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BATTERY ENERGY STORAGE SYSTEM

Unique Asset for Power Generation & Flexible Grid Operation

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Introduction

- Energy storage systems encompass a broad range of renewable energy technologies including:
  - Electrochemical (battery energy)
  - Compressed air – (2003) Sempra Norton CAES Project located in Norton Ohio
  - Pumped hydro
  - Thermal and inertia (flywheel) energy systems –(10/2016) HECO with Amber Kinetics Inc.Gen2 Model 25 Flywheel inertia system.
- Battery Energy Storage System (BESS) offers least-cost technology and the opportunity for providing stability and reliability to the transmission grid system.
- BESS offers good business opportunities to investors and independent power producers (IPPs) in the energy capacity markets.

Battery Energy Storage System

- BESS technology stores electrical energy from traditional power generation sources during off-peak periods, and from intermittent generation sources, such as solar and wind turbine power farms.
- BESS consists of a battery charging controller, storage batteries, direct current (DC) to alternating current (AC) inverters, medium voltage (MV) to high voltage (HV) power transformers, reactive power controller and HV interconnection hardware for connection to the grid.

Companies in the forefront in BESS field: ABB, GE, S&C Energy, Borrego Solar Systems, Stem Inc., LG Chem, Tesla, SMA; Redflow and Sunverge in Australia; Kokam and Samsung in South Korea; Hitachi in Japan.

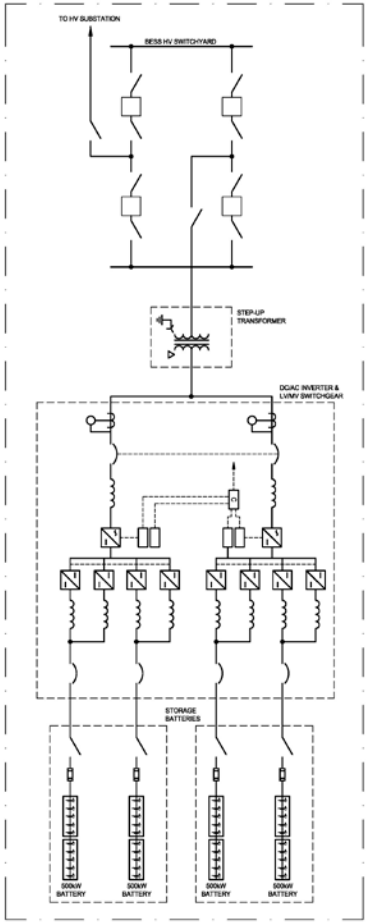

Figure A: Typical Single-Line Diagram of Battery Energy Storage System.

Battery Energy Storage System

Size

- The required battery energy storage system size ranges from 1 MW to 500 MW with target discharge duration ranging from one to six hours.
- Utilities favor BESS because they are easily scalable and can be located almost anywhere in the system.
- BESS offer least-cost opportunity for potential levelized energy cost to a Power Transmission and Distribution Company (PTDU).
- Large-scale battery energy storage systems are being applied in many countries across the globe.

Battery Technologies

- Existing and emerging battery technologies:
  - Lithium-ion (Li-Ion)
  - Lithium-ion-phosphate and graphite
  - Lithium-titanate
  - Lithium-sulfur
  - Lithium-air
  - Lithium-cobalt
  - Lithium-phosphate
  - Zinc-bromide
  - Zinc-air flow
  - Zinc-iron redox
  - Zinc hybrid cathode
  - Nickel-cadmium (Ni-Cd)
  - Advanced lead acid flow
  - Sodium-sulfur (NaS)
  - Sodium-nickel-chloride
  - Deep-cycle VRLA, valve-regulated
  - Deep-cycle AGM maintenance-free
  - Deep-cycle sealed, maintenance-free
  - Power-Cube (PbC)
  - Vanadium-redox (VR)
  - Iron-chromium Fe-Cr)
  - Hydrogen bromide (H-Br) flow
  - Magnesium-antimony liquid metal
- Aim is to achieve a low-cost, modular, high-energy density, long duration, fast response and environmentally sustainable BESS.
- The market share analysis shows a rise in popularity for lithium-ion, zinc bromide* and sodium-sulfur battery technologies.

* In Australia

Modular Battery Energy Storage Facility Architecture

- Battery energy storage systems are being designed and constructed in conformance with various industry codes and standards such as ANSI, IEEE, IEC and ASTM.
- Efforts also are being directed toward development of a set of technical specifications and standards to create a model for flexible transportable modular energy storage architecture (MESA), which could be used for different size projects.

Codes and Regulations

- Codes and regulations prepared by independent system operators and transmission system grid operators traditionally focused on static reactive power control, power factor and dynamic requirements, such as low-voltage, ride-through capability.
- Codes and regulations now evolving have more demanding requirements, including dynamic control of reactive power.
- A grid study is required to identify the weak points where electrical energy available cannot meet the load demand in certain time periods.
- The grid operators can then make decisions on the optimal point of connection where a battery energy storage system can help to meet load demand and enhance the system reliability.
- Load demand forecast, system lifetime and life-cycle costs, are considered to see if the system will improve operational efficiency.

Interconnection Service

- Commercial BESS offers a cost-effective, viable alternative alongside a peaking plant and other resources.
- BESS provides a more responsive, fast, economic and reliable reserve resource to the grid as it can be applied both as energy resource or capacity resource when applying for network interconnection service to an area transmission system.
- Commercial software now available are capable of monitoring and controlling more than a single battery energy storage facility and also enables the grid operators to visualize their entire grid network.

Testing, Inspection, Verification and Certification

- Type tests on battery storage components including cells, module and power converters, etc., are required to provide assurance on the design and manufacturing technologies adopted for these components.
- There are a number of test facilities* in United States and in Europe where battery storage system developers and vendors can test their battery storage components or complete systems under controlled conditions by independent entities.
- These facilities provide services in product development, testing, performance validation and safety evaluations.
- They follow “Uniformly Measuring and Expressing the Performance of Energy Storage Systems” protocol and, thus, play an important role in the acceleration and commercialization of battery energy storage technologies.

* DOE/SNL, DNV-KEMA, EPRI and BPA

Technology Assessment

- The important factors in selection of a BESSF include right type of battery technology, understanding of the battery lifespan and output degradation, full or partial charging duty, required operating time, number of cycles and efficiency.
- Technical-economic assessment and evaluation software tools are now available that help in selecting the best BESS technology option. These tools analyze operation requirements of the grid system, including deliverable power, discharge duration, cycle life, system regulation, efficiency and grid upgrade deferral.
- The software also can determine the total cost of an energy storage system, return on investment and cost-benefit ratio, which enables better investment decisions.
- PJM Interconnection in Audubon, Pennsylvania, has established a Storage Application Center, which tests and validates the next generation of storage applications in a real-world environment.

Economic Assessment

- Key challenges to battery energy storage system sustainable growth are project uncertainty, product guarantees, insurance protection, government tax incentives and energy capacity warranties.
- The cost of a BESS is high compared to traditional power generation resources and no single battery technology has emerged as a preferred choice so far.
- Government incentives, loan guarantees and innovative financing models are available and are being introduced to spark strong interest in the BESS industry.

Bill introduced in the U.S. Senate by Senator Martin Heinrich, D-New Mexico, and Mike Honda, D-California, and Rep. Tom Reed, R-New York to provide 30 per cent tax credit for stand-alone energy storage technologies that wind and solar receive from the Federal Government.

Independent Engineering Review

- An independent engineering (IE) review is required to assess the commercial maturity of the selected battery technology, design reliability, system configuration, power conversion hardware, battery management system, testing, regulatory, safety and environmental compliance, warranty and guarantees.
- It also includes an independent review of ISO or utility capacity contracts and customer performance agreements, potential penalties and guarantees to capture the risk to near term and future revenues.
- It generally ensures that the selected battery technology and project designs are reliable and robust enough to satisfy the performance and lifetime projections that will support the project. The IE review report is very valuable tool to financial institutions, which are looking for opportunities in financing promising projects.

Conclusions

- BESS provides commercial or industrial customers, power marketers and utilities the means to respond to power shortages and brownouts.
- Reduces power fluctuations, enhance system flexibility and stabilize price spikes.
- Some IPPs and area utilities have more than eight years of operating experience with BESS rated 50 MW and higher, and have reported high satisfaction with the facilities and substantial savings to customers.
- Forecasts call for lots of growth for battery energy storage systems.
- Large-scale battery energy storage systems are expected to become a very important part of the power delivery system in the coming years.