Grid Scale Energy Storage

Applications & Technologies

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ENERGY STORAGE RESEARCH, DOE
Energy Storage provides Energy when it is needed just as Transmission provides Energy where it is needed.
An Unbuffered, Stressed Complex System is inherently Vulnerable to Collapse

An Increasing Reliability Threat!

The U.S. Electric Grid
A Technological Marvel!
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

Aerospace

Military

Traction

Ships

Utility

Hybrid Electric Vehicles

Aerospace

Military

Traction

Ships

Utility
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

10 MW - 30 sec at Microchip Plant

40 MW in Fairbanks, Alaska
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!

Kirby 2004
Regulation by fast storage may be twice as effective than gas turbines and 20 times more effective than steam turbines. (Y. Makarov, PNNL,)

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

2x 100kW/15 min Flywheel systems
CEC / DOE and NYSERDA / DOE

Frequ. Reg. Needs will Double with 20% wind
Recent Developments:

AES tests 2 x 1MW / 15min Altairnano in PJM.

and 2x 1MW A123 batteries in CA-ISO

2x1MW / 15 min Beacon Flywheel Systems
Installed in Massachusetts

1MW to be installed at AEP or NY State

$50M for Regulation in Stimulus Package!

FERC Order 890, requires ISOs to develop tariffs, market rule, and control algorithms, to open markets for new technologies to provide ancillary services
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
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
In Texas on Feb. 26, 2008 Wind Power dropped 1400MW in 10 Minutes. Blackouts were avoided by massive Load shedding by industrial Customers.

March 08, there were 933 Negative Pricing Intervals = 38% of 15min. intervals Max. Price = $2303; Min. Price = -$1983 $/MWh
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

$50M for Large Batteries 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

$60M for CAES in Stimulus Package!

Huntdorf, Germany, 290 MW
McIntosh, Alabama, 110 MW
Iowa Stored Energy Park, 268 MW
2000 MW of wind in region

Glacial Drift Devonian Carbonates
Mackoketa Shale
Galena
Decorah-Platteville
St. Peter (Storage Zone)
Prairie Du Chein
Jordan
Eau Clair Sand & Shale
Mt. Simon Sandstone
Pumped Storage Hydro-Electric Power

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

Ameren: Taum Sauk, Missouri, 440MW May, 2010

Grasslands:
3000 MW aggregated wind
300 MW pumped hydro
→ Green Baseload Energy
Stimulus Funding for Storage Demonstration Projects (ca. $200M)

A ten-fold Increase in Power!

Large Battery System (2x10MW)
Compressed Air (2x150MW)
Frequency Regulation (2x20MW)
Distributed Projects (5x1-3MW)
Technology Development
Distributed Storage, Distributed Generation, and Distributed Intelligence will be essential for the Grid of the Future.
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

ESA Meeting, May 4-7, Charlotte, NC