Electrical Energy Storage

Progress and Promise

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ENERGY STORAGE RESEARCH, DOE
Without technological breakthroughs in efficient, large scale Energy Storage, it will be difficult to rely on intermittent renewables for much more than 20-30% of our Electricity.

Secretary Chu, Feb. 2010

The need for regulation services can dramatically increase as the amount of variable renewable resources is increased. Local storage is among the best means to ensure we can reliably integrate renewable energy resources into the grid.

Chairman Wellinghoff, FERC, March 2010

Transmission and storage capacity are key issues for energy resource planning. If you like wind power, you have to love transmission and storage.

Terry Boston, CEO, PJM, June 2010
Energy Storage provides Energy 

*when* it is needed

just as Transmission provides Energy 

*where* it is needed
Stored vs. Delivered Energy:

- 2.5% U.S
- 10% Europe
- 15% Japan

Which Country has most Outages?
Scales of Power

Current (A)

Voltage (V)

Consumer Products

Hybrid Electric Vehicles

Military

Utility

Ships

Traction

Aerospace
RELIABILITY AND POWER QUALITY

Has Become a Necessity for the Digital Society

Commercial
Outage Costs for U.S. Industry estimated at $79 Billion Annually in a recent study by Joe Eto, LBL

Total U.S. Cost of Electricity $250 Billion Annually

Momentary Interruptions (<5min) are More Costly than Sustained Interruptions

40 MW in Fairbanks, Alaska

10 MW - 30 sec at Microchip Plant
VOLTAGE and FREQUENCY REGULATION

Market ready
Grid Frequency Regulation with Fast Storage:

Current method to balance constantly shifting load fluctuation is to vary the frequency and periodically adjust generation in response to an ISO signal. Fast storage can respond instantaneously!
Regulation by fast storage may be twice as effective as gas turbines (Y. Makarov, PNNL,)

Flywheels yield a 70-80% Reduction in CO2 emission over present methods (Fioravanti, KEMA, 2007)

For 20% wind in CA, Frequency Regulation needs will double CAISO

FERC Order 890, requires ISOs to develop tariffs, market rule, and control algorithms, to open markets for new technologies to provide ancillary services

2x 100kW/15 min Flywheel system Demos

CEC / DOE and NYSERDA / DOE

2 x 1MW / 15 min Flywheels in NE-ISO

4 x 1MW / 15min Li-Ion in PJM. CA-ISO
ARRA - Beacon Power:
20MW Flywheel Storage for Frequency Regulation in PJM

20 MW Flywheel System in NY State initiated with DOE Loan Guarantee
2 more 20 MW systems proposed (flywheels and Li-Ion)
PEAK SHAVING
ENERGY MANAGEMENT
UPGRADE DEFERRAL

Near commercial

1.2 MW / 6hr NaS Battery for Substation Support

3 x 2MW for Substation Support, and Reliability during 2009
ARRA - East Penn:
3MW Frequency Regulation + 1MW / 1hr Demand Management
Using new Lead-Carbon Technology

Testing at Sandia

New >200MW East Penn Battery Manufacturing Plant at Lyon Station, PA

5 Distributed Projects = 9MW in Stimulus Package
RENEWABLES DISPATCH
SMOOTHING, RAMPING,
and PEAK SHIFTING

increasingly considered
Grid Voltages near Condon, OR, Windfarm

Wind Ramps in BPA Territory

Diurnal Pattern in California & Texas
On Peak Wind - the Reality

[Diagram showing wind nameplate capacity and wind capacity on summer peak for different NERC regions.]

Source: NERC 2008 Summer Reliability Assessment
Diurnal Storage for Wind and Solar

Xcell’s 1MW / 6hr Sodium-Sulfur Facility
Luverne, Minn.
Complementing 11 MW Wind

Rokkasho, Japan:
34 MW / 7 hr NaS Storage
Complementing 51 MW Wind

25 kW / 2 hrs
15 year life time
Utility dispatchable
ARRA- Primus Power:
25MW / 3hr battery plant for the Modesto, CA Irrigation District, firming 50MW of Wind, replacing $75M of Gas fired Generation.

3 Large Battery + Wind Projects = 53MW in Stimulus Package!
Compressed Air Energy Storage (CAES)

Inexpensive Off-Peak Power to Compress Air for Storage in Aquifers, Salt Domes or Caverns. On-Peak, Compressed Air is used as Input for Gas Turbine Compressor, increasing Efficiency.

Huntdorf, Germany, 290 MW

McIntosh, Alabama, 110 MW

Iowa Stored Energy Park, 268 MW

2000 MW of wind in region
ARRA - NYSEG:
180 MW / 10hr Compressed Air Energy Storage Facility in Watkins Glen, NY

Layered Salt formation
Gas Pipe Line
Transmission Line
Installed Wind Generation

2 CAES Projects = 450MW in Stimulus Package!
ARRA - SustainX:
Development of Isothermal Compressed Air Energy Storage Using Hydraulics

Experimental isothermal efficiency of 94.9% is achieved with the use of SustainX’s technology as compared with 54% for an adiabatic technique.
Pumped Storage Hydro-Electric Power

US – 20 GW
EU – 32 GW
US Proposed: 15-30 GW

Ameren: Taum Sauk, Missouri, 440MW re-commissioned May, 2010

Grasslands Plan:
3000 MW aggregated wind
300 MW pumped hydro
→ Green Baseload Energy
ARRA Stimulus Funding for Storage Demonstration Projects ($185M)

A ten-fold Increase in Power Scale!

Large Battery System (3 projects, 53MW)
Compressed Air (2 projects, 450MW)
Frequency Regulation (20MW)
Distributed Projects (5 projects, 9MW)
Technology Development (5 projects)

$585M Costshare!
Goal: Reliable Energy Storage Technologies that are Economically Viable for Widespread Deployment

Figure 1: Using Deployment Incentives Through the Technology Cycle

- Production Tax Credits
- RES (no carve-outs)
- Reverse auctions
- Feed-in tariffs (low)

- Mature, lowest cost technologies (e.g., hydro)

- Applied RD&D
- Cost-sharing projects

- Prototype and demonstration technologies

- Emerging, high-cost technologies (e.g., PV)

- Investment Tax Credits
- RES carve-outs
- Rebates
- Feed-in tariffs (high)
- Loan guarantees

Abbreviations used: RES = Renewable Electricity Standard; PV = Photovoltaics

Federal R&D Grant Programs
X Prize Awards

A. Jackson, U.S Senate Staff
Industry 10 year Expectations

Without Investment Tax Credit

- 1,500 MW Pumped Hydro
- 700 MW CAES
- 1,500 MW Renewable Integr.
- 12,000 MW T&D Support
- 1,100 MW Frequency Reg.
- 2,100 MW Thermal Storage

20% Investment Tax Credit for Storage Facilities
Currently considered in Congress
Our Goal is to make

Energy Storage

Ubiquitous

on the Electric Grid!!
RESOURCES:

www.sandia.gov/ess

www.electricitystorage.org

EPRI/DOE Energy Storage Handbook

DOE Program Review, Nov. 2-4, DC
Electro-Thermal Energy Storage
Peak Shifting

Inexpensive Off-Peak Power to make ice or chill Water. On-Peak, energy is used to displace large numbers of 3 phase inductive motor loads for compressors. Market ready, relatively low cost, high round trip energy efficiency, long life.

Southern California Public Power Authority
Member Utilities & Ice Energy
53 MW for 6 hours daily during summer peak
63 Gigawatt hours peak shift annually

Credit Suisse, NY - NYSERDA & CALMAC
1 MW, 2 Gigawatt hours peak shift annually

Princeton University, NJ
8 MW
Turbine Inlet Cooling & District Cooling