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Large Scale Energy Storage

Introduction

Greenhouse gas emission reduction is a driving force behind implementation of many renewable energy generation sources such as wind and solar. Depending on weather conditions, power outputs of solar and wind farms vary greatly, making them difficult to predict when the power will be available from the renewable sources. As a result, integration of renewable energy sources to utilities requires complex control since utilities need to continuously match supply with demand. Decoupling energy generation and its usage will require installation of large scale energy storage systems. Both large scale energy storage systems near the renewable power generation sources and at customer sites will allow easy integration of variable sources to the grid.

Types of Energy Storage

Types of energy storage include compressed air; flow batteries; pumped heat; flywheel; and pumped hydro (pumping water up a hill at times of surplus energy, so that we can later to create hydroelectric power during the peak demand). Each of these storage technologies is suitable for certain applications: energy management, backup power, load leveling, frequency regulation, voltage support, and grid stabilization. As a result, energy storage types mentioned above can't meet the demand of all grid applications, requiring storage portfolio strategy. Adoption of different energy storage technologies at different levels of power distribution will increase power system resiliency.

Technology Overview

Presently, pumped hydro comprises 95% of the storage systems installed in the US. Pumped hydro currently employs off-peak electricity to pump water from a reservoir up to another reservoir at a higher elevation. When electricity is needed, water is released from the upper reservoir through a hydroelectric turbine into the lower reservoir to generate electricity. New capabilities of pumped hydro, through the use of variable speed pumping, has the potential for the additional services that may be used to assist in the integration of renewable energy sources. Compressed air energy storage (CAES) stores energy using compressed air, usually in underground caverns, to deliver power when needed at a later time. Large geographic requirements make pumped hydro and CAES installation site specific.

In contrast to the capabilities of these two technologies, various electrochemical batteries and flywheels can address demands at lower power levels with shorter discharge times, ranging from a few seconds to six hours. In addition, these technologies have no geographic constraints.

There are several different electrochemical battery technologies such as lithium ion, sodium sulfur, and lead acid, currently available for commercial applications. Widespread adoption of these technologies is limited due to challenges in energy density, power performance, charging capabilities, safety and system cost.

Flywheels in commercial installations are limited to frequency regulation. Flywheel plants receive electricity and convert it into spinning discs, whose speed is modulated (up or down) to match shifts in energy to or from the grid, which ensures steady power (60 Hz) is supplied to the grid.

Other emerging technologies include: flow batteries, superconductive magnetic energy storage (SMES), electro-chemical capacitors (EC) and thermochemical energy storage.

Distributed Energy Storage

Grid level energy storage will enhance integration of large scale renewable energy sources. Implementation of small scale photo voltaic (PV) systems at customer sites is also creating an opportunity for customer energy storage, improving reliability and increasing economic benefits. For long, uninterruptable power and thermal energy storage systems have been used by customers to increase reliability of electrical systems. The value proposition for installation of distributed energy storage at customer sites depends on the time-of-use rates and demand charges. However, their implementation has the potential of reducing capital expenditures required for installation of additional peak power generation capacities by the utilities.

Conclusion

Reduction of greenhouse gases will require installation of variable power sources, requiring adoption of energy storage systems. Primary barriers to widespread adoption of storage systems include cost, performance, safety, equitable regulatory environment and industry acceptance, with a need to focus on the reduction of these barriers at national and local levels.

References:

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