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TRENDS IN RENEWABLE ENERGY SOURCES FOR SMART GRIDS AND MICRO GRIDS

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Abstract—In this paper, the increasing role of renewable energy sources basically photo voltaic system is being discussed firstly.Next the various technologies being implemented in the existing system to be more reliable, safer,stable all this aspect are being defined by a term Smart Grid.In the last section the role of disturbtion of electrical energy to the islanded areais discussed.

Keywords—RES, Smart Grid, Micro grids

I. Introduction

Renewable energy supply holds a main necessity for modern worlddue to the load demand caused by the larger consumption and population growth. For many decades, the energy boom was relied on fossil fuels. As oil, coal and natural gas hugely affects global warming, major pollution and other environmental concerns associated with such energy sources Renewable energy sources are seen as some of the major important solutions for the coming future and they need to be very focused on further developed in order to take over major the energy production. Many technologies exist and new emerging technologies are also being implemented. This scale of implementation will differ. Most of the renewable technologies are based on weather conditions and are very challenging in respect of the integration into the grid system.

Electrical power systems are fundamentally dependent on communications, control and computation for ensuring stable, reliabililty, efficient operations. Generators rely on governing system and automatic voltage regulators to control the effects of disturbances that continually buffet power systems.Flexible AC transmission system (FACTS) devices, such as static var compensators (SVCs) and high-voltage DC (HVDC) schemes, rely on feedback control to enhance system stability. At a higher level, energy management systems (EMSs) use supervisory control and data acquisition (SCADA) to collect data from expansive power systems and sophisticated analysis tools to establish secure, economic operating conditions.

According to The European Regulators Group for Electricity and Gas (ERGEG), developed based on the definition from the European Technology Platform Smart Grids (ETPS): smart grid is an electricity network that can cost efficiently integrate the behavior and actions of all users connected to it.

Smart grid is characterized by the following:

– Self-healing

– Consumer friendly

– Resistant to physical and cyber attacks

– Optimizes asset utilization

– Eco-friendly

– The use of robust two-way communications, advanced sensors and distributed computing technology

– Improve the efficiency, reliability and safety of power delivery and use.

Fig.1.smart grid model

Next section-II deal few ascpects on renewable energyfor photo voltaic.In section-III highlights the smart grids technologies for better reliable system .section-IV will lighted with role of RES in Micro Grids.And Final section will a conclusion for RES,smart grids, micro grids.

II. Renewable Energy Sources

Contribution of renewable energy sources significantly reduced the emissions of greenhouse gases and other harmful pollutants into the nature, most of countries are developing technologies for more efficient and reliable systems use (e.g. wind farms and solar photovoltaic (PV) systems) in electric energy generation due to greenhouse gasses and other pollutants which is leading to global warming, the demand for renewable energy sources is

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rapidly growing. In fact, in the past several decades, the global demand for renewable energy sources for electricity generation has dramatically decreaed the demand of conventional fossil fuel. Therefore, many countries have developed technology to more efficiently and reliably use such sources for electric power generation. The United States (US) has led such a rapid expansion of renewable energy resources, particularly in photovoltaic (PV) and wind energy. For example, in 2012, the US produced 140.9 terra watt hours (TWh) of electric energy from wind power plants, accounting for the largest percentage of the world production, or 26.4% [1]. (In December 2014, the US was the second leading producer with a cumulative capacity of 65,879 megawatts (MW), after China, 114,763 MW [2]). In 2015, renewable energy sources for US electricity generation account for 13.19% of total net electricity production, or 4092.9 TWh (6.32% hydroelectric, 4.44% wind, 1.57% biomass, 0.45% PV, and 0.41% geothermal) [3]. At such a low fraction (e.g. 13.19%), electricity generated from other renewable energy sources in the US, excluding hydropower, the area shaded in red in Fig 1, have exhibited relatively steady increase since the mid-1980s (Fig 1). In other words, the country is expected (a) to meet new demand by increasing renewable energy sources abundant throughout the country (e.g. wind, biomass, geothermal, and solar), (b) to cope with highly unstable prices of conventional fossil fuels, and (c) to reduce the release of greenhouse gases and other pollutants into the atmosphere (in accordance with the United Nations Framework Convention on Climate Change). Thus, the ratio of renewables, including hydropower, to total US electricity supply decreased by the end of 1900s but increased after that, as shown in Fig 2.[4]

Fig.2: Electrical Energy from RES (data1950-2013for USA)

To estimate the extent to which US renewables can increase, many studies have examined their future potential and predicted that they will either slightly or significantly increase. For example, the reference scenario shows that renewable energy sources for US electricity generation could comprise as much as 18% of total electricity production in 2040 (909 TWh of 5056 TWh) [6]; and another study forecasted that by 2050, they could account for as much as 80% [5]. Using commercially available techniques, both studies, while showing different growth rates, estimated that US renewables would continuously increase. Therefore, the objective of this article is to (a) examine the recent trends in renewable energy sources for electricity generation in the US and (b) discuss the projections of their future. For this purpose, this article initially examines the current activities devoted to US renewable energy sources in the following order: hydroelectric, wind, biomass, PV, and geothermal energy sources. Then, it compares several case studies that forecast their potential and success.

A. PV Energy

Using semiconductors devices with the photo voltaic (PV) effect, PV systems convert solar radiation energy into direct current (DC) electric energy. USA solar PV systems can be divided into residential and commercial roof-mounted systems with up to 5 MW in capacity (typically connected to the distribution side) and utility ground-mounted PV farms >5 MW (typically connected to the transmission side) [7]. The US solar industry experienced a banner year in 2014. In fact, the newly installed capacity of US PV plants amounted to 6201 MW in DC capacity, shown in Fig 2 , and by the end of the year, it had reached a cumulative capacity of 20 GW [8]. In the 12 months prior to 31 March 2015, the country had produced 20.23 TWh, <0.5% of total US electricity generation and 3.7% of total US renewable generation [9].

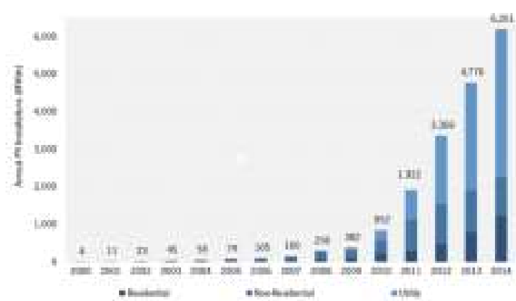

Fig.3: Annual PV capacity of newly installed system in the USA

B. Future status of PV power generation

Within only few decades, solar power in the USA could represent the second largest source of renewable electricity after wind, excluding hydropower. One study predicts that the US solar power industry will produce 110.1 TWh in the reference case in 2040, 2.2% of total electric power generation of the nation in 2040 (e.g. 5056 TWh), or 12.1% of total renewable power generation (e.g. 909.1 TWh). In 2040, its net generation capacity will be 60.6 GW, accounting for 5.2% of total net generation capacity (e.g. 1170 GW) and 22% of total renewable generation capacity (e.g. 275.2 GW) [6]. Another study estimates that in the 80% renewable scenario, a cumulative installed capacity of US solar power plants will range between 91 and 330 GW, which corresponds to 2.9–22% of overall US renewable electricity generation capacity in 2050 [5].

Furthermore, the Sun Shot Initiative, initiated by the US Department of Energy, plans to increase US cumulative capacity to 330 GW by 2030 and 715 GW by 2050 [9]. According to these studies, the US solar industry, expected to grow continuously and rapidly for several decades, will probably become the second largest source of renewable energy after wind, excluding hydropower.

c. Future in India

India takes the No. 1 spot on this trends list for its sheer volume of activity in the solar sector in 2016. The country is mobilizing to boost solar capacity in the country to 100 GW by 2022, if not sooner. This year, India issued its first call for solar power projects with energy storage and set out about $3 billion in state funding for developing the country's solar panel manufacturing infrastructure. Meanwhile, the global investment community has begun backing activity in the country, with more than $100 billion in commitments that support solar development. As the foundation for large-scale solar in India continues its momentum in 2017.[10]

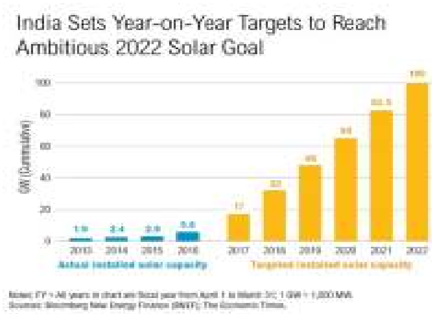

Fig.4. Stats of solar for India

According to the targets, India will add 12 GW of new solar power capacity this fiscal year, and add 15 GW and 16 GW of new solar capacity in FY2018 and FY2019, respectively. This will also bring the country closer to the government's commitment of providing 24-hour electricity to all Indians by 2019.[10]

III. Smart Grids

Electricity grid is generated by a central power plant and distributed to different customers through transmitting lines as shown in Figure 5. Using step-up transformer voltage is stepped- up from generating stations and transmitted through various transmission stations, stepped-down for utility distribution in from distribution substations, may be further stepped- down at points along the utility distribution lines, and again at pad- and pole-mounted transformers to provide low-voltage service to one or a several customers . Even though it is providing 99.97 percent reliability, yet still has some significant issues:

(1). Limited delivery system

(2). High cost of power outage and power quality interruption.

(3). Inefficiency at managing peak load.

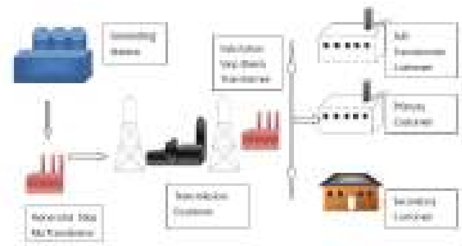

Fig.5. Existing electricity delivery system

Smart Grid is developed by the European Technology Platform for 7th Frame Work Program. Since Smart Grid is still in research stage, there is no coincidence with the accurate definition for it, what features should it have, what goal should it achieve, what is the important point for develop it.Moreover considering the varying situations in different countries-economic development, developing strategies and policies, it is hard to obtain a unified definition.[12]

A. Advantages of Smart Grids

Smart grid is not a single technology, but a combination of several technologies. By rational use different technologies, it can offer several potential economic and environmental benefits:

- Improved Reliability
- Higher asset utilization
- Better integration of plug-in hybrid electric vehicles (PHEVs) and renewable energy
- Reduced operating costs for utilities
- Increased efficiency and conservation
- Lower greenhouse gas (GHG) and other emissions

Fig.6 shows some key technologies and applications of Smart Grid

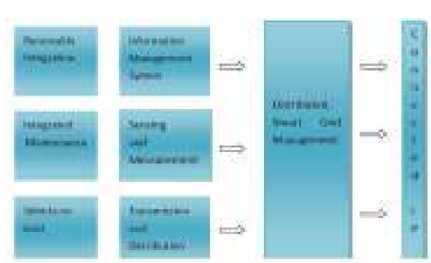

Fig.6: key technologies and applications of smart grids.

Comparison of Existing and Future Grid:

Table.I: characteristics on existing and future Smart Grid

Characteristic	Existing Grid	Future Grid
Enable Active Participation by Customers	Consumers are uninformed and non-participate with power system	Informed, involved, and active consumers - demand response and distributed energy resources.
Accommodate All Generation and Storage Options	Dominated by central generation- many obstacles exist for distributed energy resources interconnection	Many distributed energy resources with plug-and-play convenience focus on renewables
Enable New Products, Services and Markets	Limited wholesale markets, not well integrated - limited opportunities for consumers	Mature, well-integrated wholesale markets, growth of new electricity markets for consumers
Provide Power Quality for Digital Economy	Focus on outages - slow response to power quality issues	Power quality is a priority with a variety of quality/price options - rapid resolution of issues
Optimize Assets and Operate efficiently	Little integration of operational data with asset management - business process silos	Greatly expanded data acquisition of grid parameters - focus on prevention, minimizing impact to consumers
Self-healing	Responds to prevent further damage- focus is on protecting assets following fault	Automatically detects and responds to problems - focus on prevention, minimizing impact to consumer
Operate Resiliently Against Attack and Natural Disaster	Vulnerable to malicious acts of terror and natural disasters	Resilient to attack and natural disasters with rapid restoration capabilities

B. Top 10 Smart Grid Trends for 2017 & 2018

- **FeederAutomation**. A key component of distribution automation, feeder automation includes software and hardware that monitors the condition of electric lines and helps utilities improve reliability for their customers.

- **AdvancedMeteringInfrastructure(AMI)**. Comprised of advanced technology like "smart meters," AMI is commonly associated with Smart Grid.

- **Meter Data Management Systems (MDMS)**. AMI implementations can't succeed without the tools to manage, store, and correlate the interval data sets smart meters provide.MDMS is an essential component to any smart meter rollout and offers utilities a tool for basic coordination of their meter reads.

- **Analytics**. With analytics, utilities can appropriate data from smart devices in a way that allows them to better understand events and trends. Ultimately, it provides the capacity to calculate the outcome of events that, in the past, have been unpredictable and uncontrollable.

- **Distribution Management Systems.** These systems concern operational control of smart grids, for example, the ability to monitor currents and voltages in the distribution grid and issue commands to remote units such as switches and transformers. (Source)

- **Geographic Information Systems.** A GIS is a system designed to capture, store, manipulate, analyze and manage geographical data within a utility's service territory

- **Workforce Management.** In order for utilities to most effectively schedule appointments, dispatch field agents, and increase on-time responses they will leverage a mobile workforce solution in order to track operations in real time.

- **Outage Management Systems**. Operators of electric distribution systems use outage management systems to assist in the restoration of power.

- **Asset Management Systems.** These solutions provide a unified approach to monitoring and measuring the conditions of a utility's diverse and disparately located assets.

C. Contribution of Power Electronics in Smart Grids Systems:

The smart grid (SG) as a research area is advancing dealing with a wider range of topics such as power systems, energy generation and telecommunication. The conventional utility grid used to operate in a passive mode absorbing energy from the substations and delivering it to the customers. This approach is well developed but the needs of the state-of-the-art technology require a bidirectional flow of power and data. Nevertheless, smart grid systems provide more reliable, flexible, sustainable, secure and two-way communication service. Especially, integration of renewable energy sources, electrical vehicles and distributed generations (DG) in to network can be achieved in an efficient way in smart grid system. Moreover, control and monitoring capabilities, automatic configuration of the grid, actively involving of consumers in energy production extend the importance of smart grids. All these positive aspects of smart grids have been attained by integration of power electronics and telecommunication technologies with the grid. This study deals with contributions of power electronics to SG in the context of generation, conversion, distribution, and control of power. The recent power electronic devices and systems adapted to SG are also introduced in detail with several power control methods. Moreover, the renewable energy sources (RES) that is the extensively studied topic of power engineering and their integration to smart grid is also surveyed in terms of DG units, control and management features. Thus, a particular section is dedicated to RES utilization in SG covering almost all aspects of a monotype and hybrid energy plants. Finally, the survey is carried on by reviewing the most recent and comprehensive articles to highlight the importance of power electronics in a logical way in the smart grids for readers.

Power systems are fundamentally reliant on control, communications, and computation for ensuring stable, reliable, efficient operations. Generators rely on governors and automatic voltage regulators (AVRs) to counter the effects of disturbances that continually buffet power systems, and many would quickly lose synchronism without the damping provided by power system stabilizers (PSSs). Flexible AC transmission system (FACTS) devices, such as static var compensators (SVCs) and high-voltage DC (HVDC) schemes rely on feedback control to enhance system stability. At a higher level, energy management systems (EMSs) use supervisory control and data acquisition (SCADA) to collect data from expansive power systems and sophisticated analysis tools to establish secure, economic operating conditions. Automatic generation control (AGC) is a distributed closed-loop control scheme of continental proportions that optimally reschedules generator power setpoints to maintain frequency and tie-line flows at their specified values.

IV. Micro Grid

The term "microgrid" is sometimes used loosely to describe a number of concepts involving distributed generation. However, there is a specific definition of microgrids that has achieved broad acceptance: **A microgrid (MG) is a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid and that connects and disconnects from such grid to enable it to operate in both grid-connected or "island" mode[13][14]**

Two salient features distinguish microgrids from other grid-modernization efforts:

1) A microgrid is a collection of generation and load centers with fixed limits.

2) As a unit, a microgrid can operate in both grid-connected and isolated ("island") modes.

A. Micro Grid Components

- Distributed Energy Resources.
- Distributed Generation (DG).
- Distributed storage (DS).
- Commercial and Industrial Micro grids.
- Remote Micro grids.

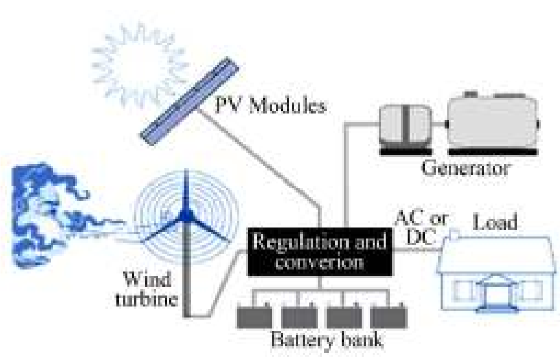

Fig.7 RES for micro grid

MG provides supporting and control services to utility such as:

- By the injection/absorption of reactive power for con- trolling voltage of grid.
- Can act as spinning reserve.
- Can provide network stability.
- By the control of regulation etc
- Avoid system blackouts

Table.II: comparison of existing system and smart grid

Existing Grid	Smart Grid
Electromechanical	Digital
One-Way Communication	Two-Way Communication
Centralized Generation	Distributed Generation
Hierarchical	Network
Few Sensors	Sensors Throughout
Blind	Self-Monitoring
Manual Restoration	Self-Healing
Failures and Blackouts	Adaptive and Islanding
Manual Check/Test	Remote Check/Test
Limited Control	Pervasive Control
Few Customer Choices	Many Customer Choices

V.Conclusion

A Smart Grid offers significant opportunities for utilities and consumers to wisely manage the energy consumption by the usage of advanced metering infrastructure and dual-way and real time communication. It also provides opportunities to wisely manage the fuel resources by potentially reducing the national need for additional generation sources, better integrating renewable and non-renewable generation sources into the grid operations, reducing outages and cascading problems, and enabling consumers to better manage their energy consumption. A Smart Grid can be a mechanism for achieving the worldwide goals in the areas of energy security, climate change, grid reliability, economic growth, and national competitiveness. Even it still has obstacles of development, DOE has the opportunity to address many of these challenges and accelerate the deployment schedule so that the nation can achieve the many benefits a Smart Grid offers.

Micro grids will provide improved electric service reliability and better power quality to end customers and can also benefit local utilities by providing dispatch able load for use during peak power conditions and alleviating or postponing distribution system upgrades. There are a number of active micro grid projects around the world involved with testing and evaluation of these advanced operating concepts for electrical distribution systems.

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