ENERGY STORAGE SYSTEMS FOR ENERGY UTILITIES: A REVIEW

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Abstract

Renewable sources of energy such as wind energy units, solar PV cells etc. have entered in the field of power generation because of quick depletion of fossil fuels and adverse environmental effects of using non renewable source of energy. However, due to intermittent nature of power generation from renewable source of energies, it creates a hindrance in developing current power grids to intelligent or smart grids. Therefore Energy Storage Systems could be one possible solution in modernizing the grids. The present work reviews usage of different Energy storage systems in power generation and its further implications.

1 Introduction

The growth in urbanization and industrialization has led to the proliferation in electric power generation units and transmission lines. Due to this, management and control of electric power system has emerged as a big issue. Moreover, new type of electrical power demand has created issues in power quality in power systems. [1-3]

Therefore energy consumption growth, advancements in generation technologies and environmental issues have led to the emergence of renewable source of energy such as solar units, wind units and small scale power units such as fuel cells. These types of sources which are generally dispersed in the network are described as Distributed Generators[4]. As the penetration of DGs into power production systems increases, more and more power quality issues in the transmission line increases because the nature of power or energy produced by these DG's is sporadic or stochastic. It also creates a gap between supply and demand which could severely harm the functioning of the power production unit such as Micro Grid [5,6]. To resolve this problem, Energy storage systems (ESS) could be the one possible solution. These systems can provide or store energy in case of variation in supply. Therefore these ESSs find applications in Flexible AC transmissions devices (FACTS) [7] where not only the transmission line transfer limits get increased but power quality of MGs can be improved. ESSs can also pump in huge power for several hours as well as for few seconds also such as the case in military applications[8].

The present paper reviews different energy storage system which are utilized in energy utilities. Meanwhile the involvement energy storage in any of the five subsystems of electrical power systems which are, generation, transmission, substation, distribution and finally to the end user consumer, could improve the supply demand imbalance. In addition to this, energy storage systems have numerous other applications such as [9]-

1. Congestion reduction in Transmission lines.

2. Extra power storage during low demand period to be used during high power periods.
3. Maintaining frequency and voltage limits within operating ranges.
4. Compensation of losses due to any failures.

2 Several Energy Storage Systems(ESS) for Energy Utilities

There are several ways to store electrical energy in the functional systems. When electricity is stored in electric fields, capacitors are used whereas when it is stored in the form of magnetic fields, Superconducting Magnetic Energy Systems are utilized. There is an another arrangement where electricity is stored via chemical reactions in batteries. Sometimes, there is a provision to store electrical energy to mechanical energy form which is possible in flywheels whereas when potential energy is used for conversion, it becomes pumped energy device. One more known energy conversion process is there where electrical energy is converted to pressure energy, generally called as compressed air energy storage system.

According to the report of Department of Environmental Quality North Carolina 2018 [10], modernization of grids includes Battery Energy Storage Systems (BESS) which can be utility owned or consumer owned. BESS comprises of various advantages such as storage of excess energy, regulation in frequency and the ability to flatten the graphs during intermittent or sporadic generation with renewable sources of energy such as wind energy or solar energy. As distribution system is an important subsystem of electric power system, so role of electric vehicles cannot be neglected in modernization of electrical power systems or grids. In this work, the consequences of inclusion of electric vehicles in utilities is studied and these are considered as consumer load.

Koohi Kamali et. al. [11] reviewed the usefulness of Energy Storage System(ESS) in micro grids using renewable energy sources. They concluded that ESS can bring new ancillary functions for the power system and hence can enable the involvement of distributed generation units. The authors emphasized numerous applications of ESS working in support with Renewable energy source (RES). The role of ESS in intelligent micro grids was also studied, which is affected by sporadic performance of Renewable source of energy, which effects the power quality. The role of flywheel storage system, electrochemical system, pumped hydroelectric storage system and compressed air storage system was reviewed along with their working principles. In addition to this, the application of each storage system in power system was analyzed and was compared to other systems as well. Moreover, the technical and physical properties of each and every system is discussed in detail also.

Similarly, Vazquez et.al.[12] presented a review on Energy storage systems used in grid and transport applications. Authors covered several aspects such as the basic technology, operating principles and converters used for storing energy. The intention behind this work was to introduce the latest reference to the engineering community as well as to the academia associated with the field of power electronics.

It was reported that the use of the high energy density lithium ion batteries in trasnportation sector has enabled adoption of plug in vehicle and HEV. It also interacted with the smart grids of the future. Storage technologies which are considered to be matured can be used in numerous other applications. However, all application requirements cannot be fulfilled. Hence new systems have been invented which offer new challenges to the

engineering community. Transport and utility storage system operates with a wider range of time versus power storage requirements. There are numerous advantages of transport and utiliy applications ranging from technical aspect to cost aspects. For example, the use of electric vehicle leads to 80% reduction in CO_2 and profits can be increased with low loads requirements in power transmision line.

Roberts et.al.[13] reported new types of energy storage systems that are used with power grids and the different ways these systems are coupled with the grid. As more and more avenues for renewable energy sources are increasing, accordingly storage systems are seen as an important link in power grids. Smart grids having dynamic loads will operate and function in a better way with the help of energy storage systems. Gradually market rules are adjusted to take advantages of bulk and distributed storage devices. More complex electrical networks are proven to be much more capable and reliable to function as an integrated grid.

Yang et.al. [14] reviewed four types of electrochemical technologies, which are redox flow batteries, Na-beta alumina membrane batteries, unique Li-ion batteries and lead-carbon technologies, that have potential to solve broad market needs. These technologies not only meet the requirements of the grid but also fulfill the economic consideration for end-user application. These applications range from power reliability, regulation, power management to renewable energy usage. These present a firm challenge in the form of cost consideration which makes it difficult for these technologies to enter broad markets. In addition to this, performance of these technologies under different conditions also post a challenge. Therefore, authors reported that performances should be improved, costs should be decreased and improvements in material, cell design and system design should be achieved.

3 Conclusion

Energy storage system has achieved a significant place in the power grids because inclusion of these systems have brought in power grid reliability and sustainability. Review suggests that ESS are of various form such as electrochemical technologies, flywheel storage system, compressed air storage technologies to be used in transportation and grid utilities. Modernization of grids using renewable source of energy and invention of Electrical vehicles demand robust energy storage systems.

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