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Energy Storage System and Their Technologies

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Abstract:

Immediate response of electricity generated from renewable sources can rarely be provided because these supplies cannot deliver regular supply to consumption need. Greater network load stability is this decentralized production and it requires energy storage, which generally uses lead batteries as apotential solution. Lead batteries cannot store large amounts of energy in small volume and also cannot resist high cycling rates. Therefore, other types of storage technologies are being developed and applied. This paper highlights the need of the storage of energy to make the power networks strengthened and to make the load levels maintained. Many kind of storage methods are discueesd here among which some are still under the development. Different techniques of electricity storage and their application are also discussed in this paper.

Keywords: *Renewable Energy, Storage Compressed Air, Batteries, Thermal Energy Storage*

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Introduction

Electrical energy is readily available energy at the lowest price and is an invisible, omnipresent product and has been considered as common consumer goods. The production of electricity is highly centralized at present time and its end users are unable to get this. Daily and seasonal needs of the electricity determines the loads leveling at the initial stage but also by the insufficient production due to the contribution of secondry modes like hydraulic and thermal plants. Stored energy also used by these plants such as water is used for the pumped storage plants and fossile fuels are used for the thermal plants. The difficulties of stabilizing the power network is increased due to the delocalized electricity production and by introducting the variables, fluctuating sources such as renewable energy (solar, wind turbines etc.), it is mainly decreased due to supply demand imbalance. It is therefore convenient to generate energy by transmitting, converting and storing it. But it is difficult to store because storage requires bulky, costly equipment although it become a need. It is important to know that the centralized production of electricity promotes the development of a complex system of energy production transmission. The enrgy contet, conversion methods for the storage of alternate current was unreliable, very costly and were not in trend in the pre 1980. The belief that electricity cannot be stored is braught about by the fact that electricity is mass produced, transmitted and used in alternative current. But now it is declared that the electricity can be stored even in indirect storage.

Technical and economical advantages of energy storage

Electricity storage becomes as an interesting venture by the main economical advantages which are described as follows:

1. Energy transfer:

The transformation of a very low cost primary energy source which are used in regular power plants yields the intermediary energy. It can be stored and utilized as a substitute for the expensive power which is used in peak load power stations or can be utilized for the virtual energy at an appropriate time. The two modes of energy production for which storage is very important are as follows:

- First mode of energy production is conventional energy production which can compensate the temporary production loss of generating unit. It avoids penalties by fulfilling the commercial obligation of pre-sold energy supply.
- Second is renewable energy production, which makes this type of predictable energy and its storage adds the value to the supplied current. Only a portion of the nominal production capacity can be satisfied by the stored power although energy should be made available due to the contractual compromise.

2. Network savings:

Many generating units, various levels of transmission and distribution lines, associated stations and substations and many consumers with wide ranging power requirements are included by the power networks. Inequality and fluctuation characterizes the power consumption by users which means that the minimum consumption is nearly half of a maximum peak. In peak and average power levels ratio, end user demand is often have the value of 10 which causes the over dimensioning of production and transmission equipment which does not designed for average daily consumption but only for function of peak in demand. Fluctuation can be reduced to a minimum by the load levelling which makes the supply more predictable and also the existing transmission and distribution facilities for many years. Reduction of the installed power and to get the most from the existing network, is helped by the levelling of consumption at the final distribution level.

3. Kinetic advantages:

Instant response to demand can be provided by the flexibility of future storage and retrieval sysems, it also adds the flexibility to the network in terms of load levelling. Temporary production shortage causes network imbalance which can be predicted possibly. The need of the production could also be the cause of failure of the production.

4. Electricity storage systems:

It can be achieved effectively. Electricity storage must be first transformed into another form of storable energy and also must be thransformed reverse as per the need. For storing every forms of energy such as mechanical, chemical and thermal, there are many possible techniques. According to the applications of storage techniques, it can be divided into four categories which are:

A. Low power application in isolated areas which is essential to feed transducers and emergency terminals

B. Medium power application in isolated areas

C. Network connection application with peak levelling

D. Power quality control applications

Here in first two categories, energy can be stored as kinetic energy, chemical energy, compressed air, hydrogen or in supercapacitors as these are for small scale systems. In three and four categories, energy can be stored as gravitational energy, thermal energy, chemical energy or compressed air as these are for large scale systems. Ctegory four is further divided into many types which are as follows:

1. Pumped Hydro Storage (PHS):

This technique is easily can be achieved and it is the main advantage of this technique. It uses the highly concentrated renewable energy source that is power of water. This technique is most applicable to high power applications. In this technique, water flows outside of the upper reservoir to activate the turbines and generating the high value electricity for peak hours as per the high demand, while during the low demand these station pumps the water from lower reservoir to the upper reservoir using electricity. Height of the waterfall and the volume of water are the two parameters on which storage capacity is based on.

2. Thermal Energy Storage (TES):

Depending on the use of sensible or latent heat, thermal energy storage system is divided into two: Latent – fussion – heat TES and Sensible heat thermal storage, where latent heat storage uses the liquid – solid transition of a material at constant temperature and heating a bulk material yields the sensible heat thermal storage. The stored energy by this system is 40,000kWh of the thermal energy which is equal to almost 1 day of sunlight.

3. Compressed Air Energy Storage (CAES):

This technique is dependent on the relatively mature technology having several high power projects in place. Nearly two third of the power is used by the power plant with standard gas turbine to compress the combustion air. High pressure (40-70 bars) and near ambient temperature is needed to achieve compressed air energy storage. The geological criteria will be eliminated by this method and it make the system easier to handle and operate.

4. Small-scale compressed air energy storage (SSCAES):

It will be good to use compressed air storage under high pressure in cylinders for small and medium scale applications. It is the function of recharging and discharging power. The number of cycles are mainly limited by the mechanical fatigue of the cylinders. United States has been proposed this type of installation as temporary network support.

5. Energy storage coupled with natural gas storage (NGS):

Coupling of the underground natural gas storage with electricity is done by this technique. The consumtion of energy for compression which could be released in the form of electricity is caused by the pressure difference between high pressure gas storage in reservoirs and gas injected with a maximum service pressure of 60-80 bars.

6. Energy storage using flow batteries (FBES):

Two electrolyte sytems in which the chemical compound used is in liquid state with the electrolyte for energy storage is called flow batteries. This is the sytem which limits the capacity of standard batteries and also overcome the limitations of standard electrochemical accumulators hence called limited mass system. Large quantities of energy can be stored by using large reservoirs and coupling a large number of cells, and then electrolyte is pumped into the reservoirs to release it.

7. Energy storage in supercapacitors:

In this technique, both the characteristics of capacitors and electrochemical batteries are involved in the components increasing the capacity of cycling. Here insulating material is replaced by electrolyte ionic conductor where ion movement is parallel to the conducting electrode with a large specific surface this is the exception in its principle other than the capacitors. These are generaly very durable and persist for 8-10 years with 95% efficiency.

8. Flywheel energy storage (FES):

This include massive and composite flywheel coupled with a motorgenerator and special brackets. High capacity flywheels are needed for storing the energy in an electrical power system. It is not feasible to store the enrgy for long term by this apparatus because of the friction losses of 200 tons flywheels which are estimated at about 200 Kw.

Characteristics of Energy Storage Techniques

Energy storage techniques can be classified according to some criterias such as the type of application (permanent or portable), storage duration (short or long term) and type of production (maximum power needed). The fundamental characteristics of the storage systems needs to analyze critically for establishing the comparison criteria of technology.

There are some characteristics of the storage systems for the selection criteria are listed below:

- Storage capacity
- Available power
- Depth of discharge or power transmission rate
- Discharge time
- Efficiency
- Durability
- Autonomy
- Costs
- Feasibility and adaptation to the generating source
- Self-discharge
- Mass and volume densities of energy
- Monitoring and control equipment
- Operational constraints
- Reliability
- Environmental aspect

Review of Literature

SOCACIU, (2012) overview on the storage of solar heat collected in summer for space heating in winter. The need to find a better way to itilize energy, especially in the area of energy storage as the global warming is becoming one of the most urgent problems in the world. She classified the solution into the sensible, latent and thermochemical heat stores. If the resultant of the reaction can be well separated, the storage mediums will be very stable this is the amin advantage of the technology and suitable for long term storage.

Chopade, Kauthalkar and Shrama, (2013) dealt with the storage of solar thermal energy in materials which undergoes phase change. It smoothens the output and improves the energy systems and reliability. Developing inexpensive and efficient storage devices is and important as developing new sources of energy. Compactness and heat supply at constant temperature is the main advantage of heat storage in pahse change material. Methods of incorporating PCMs into other lightweight building materials such as plywood, and ceiling and floor tiles alos being the topic of research.

Khare et al., (2013) demonstrated the use of material selection software package and also identified suitable sensible heat storage amterials for high temperature system. To find out a suitable material is a time consuming and difficult process. It is found that the common material such as alumina, silicon carbide, high temperature concrete, graphite, cast iron and steel is more effective and suitable for the sensible heat storage. High alumina concretes and alumina silicate geopolymers were found as a promising group of sensibke heat storage media as they are high temperature composite materials.

Luo *et al.*, (2014) provides a comprehensive and clear picture of the state of the art technologies available and where they would be suited for integration into a power generation and distribution system and also overviewed of the operation principles, technical and economic performance features also the current research and development in the important electrical energy storage technologies, which are based on the types of enrgy stored into six main categories. They made clear that there is no suitable commercialized technology for seasonal energy storage at present.

Boda, Phand and Kotali, (2017) presented the investigation and analysis of thermal energy storage incorporating with or without Phase Change Material (PCM) for use in solar water heaters.Phase change material has low range of temperature and high energy density of melting and solidification as compare to the sensible heat storage. In this paper, reviews of previous work on the latent storage has been discussed and provided an insight to recent efforts for developing new classes of phase change materials.

Meena and Choudhary, (2017) reviewed on the thermal energy storage in sensible materials. Pebble bed system is simpler and economical in design and development to store solar energy in sensible heat storage materials as compare to the latent or thermo chemical energy storage. The study thows that pebble bed thermal energy storage predicts the behaviour of porous media for heat transfer and energy storage the result of which is well in experimental data.

Sarbu and Sebarchievici, (2017) focusses on thermal energy storage technologies providing a way of valorizing solar heat and reducing the energy demand of buildings. It is the technology which stores the thermal energy by heating or cooling a storage medium for further use of the stored energy. In this review sevral principles of energy storage methods and calculation of storage capacities are described. Accumulation and discharge of heat and cold can be done by the thermochemical reactions as per the demand and humidity also can be control in a variety of applications by the use of different chemical reactants.

Conclusion

This study reviewes the available energy storage technique which are applicable for electrical power systems. By careful studeying the objective, we found that it needs improvement and optimization of power electronics in the field of storage techniques and it is often used in the transformation of electricity into storable energy. Optimization of the techniques in terms of cost, efficiency, reliability, maintenance, social and environmental impacts, etc. will be promoted by the study of complete system. Storage is a key element for the growth of renewable energies. If the source of energy is connected to the distribution network, the storage will not be need.

References:

Boda, M. A., *et al*. "Various Applications of Phase Change Materials: Thermal Energy Storing Materials." *International Journal of Emerging Research in Management and Technology*, vol. 6, no. 4, 2017, pp. 167–171.

Chopade, Shripad, *et al*. "Solar Heat Energy Storage in Phase Change Materials." *International Journal of Engineering Research and Applications*, vol. 3, no. 4, Aug. 2013, pp. 471–473.

Ibrahim, H, *et al*. "Energy Storage Systems—Characteristics and Comparisons." *Renewable and Sustainable Energy Reviews*, vol. 12, no. 5, 2008, pp. 1221–1250.

Khare, S., *et al*. "Selection of Materials for High Temperature Sensible Energy Storage." *Solar Energy Materials and Solar Cells*, vol. 115, 2013, pp. 114–122.

Luo, Xing, *et al*. "Overview of Current Development in Electrical Energy Storage Technologies and the Application Potential in Power System Operation." *Applied Energy*, vol. 137, 2015, pp. 511–536.

Meena, P. M., and Manju Choudhary. "Thermal Energy Storage in Sensible Materials: A Review." *International Journal of Advance Research, Ideas and Innovations in Technology*, vol. 3, no. 6, 2017, pp. 607–613.

Sarbu, Ioan, and Calin Sebarchievici. "A Comprehensive Review of Solar Thermal Energy Storage." *Energy Storage*, June 2017

Sharma, Atul, *et al*. "Review on Thermal Energy Storage with Phase Change Materials and Applications." *Renewable and Sustainable Energy Reviews*, vol. 13, no. 2, 2009, pp. 318–345.

SOCACIU, Lavinia Gabriela. "Seasonal Sensible Thermal Energy Storage Solutions." *Leonardo Electronic Journal of Practices and Technologies*, Dec. 2011, pp. 49–68.

SOCACIU, Lavinia Gabriela. "Thermal Energy Storage: an Overview." *Applied Mathematics and Mechanics*, vol. 55, no. 4, 2012, pp. 785–794.