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ENERGY STORAGE SYSTEMS FOR ADVANCED POWER APPLICATIONS

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ABSTRACT:
While energy storage technologies do not represent energy sources, they provide valuable added benefits to improve stability, power quality, and reliability of supply. Battery technologies have improved significantly in order to meet the challenges of practical electric vehicles and utility applications. Flywheel technologies are now used in advanced non polluting uninterruptible power supplies. Advanced capacitors are being considered as energy storage for power quality applications. Superconducting energy storage systems are still in their prototype stages but receiving attention for utility applications. The latest technology developments, some performance analysis, and cost considerations are addressed. This paper concentrates on the performance benefits of adding energy storage to power electronic compensators for utility applications.
Keywords: HPLC, PDA, stability indication method, drug.

1. INTRODUCTION:

Electric power systems are experiencing dramatic changes in operational requirements as a result of deregulation. Continuing electric load growth and higher regional power transfers in a largely interconnected network lead to complex and less secure power system operation. Power generation and transmission facilities have not been able to grow to meet these new demands as a result of economic, environmental, technical, and governmental regulation constraints. At the same time, the growth of electronic loads has made the quality of power supply a critical issue. Power system engineers facing these challenges seek solutions to allow them to operate the system in a more flexible, controllable manner. When power system disturbances occur, synchronous generators are not always able to respond rapidly enough to keep the system stable. If high-speed real or reactive power control is available, load shedding or generator dropping may be avoided during the disturbance. High speed reactive power control is possible through the use of flexible ac transmission systems (FACTS) devices. In a few cases, these devices are also able to provide some measure of high speed real power control through power circulation within the converter, with the real power coming from the same line or in some cases from adjacent lines leaving the same substation. However, a better solution would be to have the ability to rapidly vary real power without impacting the system through power circulation. This is where energy storage technology can play a very important role in maintaining system reliability and power quality. The ideal solution is to have means to rapidly damp oscillations, respond to sudden changes in

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load, supply load during transmission or distribution interruptions, correct load voltage profiles with rapid reactive power control, and still allow the generators to balance with the system load at their normal speed. Custom power devices use power converters to perform either current interruption or voltage regulation functions for power distribution systems. Recent developments and advances in energy storage and power electronics technologies are making the application of energy storage technologies a viable solution for modern power applications. Viable storage technologies include batteries, flywheels, ultracapacitors, and superconducting energy storage systems. Although several of these technologies were initially envisioned for large-scale load levelling applications, energy storage is now seen more as a tool to enhance system stability, aid power transfer, and improve power quality in power systems.

2. RELATED STUDY:

Electrical energy in an ac system cannot be stored electrically. However, energy can be stored by converting the ac electricity and storing it electromagnetically, electrochemically, kinetically, or as potential energy. Each energy storage technology usually includes a power conversion unit to convert the energy from one form to another. Two factors characterize the application of an energy storage technology. One is the amount of energy that can be stored in the device. This is a characteristic of the storage device itself. Another is the rate at which energy can be transferred into or out of the storage device. This depends mainly on the peak power rating of the power conversion unit, but is also impacted by the response rate of the storage device itself. The power/energy ranges for near-to-midterm technologies are projected in Fig. 1. Integration of these four possible energy storage technologies with flexible ac transmission systems (FACTS) and custom power devices are among the possible power applications utilizing energy storage. The possible benefits include: transmission enhancement, power oscillation damping, dynamic voltage stability, tie line control, short-term spinning reserve, load leveling, under-frequency load shedding reduction, circuit break reclosing, subsynchronous resonance damping, and power quality improvement.

Although superconductivity was discovered in 1911, it was not until the 1970s that SMES was first proposed as an energy storage technology for power systems [1]. SMES systems have attracted the attention of both electric utilities and the military due to their fast response and high efficiency (a charge–discharge efficiency over 95%). Possible applications include load leveling, dynamic stability, transient stability, voltage stability, frequency regulation, transmission capability enhancement, and power quality improvement.

3. PROPOSED METHODOLOGY:

When compared with other energy storage technologies, today's SMES systems are still costly. However, the integration of an SMES coil into existing FACTS devices eliminates

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the cost for the inverter unit, which is typically the largest portion of the cost for the entire SMES system. Previous studies have shown that micro 0.1 MWh and midsize (0.1–100 MWh) SMES systems could potentially be more economical for power transmission and distribution applications. The use of high temperature superconductors should also make SMES cost effective due to reductions in refrigeration needs. There are a number of ongoing SMES projects currently installed or in development throughout the world.

SMES's efficiency and fast response capability (milliwatts/millisecond) have been, and can be further exploited in applications at all levels of electric power systems. The potential utility applications have been studied since the 1970s [6]. SMES systems have been considered for the following: 1) load leveling; 2) frequency support (spinning reserve) during loss of generation; 3) enhancing transient and dynamic stability; 4) dynamic voltage support (VAR compensation); 5) improving power quality; and 6) increasing transmission line capacity, thus enhancing overall reliability of power systems. Further development continues in power conversion systems and control schemes [7], evaluation of design and cost factors [8], and analyses for various SMES system applications. The energy–power characteristics for potential SMES applications for generation, transmission, and distribution are depicted.

Batteries are one of the most cost-effective energy storage technologies available, with energy stored electrochemically. A battery system is made up of a set of low-voltage/power battery modules connected in parallel and series to achieve a desired electrical characteristic. Batteries are "charged" when they undergo an internal chemical reaction under a potential applied to the terminals. They deliver the absorbed energy, or "discharge," when they reverse the chemical reaction. Key factors of batteries for storage applications include: high energy density, high energy capability, round trip efficiency, cycling capability, life span, and initial cost.

Batteries can be designed for bulk energy storage or for rapid charge/discharge. Improvements in energy density and charging characteristics are still an active research area, with different additives under consideration. Lead-acid batteries still represent a low-cost option for most applications requiring large storage capabilities, with the low energy density and limited cycle life as the chief disadvantages. Mobile applications are favoring sealed lead-acid battery technologies for safety and ease of maintenance. Valve regulated lead-acid (VRLA) batteries have better cost and performance characteristics for stationary applications. Several other battery technologies also show promise for stationary energy storage applications. All have higher energy density capabilities than lead-acid batteries, but at present, they are not yet cost effective for higher power applications. Leading technologies include nickel–metal hydride batteries, nickel–cadmium batteries, and lithium-ion batteries. The last two technologies are both being pushed for electric vehicle applications

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where high energy density can offset higher cost to some degree. Due to the chemical kinetics involved, batteries cannot operate at high power levels for long time periods. In addition, rapid, deep discharges may lead to early replacement of the battery, since heating resulting in this kind of operation reduces battery lifetime. There are also environmental concerns related to battery storage due to toxic gas generation during battery charge/discharge. The disposal of hazardous materials presents some battery disposal problems. The disposal problem varies with battery technology. For example, the recycling/disposal of lead acid batteries are well established for automotive batteries.

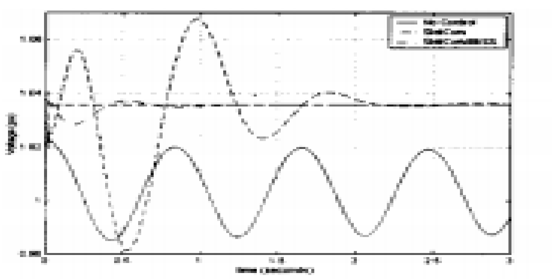

Fig.3.1. Voltage waves with storage.

5. CONCLUSION:

Among the potential performance benefits produced by advanced energy storage applications are improved system reliability, dynamic stability, enhanced power quality, transmission capacity enhancement, and area protection. An energy storage device can also have a positive cost and environmental impact by reducing fuel consumption and emissions through reduced line losses and reduced generation availability for frequency stabilization. FACTS devices which handle both real and reactive power to achieve improved transmission system performance are multi-MW proven electronic devices now being introduced in the utility industry. In this environment, energy storage is a logical addition to the expanding family of FACTS devices. As deregulation takes place, generation and transmission resources will be utilized at higher efficiency rates leading to tighter and moment-by-moment control of the spare capacities. Energy storage devices can facilitate this process, allowing the utility maximum utilization of utility resources. The new power electronics controller devices will enable increased utilization of transmission and distribution systems with increased reliability. This increased reliance will result in increased investment in devices that make this asset more productive. Energy storage technology fits very well within the new environment by enhancing the potential application of FACTS, custom power, and power quality devices.

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