Renewable Energy Integration into Smart Grid-Energy Storage Technologies and Challenges

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Abstract - *Electric energy is essential to increase productivity and ensure a high quality of life; therefore, the relationship between electric power and economic growth is crucial. However, the consequence of the current worldwide economic growth and electricity demand is the depletion of energy resources. An essential and effective way to prevent the depletion of resources and promote economic growth at the same time is the application of the concept of energy efficiency through energy management systems; this is being the basic principle of the Smart Grid. It can play a crucial role in the transition to a sustainable energy future in facilitating smooth integration of high shares of variable renewable energies. Electricity storage is extremely useful for adding flexibility to electric grids because it helps to deal with the variability and unpredictability of renewables. This paper discusses the potential of the energy storage technology to enhance the integration of renewable energy to the smart grid and to advance greater levels of energy efficiency addressing the difficulties*

Key Words: **Smart Grid, Renewable Energy, Electrical Storage, Energy Efficiency, Integration.**

1. INTRODUCTION

Worldwide renewable energy capacity and technologies are growing rapidly. In order to solve global environmental problems, renewable energies such as solar and wind will be widely used. For wind and solar power and few other renewable technologies growth accelerated very rapidly.
The solar power reaching to the earth's surface is about 86, 0000 TW. , covering 0.22% of our planet with solar collector with an efficiency of 8% would be enough to satisfy current global energy need.

Wind farm may reliable may be reliable to produce power for 40% of hours in the years. All renewable energy sources have vast potential to reduce the dependency on coal, fossil fuel and CO_2 emission in electric sector .Hydroelectricity and geothermal sites are now become cheapest way to generate electricity. Renewable Energies have already drawn attention of nation and all the sectors are being developed.

The increased penetration of renewable energy sources, high capital cost to accommodate the peak load demand and large capital investment to improve the grid reliability and smart grid initiatives are lead to the development of electrical energy storage system. The Smart Grid integrates facilities on both the utility (grid) side and the customer side by using advanced information technologies; the benefits from this can only be achieved if storage is available. EES is therefore considered to be a main component of the Smart Grid, among other things as a basic requirement for coping with electrical outages caused by disasters.

2. SMART GRID TECHNOLOGY

The Smart Grid is a compilation of concepts technologies, and operating practices intended to bring the electric grid into the 21st century .A "smart grid" is an electric grid system where all accomplices in the grid system (i.e. electricity generators, transmission and distribution operators, electricity consumers) communicate and work with each other to raise the efficiency and reliability of the grid. The smart grid delivers electricity to consumers using two-way digital technology to enable the more efficient management of consumers' end uses of electricity as well as the more efficient use of the grid to identify and correct supply demand-imbalances instantaneously and detect faults in a "self-healing" process that improves service quality ,enhances reliability, and reduces costs The smart grid is more than simply installing smart meters – by bringing an information technology to the electric grid, we will develop numerous applications that use the devices ,networking and communications technology, and control and data management systems.

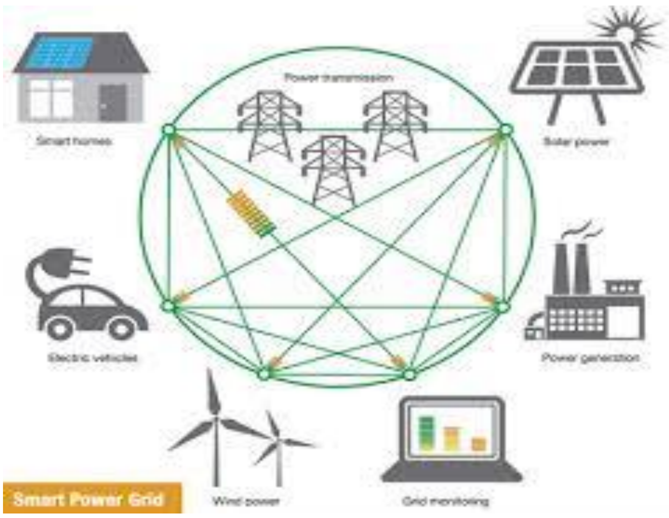

Fig -1: Smart Grid

3. CHARACTERSTICS OF SMART GRID

The principal characteristics of a smart grid to full-fill the objective of electrical power sector, the Smart Grid has the great characteristics are :

1. Safe and Reliable: The electricity is still on the power supply capacity for the user, rather than a large are a power outgain large electricity failures, malfunctions, natural disasters and extreme weather, or man -made damage done to maintain.

2. Efficient and Economical: power grid, will be able to improve the economic benefits through related Policy innovation, management and energy efficient, and market competition orderly. Power networks are supported to provide for rational allocation of resources to power deal effectively with the electricity market, to reduce power loss and improve the energy efficiency and finally.

3. Clean and Green: With the large-scale of renewable energy sources, Smart Grid can reduce the potential impact on the environment e.g., carbon emission reduction, more green energy.

4. Optimization: The most appropriate price of the electrical energy provide to the society. Smart grid to optimize resource utilization; reduce investment costs and operation and maintenance costs. Quality of power meets industry standards and consumer needs.

5. Interactive: With the interaction and real-time response to the power market and users, the services are increased. Mature wholesale market operations in place, well integrated nationwide and integrated with reliability coordinators.

6. Self-healing: The new power grid has a features Self-healing. It is a process that improves services quality, enhances reliability and reduces costs. It identifies and correct supply demand imbalance instantaneously and detect faults.

7. Flexible and Compatible: The new power grid can support correct, reasonable integration of renewable energy resources and it is suitable for integration of distributed generation and micro power grid .Moreover, it can improve and enhance the function of demand side management to achieve the efficient interaction capability with consumers. It is compatible with the present grid also.

8. Integrated: A unified platform and model are employed on a grid. It can obtain good quality of integration and information sharing of power grid and to achieve standard, normative and refined management that integrates the infrastructure, processes, devices, information and structure of market so that electricity can be generated, distributed, and used more efficiently and cost effective.

4. PROBLEMS WITH THE CURRENT GRID

An electrical grid is an interconnected network to deliver Electricity from suppliers to consumers. The electrical grid has evolved from an insular system That serviced a particular geographic area to a wider, expansive network that incorporated multiple areas.

The electric power grid is a complex system that transfers electricity generated at power plants to substations via transmission lines, and then to a variety of consumers throughout the nation via distribution lines. This system was developed by connecting local grids to form more robust and larger networks. While this methodology worked in the past, widespread development has overburdened the grid in high-demand regions. As a result of this increase in demand, the grid often experiences interruptions in electric service. Many of these interruptions occur due to problems at the distribution level and may be mitigated by distributed energy storage approaches. Service interruptions exhibit the inefficiencies of current grid networks and emphasize the dire need to modernize the electric grid so that it can respond to increasing electricity demands and shifts in generation sources. While building new generation plants and transmission and distribution lines is a costly and time-consuming endeavor, energy storage can optimize the capacity factor of current grid operation.

Advanced storage could provide a reliable and cost-effective alternative to infrastructure expansion. Perhaps the most significant trend driving the need for grid-scale energy storage is the shift to renewable energy sources, such as wind and solar. While coal has traditionally been the largest fuel source for electricity generation, emphasis on cleaner energy and decreased reliance on fossil fuels and other non-renewable sources has placed greater attention on renewable sources for electricity generation.

5. ENERGY STORAGE:

In the past, power systems utilities have operated in its simpler form via one-way transportation from large power plants distant from the point of consumption. With the introduction of distributed and renewable energy resources, Electrical Energy Storage (EES) applications (after long disregard) are making a comeback, upon the recognition and technological advancement of its role in adding flexibility, controlling intermittence and provide uninterruptible power supply to the network .Electric power is a commodity that may be wasted if it is not preserved or consumed. In particular, the electricity generated using renewable energy resources (such as solar and wind generation, which do not work all the time and have huge fluctuations due to their stochastic nature) is difficult to adjust in response to the demand needs. Therefore, storage means are needed to avoid stability problems since it is not feasible anymore to consider building more inefficient, over-designed and expensive power plants as an ultimate solution. Being the main advantage of EES systems the release of additional capacity to the grid when it is valuable, their numerous applications will strengthen power networks and maintain load levels even during critical service hours. As a result, EES systems represent the critical link between the energy supply and demand chains, standing as a key element for the increasing grid integration of renewable energies, as well as for distributed energy generation spread and stand-alone power systems feasibility. Moreover, in a broader sense, EES will enable the Smart Grid concept to become a reality .Electricity supply in combined conventional and decentralized grids using renewable energy resources requires affordable and reliable power management mechanisms, including sustainable storage systems, despite of some drawbacks in storage systems applied to electricity, related to the type of technology and operating costs.

5.1 Technical Benefits

The most relevant technical benefits of EES are the following:

a) Bulk energy time-shifting, for load levelling and peak shaving, providing electricity price arbitrage. For instance, electric vehicles represent one type of EES that can provide these power management benefits, leading to smart grid and RES integration.
b) EES may play an important role in the integration of renewable energy into the grid.
c) More efficient use and contribution of renewable energy is guaranteed using EES, also fomenting the use of distributed energy supply options in grids.
d) Several base-load generation plants are not designed for operation as part load or to provide variable output. However, storage may provide attractive solution to these drawbacks by setting the optimal operation point, rather than firing standby generators. In addition to that, EES have superior part-load efficiency.
e) Efficient storage can be used to provide up to two times its capacity for regulation applications; using full charge (down) and full discharge (up).
f) Storage output can be changed rapidly giving a ramping support and black-start to the grid (from none to full or from full to none within seconds rather than minutes)
g) EES is a practical way to provide transmission congestion relief
h) Energy storage can be used as a solution for improving grid service reliability.
i) There are always ideal locations for portable EES in a distribution system. On top of that, these systems can be also relocated so that after a certain number of years, when an upgrading of the system is performed, portable EES can be moved and used to perform the same function again.
j) Energy storage can benefit utilities or independent system operators allowing transmission and distribution upgrade deferrals.
k) EES can serve as a stand-by power source for substations on-site and distribution lines, or to add transformers.
l) In the near future, ESS technologies may facilitate other non -electrical energy uses, like transportation and heat generation.

5.2 Economic Benefits

The most relevant economic benefits of EES are the following:

a) Energy storage can cut costs for customers of electricity.
b) In general, off-peak electricity is cheaper compared to high-peak electricity, and this also benefits the seller of electricity.
c) It plays a key role on stabilizing the electricity market price freeing the power sector from
Speculations and the volatility imposed by fossil fuels.
d) EES usage also overrides the need for peak generation, avoiding unnecessary additional cost burdens for generators.
e) It will contribute to the economic development and employment opportunities for many countries.
f) It will allow more efficient use of renewable and off-peak generation capacity, encouraging more investment opportunities on these technologies.
g) EES may help to avoid transmission congestion charges, which are very expensive and most of utilities try to avoid them in a deregulated market environment.
h) Reduces the need for transmission and distribution capacity upgrades, thus minimizing unnecessary investments.
i) Increases and improves availability of ancillary services, reducing penalties to generators and the cost of over dimensioning infrastructures.
j) Allows a market-driven electricity dispatch, fostering proactive participation of the customers to secure their benefits and creates a cost sharing scheme in the power system.
k) Storage tends to lower GHG and other emissions, reducing carbon cost. However this cost reduction is specific to the resource and varies greatly between technologies.
l) Compared to an average value for power-related installations under construction today, the cost of the storage components is relatively inexpensive.

6. ENERGY STORAGE TECHNOLOGIES:

A widely-used approach for classifying EES systems is the determination according to the form of energy used. EES systems are classified into mechanical, electrochemical,

chemical, electrical and thermal energy storage systems. Hydrogen and synthetic natural gas (SNG) are secondary energy carriers and can be used to store electrical energy via electrolysis of water to produce hydrogen and, in an additional step, methane if required. In fuel cells electricity is generated by oxidizing hydrogen or methane. This combined electrolysis is a fuel cell process and also an electrochemical EES. However, both gases are multi-purpose energy carriers. For example, electricity can be generated in a gas or steam turbine. Consequently, they are classified as chemical energy storage systems. Thermal energy storage system as well, although in most cases electricity is not the direct input to such storage systems. But with the help of thermal energy storage the energy from renewable energy sources can be buffered and thus electricity can be produced on demand. Examples are hot molten salts in concentrated solar power plants and the storage of heat in compressed air plants using an adiabatic process to gain efficiency.

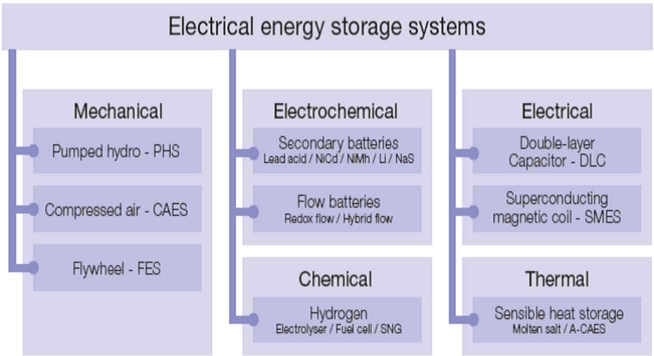

Fig -1 Classfication of Electrical Energy Storage

7. ENERGY STORAGE APPLICATIONS

There is a wide range of EES applications for power systems. EES can be integrated at different levels of electrical systems: at generation level, at transmission level, at distribution level, and at customer level. On occasions there is a need at generation plants for a black start, which is a process of restoration of a power plant to normal operation without relying on the transmission grid support. Also, generation bridging support can be provided using EES, until a conventional generator starts up or restarts, so EES has the ability to firm generators load or give a ramping support, picking up fast load variations and allowing a given generator to level its production to the technical limits.
In power distribution systems EES may also find suitable applications counterbalancing contingency effects in order to reduce impacts of the loss of major grid components, as well as in emergency situations after a loss of major grid components. On the customer side, energy management applications of EES systems is another important function, which aims at the reduction of the invoice by securing the continuity of supply at pick hours at accessible price

However, there are some limiting factors, since most EES technologies are only used for specific applications, and may be completely unsuitable for other applications. Thus, in the next decade R&D effort should be directed towards extending the EES applications range, using a hybrid approach to complement their deficiencies and create a versatile EES system with multifunctional capabilities. Such hybridization would be similar to a well-known combination of flywheel storage with battery storage, employed not as a substitute, but as a complement, improving the batteries performance and their life.
There are many applications for EES. For some applications EES has already been commercially deployed and it will continue to be used for these applications in the future. Furthermore, some new applications for EES are emerging, such as support for the expansion of renewable energy generation, the smart grid, smart micro grid, smart houses and electric vehicles. The importance of EES in the society of the future is widely recognized, and some studies on the future market potential for EES have already been carried out. While these studies vary in target time range, target area, applications considered and so on. The study indicates that value and market size for each application can vary with circumstances in the future, and that one EES installation may be used for multiple applications simultaneously, which increases the benefits. One factor affecting the future market is the scale of new installation of renewable energies.

8. RENEWABLE GRID INTEGRATION

Increasing renewable electricity generation is an essential component in achieving a doubling of the renewable energy share in the global energy mix. Such a transition is technically feasible, but will require upgrades of old grid systems and new innovative solutions to accommodate the different nature of renewable energy generation.. In addition, smart grids offer added benefits that can further ease the transition to renewables. There are several alternatives to traditional, utility-scale Power plants.
These include:

- Supply-side options, such as distributed generation.
- Demand-side options, such as demand-side management.
- Storage options, such as EVs, batteries, and thermal storage.

Smart grid technologies can allow for optimal use of these alternative technologies, and thus avoid the need for new large power plants. These alternatives are generally amenable to direct private sector investment and can help address utility underinvestment and capital constraints. This eased integration can help enable both utility-scale renewables (such as multi-megawatt wind farms) and smaller distributed renewable generation. New flexible resources such as DSM and distributed storage make it possible to incorporate higher levels of variable resources (such as wind turbines) in a system. Supervisory Control and

Data Acquisition system that will enhance renewables integration support DSM and help pinpoint losses.

9. CONCLUSION:

With renewable power share sure to continue increasing, smart grid technologies in combination with appropriate storage technology, supporting policies and regulating will be essentially to create the grid infrastructure to support a sustainable future. Energy storage technologies have ability of adding flexibility, controlling and proving back-up generation to the electrical network. It represents the critical link between the energy supply and demand chains. It's a key element for increasing the role of renewable generation into power grid.

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BIOGRAPHIES

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