Renewable Energy Sources Integration with Smart Grid

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Abstract— Flexible, strong, and smart grids play a crucial role in the integration of variable renewable energy (RE). As high levels of variable RE penetration becomes increasingly common across power systems. 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. 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. 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.

Key words: Renewable Energy (RE), Smart Grid, Distributed Generation (DG), Wind power

I. INTRODUCTION

In recent years availability of power in world has both increased and improved but demand has consistently outstripped supply and substantial energy and peak shortages prevailed in recent years. The selection of an energy resource for electricity generation is growing concern about other aspects such as social, environmental and technological benefits and consequences of the energy source selection. Adoption of System integration by utilities will help to find ways to maintain the functionality of their current systems while also riding the wave of innovative technology that keeps them ahead of the competition. For integration of smart grid and renewable energy systems into a integrated system needs broad range of skills. These skills are likely to include advance technology, interface procedures, and general problem solving skills. The need of integrating the renewable energy into power system is to minimize the environmental impacton conventional plant [1]. 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 [2].

II. IMPORTANT FEATURES OF SMART GRID

A. 2-Way dialog

One of the main improvements that the smart grid will have over the conventional grid system is the introduction of a 2-way digital dialog system. This introduces intelligence, automation and control into the electrical grid. It enables not only the transmission of electricity from grid to home, but also the integration of an intelligent communications network.

B. Real Time Control

Through the use of the digital communications technology that the smart grid uses, real-time control can be implemented. Both the utility companies and consumers are able to see and monitor electrical usage as it occurs. This real-time control increases the reliability, efficiency and speed of the grid. It also allows for Time of use tariffs, which aims to time-shift the demand, resulting in more evenly distributed electrical usage, so new expensive generating capacity doesn't need to be built since peak demand will actually fall.

C. Ability to identify issues within the Grid

Currently, once an area loses power, the Grid is only informed once a customer complains about a lack of electricity. This can therefore lead to a long process of repairs, especially if the problem occurs in the middle of the night and no one contacts the utility company until the morning. With the introduction of the smart grid, when an area is affected by unforeseen circumstances that causes it to lose power, electricity will automatically be redirected via an alternative route ensuring there is no impact on the customer. This self-healing power of the smart grid, enables rapid fixes and allows for a more reliable, efficient electrical grid.

D. Using Electricity Closer to Home

One important feature that the smart grid will impose is the introduction of the intelligent allocation of electricity. This means that if you were to flick on the kitchen lights, the electricity required would come from the closest possible source. The current grid has many transmission problems that can lead to the loss of electricity due to the distances the electricity has to travel from the few centralized fossil fuel power plants to the home. However with the smart grid, and the introduction and integration of millions of micro power plants such as wind turbines and solar panels, electricity can be used much closer to home; thus reducing the potential losses transmission creates.

E. Distribution Intelligence

The smart grid would use distributed intelligence, which allows it to recognize these daily trends. This would enable the grid to implement miniscule delays upon the delivery of

electricity that relieves pressure and reduces the sudden increase in demand.

Data is administered where electricity is consumed, at the end of the smart grid, and can be analyzed in order to make real time decisions on the distribution of electricity. This distribution intelligence will reduce the amount of pressure that the centralized grid is put under, while also multiplying the other benefits of the smart grid.

F. Operations Centers and Resilience

The active process of getting electricity from the grid to the place where it's needed used to be fairly simple. The number of appliances in the UK was at such a number that it allowed for a small quantity of cables to easily transport the electricity. However, as the need for electricity increased, more cables were put up until it became a complex web of criss-crossing wires stretching for miles on end.

This often causes damaging oscillations within the network, which leads to blackouts and a potentially inconsistent supply. However, with the smart grid comes the introduction of new operation centres that use real-time information to help efficiently transform the electricity network into an organised system, effectively reducing the chance of blackouts and failures.

The highly technological smart grid will also have the power to resist attacks and natural disasters through the introduction of extremely assured security protocols.

G. Better Integration of Renewables in our Energy Mix

This is the feature we are dealing with. This includes the massive wind farms that are now dotted around the country as well as individual properties that have solar PV panels on their roofs. This has led to a far more complicated energy mix than we have had to deal with before, with intermittency now having a far larger impact on our energy supply than ever before.

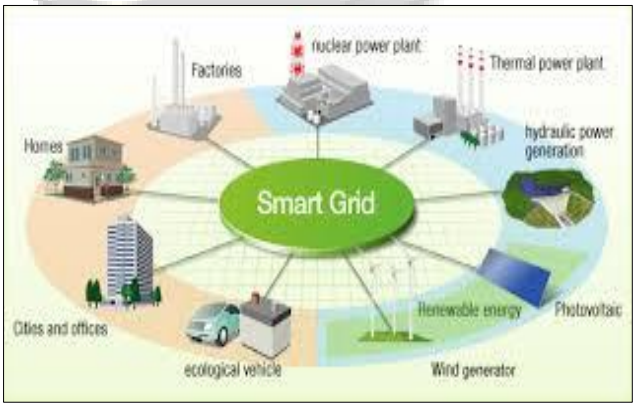

Fig. 1: Smart grid integrating with renewable energy

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 [4].

III. ROLE OF DISTRIBUTED GENERATION AND RENEWABLE ENERGY IN SMART GRID

In decades past, distributed generation (DG) consisted of a smattering of off-grid generation sources, industrial and commercial grid-connected generation—including backup supply and combined heat and power (CHP), and strategically located utility-placed generation for grid reliability. DG was fairly predictable. 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 [5]. 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 [4].

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]. Through cooperation, smart grid technology can provide the flexibility needed to integrate variable generation that is a characteristic of renewable resource such as wind or PV.

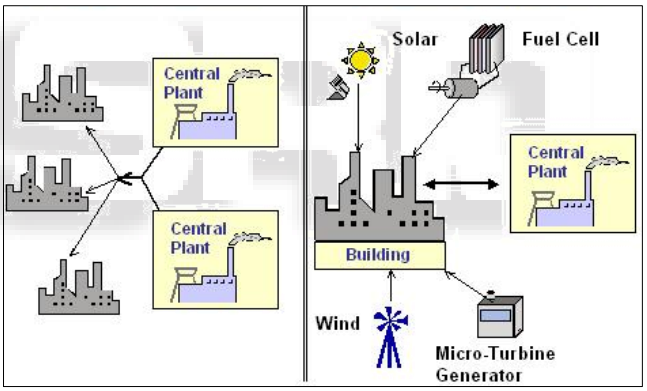

Fig. 2: Central Vs Distributed Generation

A. 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 [3].

The integration of renewable energy sources, such as photovoltaic systems (PVS) into the electrical power grid (Either low or medium voltage) throws up several technical troubles like instability, energy quality degradation, signal parameter fluctuation (current, voltage and frequency) and the renowned phenomenon of mismatch between load supply and demand. The economic problem of PV integration is the high installation cost due to lower PV penetration rate of these decentralized power stations. Indeed, electricity grids are stable systems contrarily to renewable energy plants (PV and Wind) which are decentralized, unpredictable and their connection to the grid could lead to instability while coupling them.

Many simulations and modelling works have been conducted based on smart grid backbone structure over the last decade. In general, They discuss smart grid concept and applications, design, sizing and optimal placement of the energy mix, small scale test-bed implementations in order to choose the best strategy to its implementation, voltage stability, overall system integration rate, global losses and many other factors which help economical and technical decision-making [7].

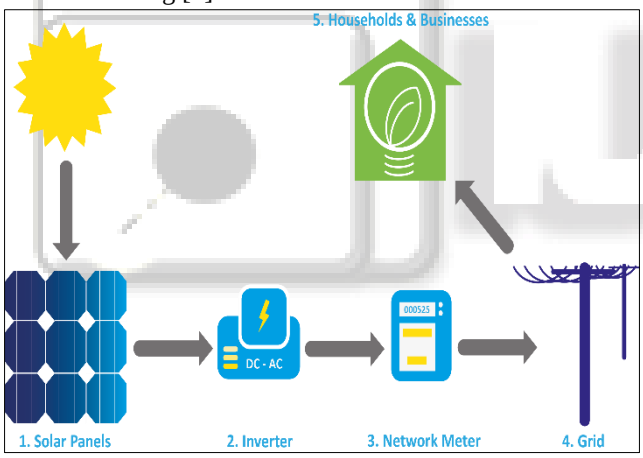

Fig. 3: PV cell Network

In this regard the focus is mainly shifts to electro-physics, Nanotechnology and materials domain. Some of the existing PVs and their efficiencies are [1]:

1) Crystalline and multi-crystalline solar cells having a efficiencies of ~11 %.
2) Thin film amorphous Silicon bearing efficiency of ~10%.
3) Thin-film Copper Indium Dieseline with an efficiency of ~12%.
4) 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 breakthrough (yielding cost reduction of PV, improved efficiency, etc.) may change the scenario [4].

B. Wind Power Smart Grid System

Wind power generation, in particular, is recognized for emitting less CO_2 (carbon dioxide) than other types of electric power generation during construction, operation, and maintenance, as well as emissions associated with the extraction, transport, and refining of fuel. The amount of wind power generation capacity being installed is growing, primarily in Europe, the USA, and China.

The control technique generally used on the wind turbine system is active-power-based control which works by controlling the active power (generated power)[8]. This technique measures the active power of the system which consists of the grid side converter and generator stator and performs the fast response control of the electric power converter to keep the measured active power equal to the active power command calculated from the wind speed as shown in figure

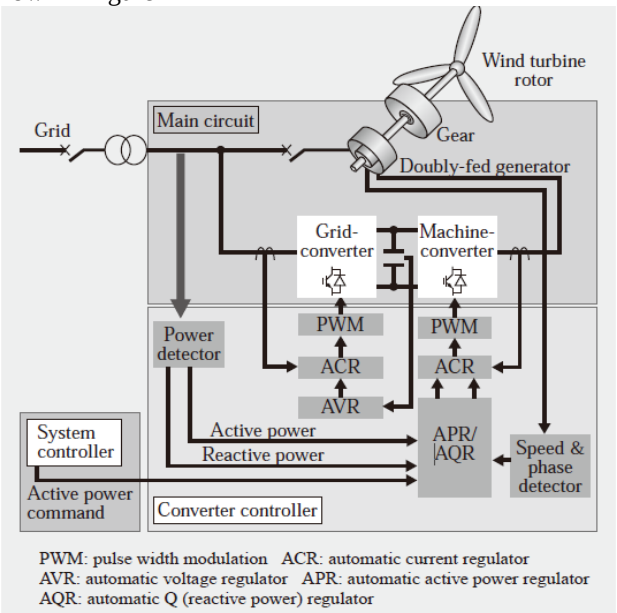

Fig. 3: Active power based control of wind power system

IV. CONCLUSION

We still face the challenge of integrating renewable energy sources into power system grids. Renewable energy system is a new option for electricity generation, especially the solar PV system as it is a clean energy resource. Recognizing the advantages of PV system, many such systems have been installed worldwide in recent years. To achieve the commercialization and widespread use, a number of issues need to be mention. These issues are related to the design and sizing of the system, the suitable and effective model that includes technical and financial aspects of PV smart grid to supply electricity, and the balance electricity price for integrating PV in a smart grid system. Earlier studies showed that the balance electricity price for integrating PV in a smart grid system dealing with the reality of using PV smart grid systems are limited. Therefore, there is a need to develop a PV smart grid system model that incorporates technical and financial aspects. This would be useful to evaluate the balance electricity price for integrating PV in a smart grid system.

Furthermore we had discussed about the generation and controlling of electrical energy from wind power and integrating it with smart grid. Because the electrical power is proportional to the product of torque and rotor speed, the generated power changes as the wind speed is not constant all the times. Active power based control had been suggested to get rid of power fluctuations.

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