

## ***DRAFT***

### **Grid Scale Energy Storage: Opportunities in Florida**

#### **Need for Grid-Scale Energy Storage**

There is a great deal of interest in, and enthusiasm for, utilizing renewable energy sources effectively in order to reduce utilization of fossil fuels, which in turn reduces CO<sub>2</sub> emissions significantly, and to move toward a more sustainable energy system. On utility scale, energy storage is critical to utilize renewable energy because of the intermittent nature of renewable energy sources such as photovoltaic and wind turbine. The technology will allow utilities to use the distribution network more efficiently, as power plants can be operated at a higher percentage of capacity while ensuring electrical supply at all times, thereby reducing the demand for peaking power plants that have the lowest efficiency with highest operating cost.

#### **Current State of the Art Technologies for Utility Scale Energy Storage**

The current state of the art storage technology can be categorized as mechanical (*e.g.*, pumped hydro, compressed air, and flywheel), electromagnetic (*e.g.*, superconducting magnets), electrical and electrochemical storage devices (*e.g.*, supercapacitors and batteries), and hydrogen/fuel cells.

- The pumped hydroelectric storage (PHES) technology has been utilized successfully for many years. It is cost effective, *i.e.*, less than \$100/kWh, but its widespread deployment is limited because of the geographical and ecological requirements.
- Next to the PHES, compressed air energy storage (CAES) is a well developed grid-scale electric storage technology. It is cost effective, but faces challenges limiting their ubiquitous deployment due to the geographical requirement.
- Flywheel storage systems store energy mechanically in the form of kinetic energy. Since the rate of energy exchange depends solely on motor-generator design, large amount of energy can be withdrawn in a very short period of time. They are suitable for power quality control.
- Superconducting Magnet Energy Storage (SMES) stores energy in large electromagnets in very low liquid helium temperature helium, *i.e.*, -260°C. Energy can be transferred very quickly and the response times are very short. It may be suitable for high value/low energy applications in which very short (~seconds) storage time is needed.
- Supercapacitor energy storage uses polarized liquid layers at the interface between a conducting ionic electrolyte and a conducting electrode. It offers extremely fast charge and discharge capability and can be cycled many times without degradation. It can provide power during short duration interruptions.
- Batteries have been utilized for small scale applications, but their potential application in grid-scale storage has been sought. Flooded lead-acid (LA) batteries and valve regulated lead-acid (VRLA) batteries are the most mature technologies and have been successfully adopted in electric power applications. NaS and lithium-ion batteries are becoming available. Flow batteries have features that make them attractive for utility-scale applications and many different electrolyte couples have been proposed.

- Hydrogen Energy Storage (HES) system uses electrical energy to split water into hydrogen and oxygen using electrolyzer. Fuel cell can be operated in the discharge process. It has low round-trip efficiency, < 50%, due to the losses in the electrolyzer and fuel cell, which makes it difficult to commercialize in near future.

Below are DOE’s “Primary Technical Requirements” and the “Secondary Technical Targets” for Grid Scale Energy Storage Technologies (2010).

**Primary Technical Requirement**

<b>Requirement Category</b>	<b>Value</b>
System Capital Cost per Unit of Rated Energy Capacity (for measured capacity at Rated Power)	< \$100/kWh
Minimum Operating Time at Rated Power (time at Rated Power for charge and discharge)	60 minutes
Maximum Response Time (time for system to go from 0% to 100% of rated power in discharge and in charge mode)	10 minutes
Rated Power Capacity for Charge and Discharge in Advanced System Prototypes	≥20kW

**Secondary Technical Targets**

<b>Target Category</b>	<b>Description</b>
Cycle Life (cycled at rated power between charge and discharge)	5,000 cycle minimum, defined as number of cycles at which >20% reduction in total energy/power capability occurs relative to initial rated values
Round-Trip Efficiency	80% at rated power for of charge and discharge
Maximum Dwell Time	Maximum 10 minute response time for reversal between charge and discharge cycles
Scalability of Storage Technology for Grid-scale Application	Potential for subsequent scaling for grid-scale deployment (1-10MW). Scalability will be assessed at the power/energy ratio of the advanced systems prototype proposed.
Internal Losses	Less than 5% loss of energy in 24 hours from fully charged state.
Safety	Consistent with transmission and distribution grid deployment at unattended locations
Calendar Life	10 years minimum

**Energy Storage Challenges and Needs**

The challenges of energy storage are i) cost of energy storage systems, ii) reliability of energy storage systems, iii) cost/benefit ratio, and iv) regulatory treatment of energy storage. Energy storage needs improved materials and system integration, over-the-horizon proof-of-concept technology demonstration, utility scale field tests to demonstrate reliability, and identification of benefits accruing from storage.

Opportunities for advancing grid-scale storage technologies include, but not limited to,

- Electrochemical energy storage with low cost materials and/or novel chemistries
- Novel approaches to compressed air energy storage (CAES)
- Flywheel technologies with high energy density
- Superconducting storage materials with high critical current density

Electrochemical energy storage using batteries is considered to be one of the most promising technologies satisfying gigawatt power and gigawatt-hours energy density requirements for large scale storage applications. Table 3 summarizes four advanced batteries commonly deployed for grid applications.

**Advanced batteries commonly deployed for grid applications**

Battery	Energy Density Wh/L	Life Cycle # Charge/Discharges	Round Trip Efficiency, %	Capital Cost \$/kW-hr
Li-Ion	Medium (80-200)	Medium (2,000-5,000)	Very High (85-95)	Very High (600-1,200)
VRB	Low (15-25)	High, (up to 10,000)	Medium (70-75)	Medium (350-500)
Zn/Br	High (130-150)	High (>10,000)	Medium (70-75)	Low (150-250)
NAS	High (145-150)	Medium (3,000-5,000)	High (85-90)	Medium (350-500)

Each battery has its own problems and issues: 1) the high cost and cycle life are major barriers in lithium ion battery; 2) VRB has low volumetric energy density and improvements in the battery’s membrane and electrolyte technologies are needed to reduce VRB capital cost, 3) the problems of Zn/Br battery are high cost of electrodes, material corrosion, dendrite formation during zinc deposition on charge, high self-discharge rates, unsatisfactory energy efficiency, and 4) NaS battery needs backup generators to keep the battery hot even during a major outage on the grid to prevent from solidification of electrode materials.

Research areas in battery technology includes new materials development (electrodes, separators, electrolytes and other components), new chemistry & concepts development for ultra low cost, high efficiency and long lasting energy storage systems.

**Florida’s Opportunities**

Florida being a relatively flat sandy peninsula can not effectively use pumped hydroelectric storage (PHES) technology or compressed air energy storage (CAES) and other than its Northern boarder Florida can not easily purchase electricity across state lines. With these constraints electrochemical energy storage using batteries is Florida’s best option. This is also couple with the opportunities led by various Utilities in Florida putting large scale PV installations throughout the state which could benefit from battery storage to satisfy peaking demand. The addition of 10-kW PV powered with lead acid battery emergency power systems to 90 emergency shelters throughout the state presents opportunities for demonstrations between

Florida Universities and the local Utility. In some cases Utilities may want to pursue demonstrations of battery load-leveling with their PV installations that are coming on line.

There will be more solicitations such as:

*The DOE Office of Electricity (OE) Energy Storage Systems Program is initiating a program through Sandia National Laboratories to fund university applied research projects in novel electrical energy storage for grid applications. The goal of this solicitation is to identify and prove new concepts that could significantly advance large-scale energy storage system technology. Applicants are requested to submit a brief Statement of Interest to Rita Baca at [rmbaca@sandia.gov](mailto:rmbaca@sandia.gov) by **September 22, 2010**. Five three-year \$600K contracts to be let.*

Plans for an Energy Storage Hub Proposal!!!!

**FESC Team Leader: Pyoungho Choi and Jim Fenton, University of Central Florida**