning stage all the way down to the electronic devices basically used for power generation, distribution, storage purpose and consumption [5].

Table I makes a contrast between Smart Grid and the existing power grid

Comparison	*Conventional Grid*	*Proposed Smart Grid*
Information flow	Unidirectional	Bidirectional
Electricity generation	Central generation	Distributed generation
Overall efficiency	Low	High
Enviromental pollution	High	Low
Sensors	Few sensor	Many sensors
Monitoring ability	Usually blind	Self-monitoring
Grid topology	radial	network

3. Role of renewable energy and distributed generation in smart grid

Around the world little change in generation of electricity is required in order to Figureht climatic changes and to increase energy security. Consequently, renewable energy resources and DG's are receiving support and their shares in electricity generation are rapidly rising. The growing renewable generation in an inflexible system is the key challenge for developers and practitioners of smart grid system. The addition of DG to the electrical distribution system has been the key driver in the evolution of distributed system; however DG hardly gets any market signals nor participates in system management for two reasons [6]. Firstly, DG is often from renewable energy sources and therefore organized on the basis of priority under fixed feed-in tariffs and not obligated from market prices. Secondly, generators in distribution networks are often too small and not equipped with technology. Furthermore, one of the problems experienced is that the increasing renewable shares may cause congestion in distribution networks [7].

While building new infrastructures, smart grid technologies can also help utilities to alleviate grid congestion and to maximize the potential of our current architecture. As smart grid technologies become more popular, the electrical grid will be made more efficient, resulting in reduction of issues of congestion. Lots of Sensors and controls will help intelligently, reroute power to other lines when required, accommodating energy from renewable sources, so that power can be transported to a greater distance, where it is needed [5] . Smart grid delivers electricity from suppliers to consumers using digital technology through control automation, continuous monitoring and optimization of distribution system, in order to save energy, reduce consumer cost and improve reliability [8].

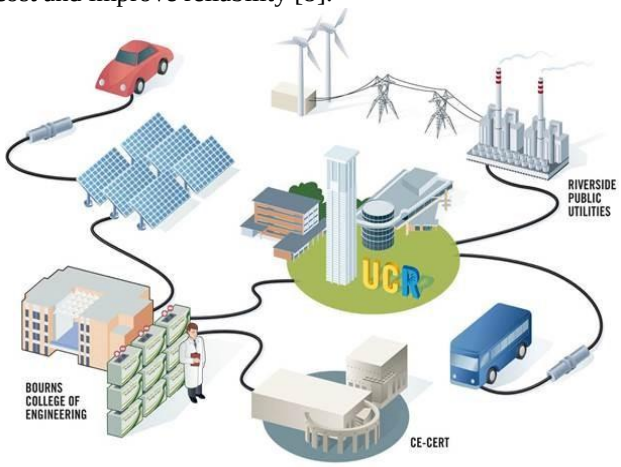

Figure 2: Renewable sources in smart grid

3.1 PV Smart Grid System

PV generates power in a manner that is essentially different than the way power has been generated in the past, and requires a power electronics interface to convert the native format of the generation so that it becomes grid compatible. Photovoltaic energy is one of the most easily scalable types of renewable energy generation; it can be produced in amounts from a few KW at the residential scale up to multiple MW at the utility scale. Due to the growing electricity demand, increase in price of petroleum products and slightly reduction in PV system cost over the last many years, the gateway and opportunities for PV smart grid system seem to be increasing.

Photovoltaic energy systems consist of arrays of solar cells which create electricity from irradiated light. The output of the PV (photovoltaic) system is primarily dependent on the intensity and duration of illumination. Solar electricity provides us with non-depleting, site-dependent and eco-friendly alternative energy option. PV offers clean, emission-less, noise-free energy conversion, without involving any active mechanical system. Since this is all electric, it has a high span time (> 20 years) [2]. There is a need of lot of work to be done to further enhance the efficiency of the solar cell which is the building block of PV system.

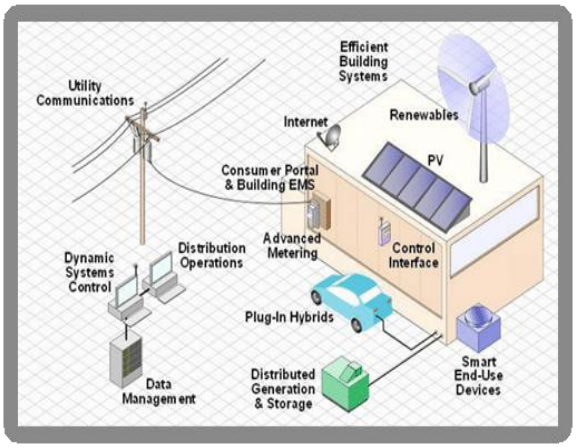

Figure 3: Photovoltaic cell network in building

In this regard the focus is mainly shifts to electro-physics, nanotechnology and materials domain. Some of the existing PVs and their efficiencies are [2]:

- Crystalline and multi-crystalline solar cells having a efficiencies of ~11 %.
- Thin film amorphous Silicon bearing efficiency of ~10%.
- Thin-film Copper Indium Diselenide with an efficiency of ~12% .
- Thin film cadmium telluride with an efficiency of ~9%.

The advantages of PV modules are minimum maintenance and easy expansion to meet the growing energy demands. This modularity permits users to tailor PV system to the desired condition. High cost and the need for the application/load to match with illumination of light output of Photovoltaic are the main disadvantage. However, technological breakthroughs (yielding cost reduction of PV, improved efficiency, etc.) may change the scenario [5].

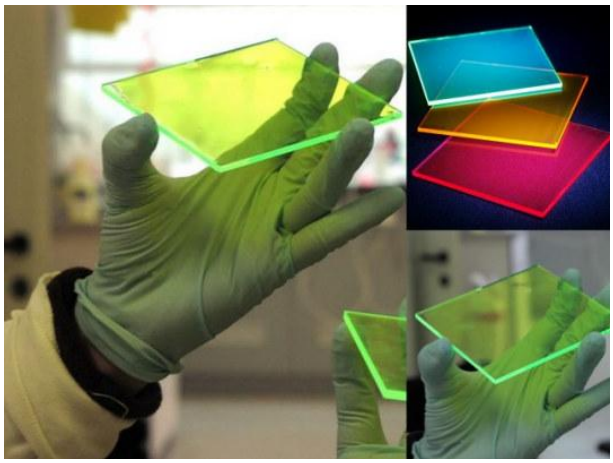

Figure 4: PV Cell

4. Conclusion

In this paper, the key technologies of smart grid have been studied and reviewed. The major importance of renewable energy, renewable energy based energy conversion systems, and distributed power generation has been reiterated. It can be concluded that with the advancements being made in the area of renewable energy and distributed power generation, Smart grid has a demanding and critical role in the future of efficient power generation and distribution.

Renewable energy system is an innovative option for electricity generation, especially the PV system as it is a clean energy resource. However, to achieve a goal, a lots of issues need to be solved or addressed. These issues are basically related to the design and size of the system, the suitable and effective model which can cover the technical and financial aspects of PV smart grid to supply electricity, and the equalized electricity price for integrating PV in a smart grid system. Further nanotechnology based solutions and applications in the devices/components could help us in near future for improving the efficiency using smart grid.

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