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

The U.S. Electric Grid
A Technological Marvel!

An Unbuffered, Stressed Complex System is inherently Vulnerable to Collapse

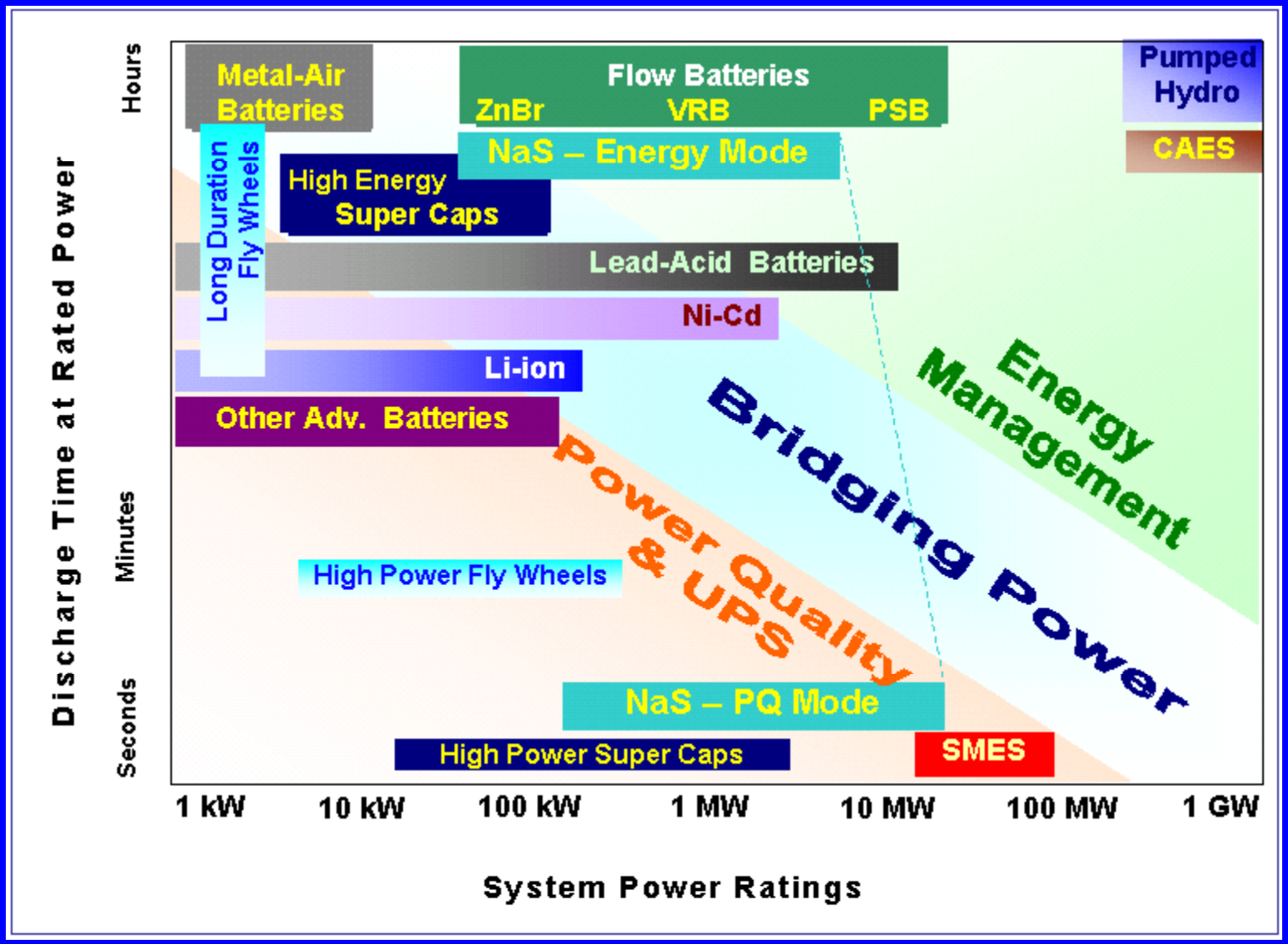
Aug. 14, 2003
An Increasing Reliability Threat!

Stored vs. Delivered Energy:

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

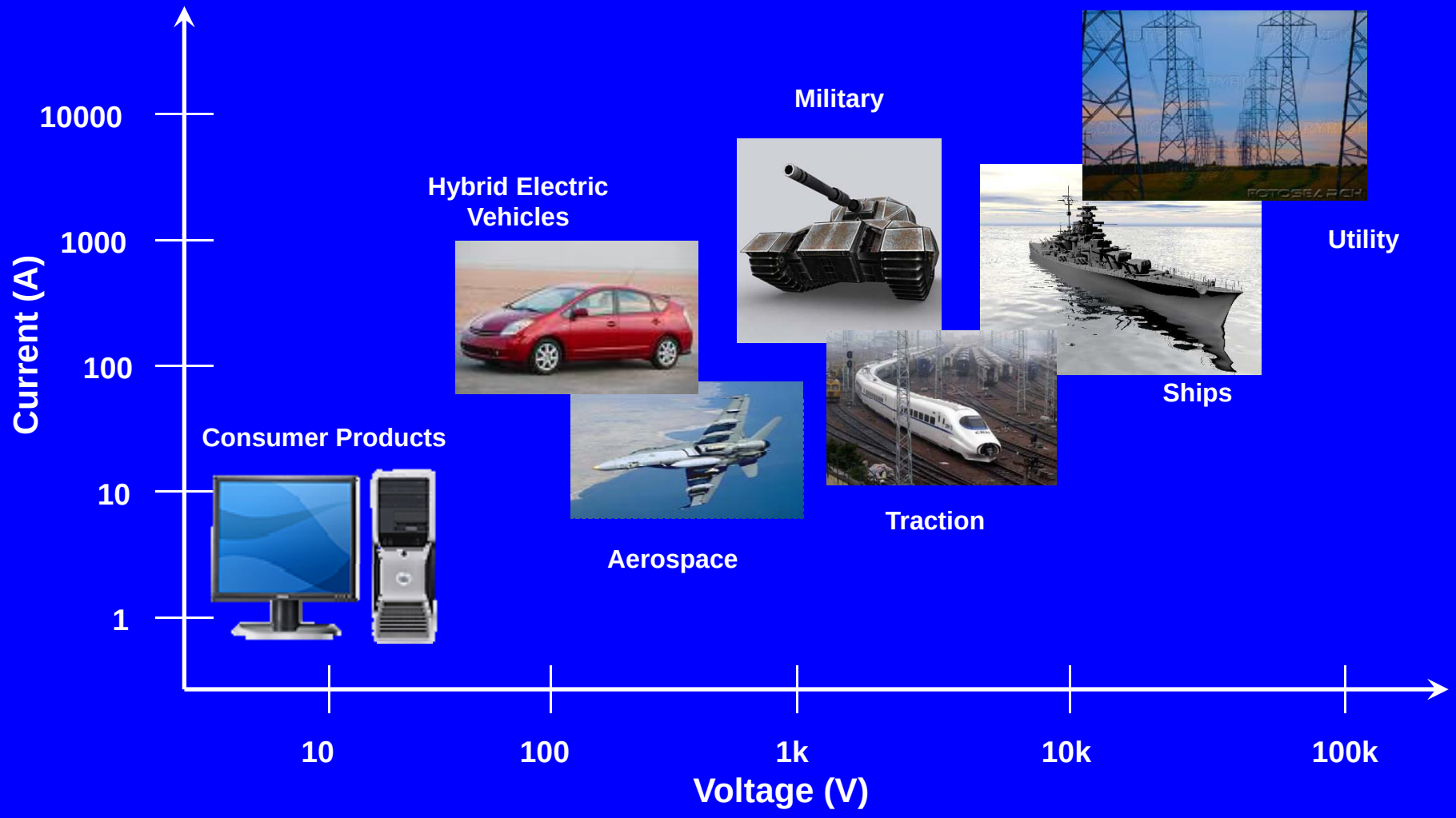
Which Country has most Outages?

Storage Technologies and Regimes of Application



A. Nourai

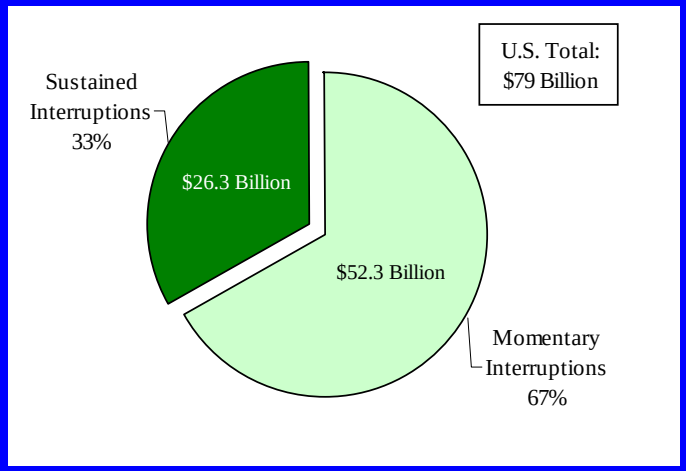
Scales of Power



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

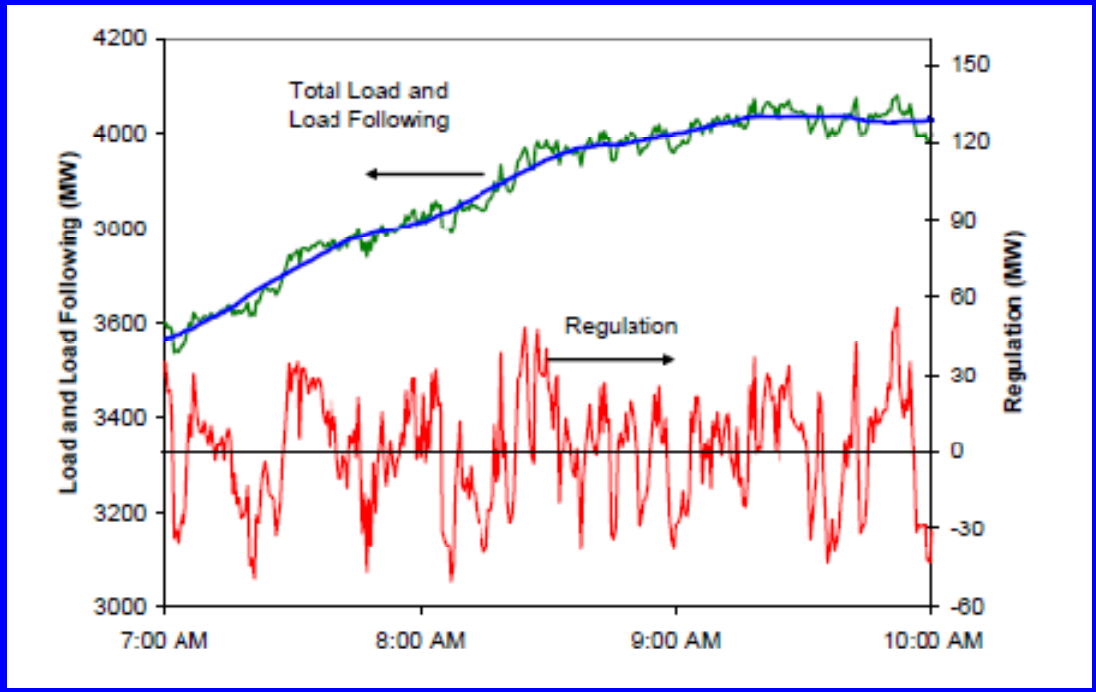
40 MW in Fairbanks, Alaska

10 MW - 30 sec at Microchip Plant

VOLTAGE and FREQUENCY REGULATION

Market ready

Grid Frequency Regulation with Fast Storage:

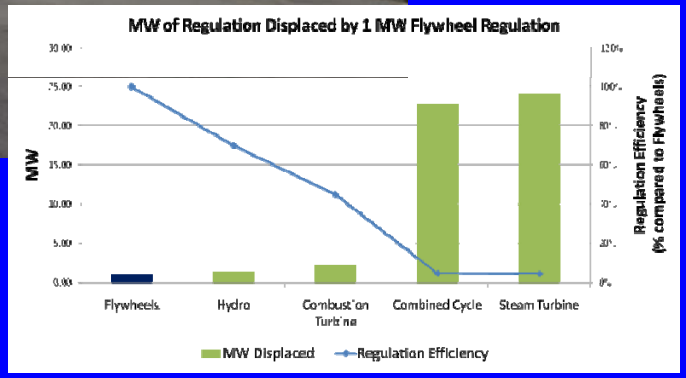


Kirby 2004

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!

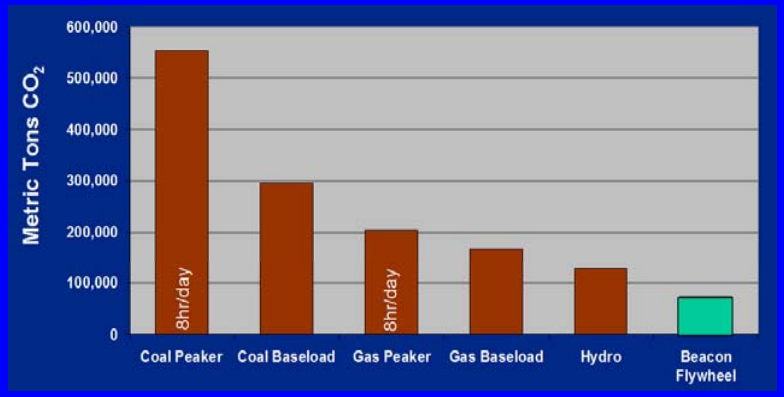
2x 100kW/15 min Flywheel systems

CEC / DOE and NYSERDA / DOE



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)



Frequ. Reg. Needs will Double with 20% wind

Recent Developments:

4 x 1MW / 15min Li-Ion in PJM. CA-ISO

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

20 MW Flywheel System in NY State initiated
20 MW Flywheel System in Illinois selected for ARRA funding

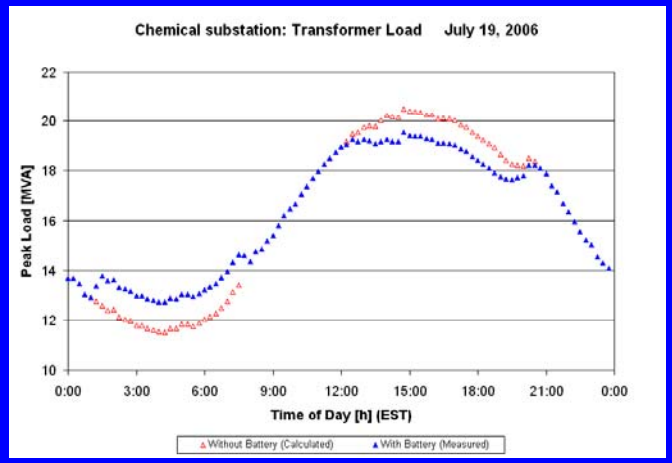
FERC Order 890, requires ISOs to develop tariffs, market rule, and control algorithms, to open markets for new technologies to provide ancillary services

PEAK SHAVING

ENERGY MANAGEMENT

UPGRADE DEFERRAL

Near commercial



Charleston, WV Appalachian Power Substation – AEP / DOE Project, June 2006

1.2 MW / 6hr NaS Battery for Substation Support

3 x 2MW for Substation Support, and Reliability during 2009

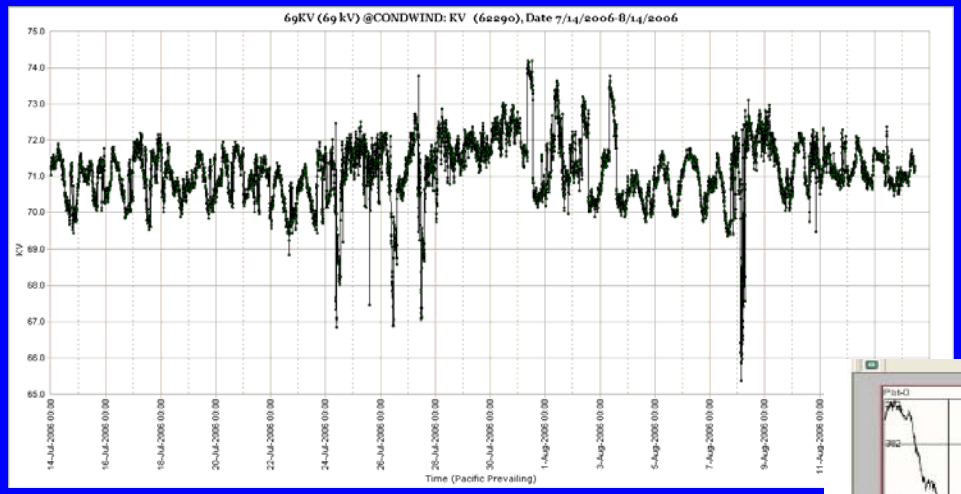
RENEWABLES DISPATCH

SMOOTHING, RAMPING,

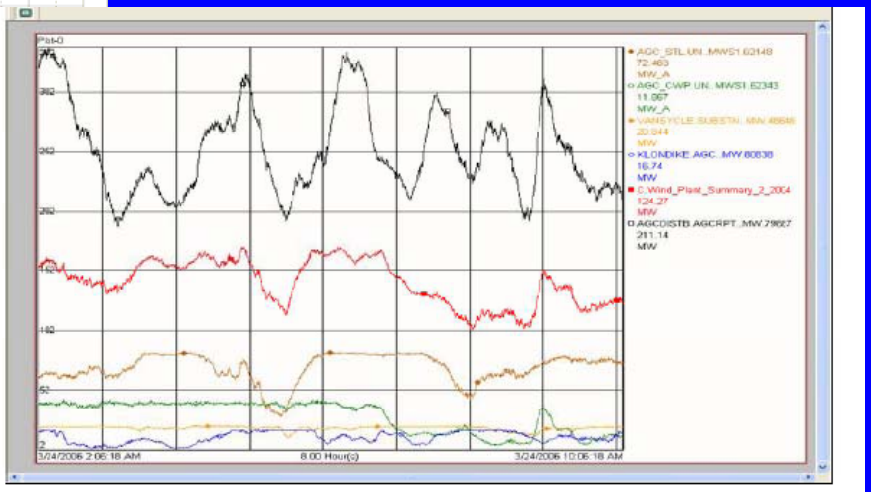
and PEAK SHIFTING

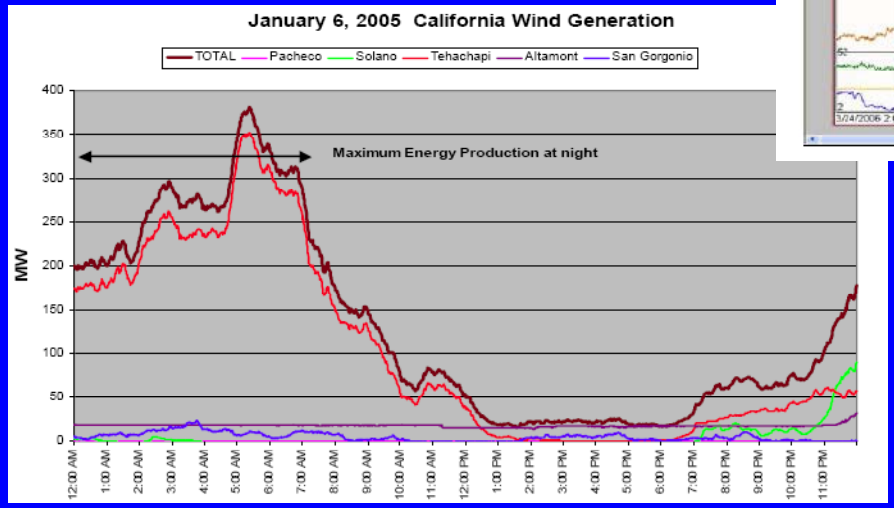
increasingly considered

Grid Voltages near Condon, OR, Windfarm



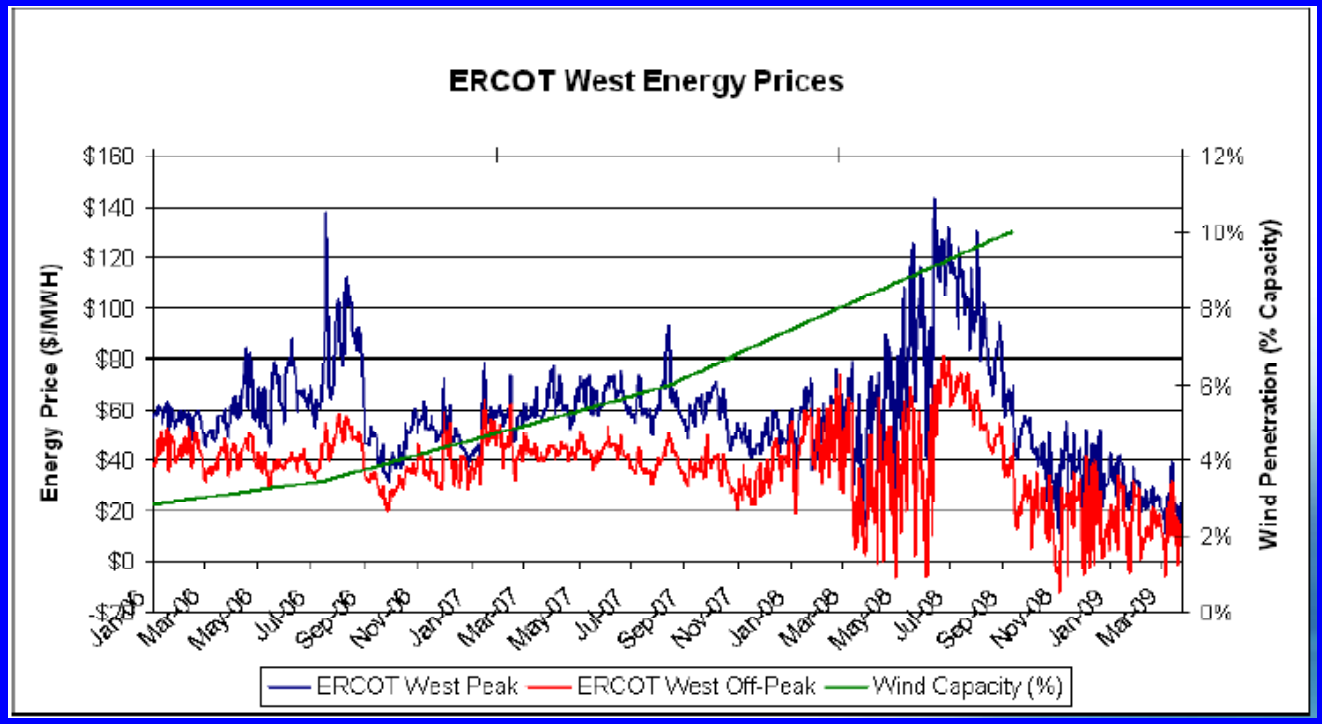
Wind Ramps in BPA Territory





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

3 Large Battery + Wind Projects = 53MW in Stimulus Package!

Compressed Air Energy Storage CAES

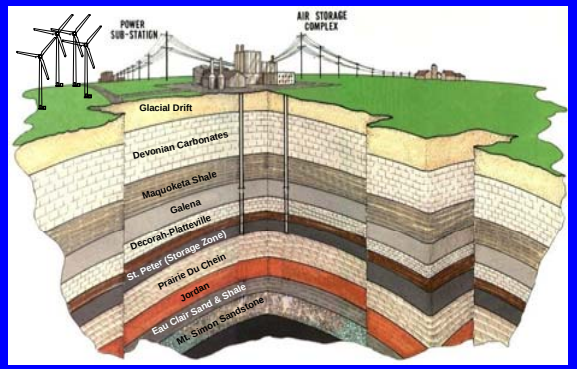
Inexpensive Off-Peak Power to Compress Air for Storage in Aquifers, Salt Domes or Caverns. On-Peak, Compressed Air is used as Input for Gas Turbine Compressor, increasing Efficiency

2 CAES Projects = 450MW in Stimulus Package!

Huntdorf, Germany, 290 MW

McIntosh, Alabama, 110 MW

Iowa Stored Energy Park, 268 MW
2000 MW of wind in region



Pumped Storage Hydro-Electric Power

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

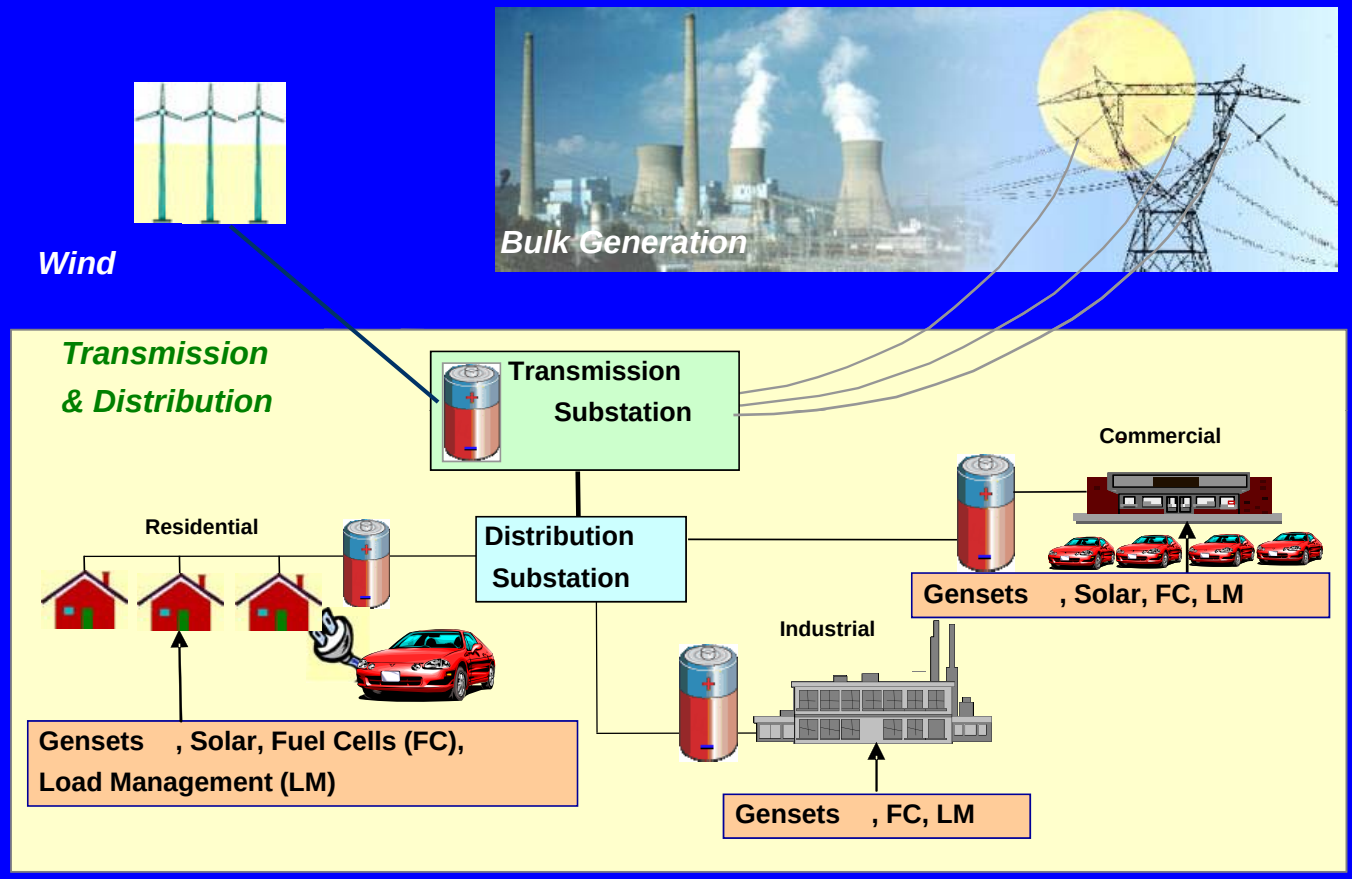
US – 20 GW
EU – 32 GW
US Proposed:
15-30 GW

Grasslands Plan:
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 (3 projects,53MW)
Compressed Air (2 projects, 450MW)
Frequency Regulation (20MW)
Distributed Projects (5 projects,9MW)
Technology Development (5 projects)



Nourai, AEP

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