Electrical Energy Storage

Progress and Promise

IMRE GYUK, PROGRAM MANAGER
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

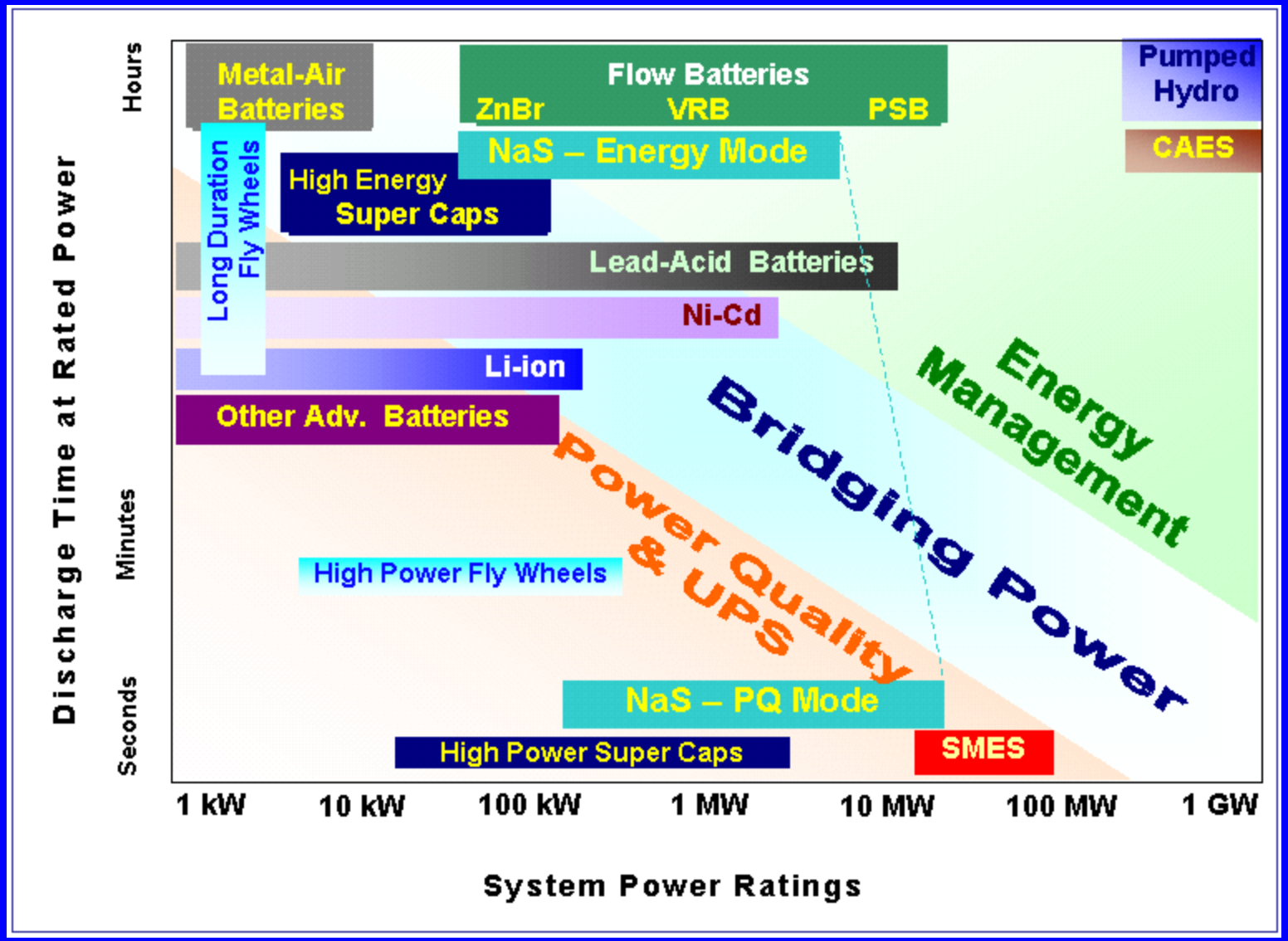
where it is needed

Stored vs. Delivered Energy:

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

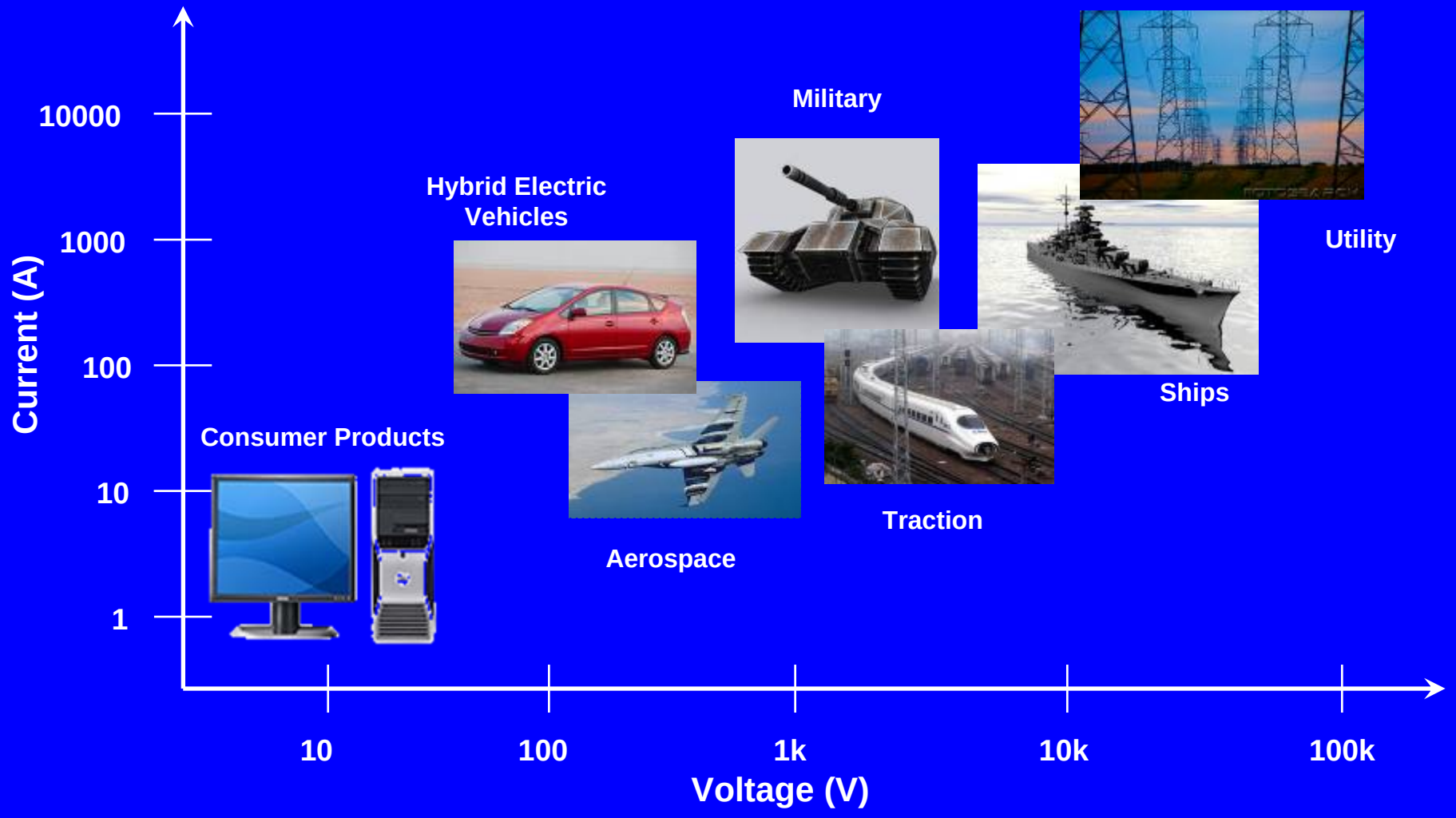
Which Country has most Outages?

Storage Technologies and Regimes of Application



A. Nourai

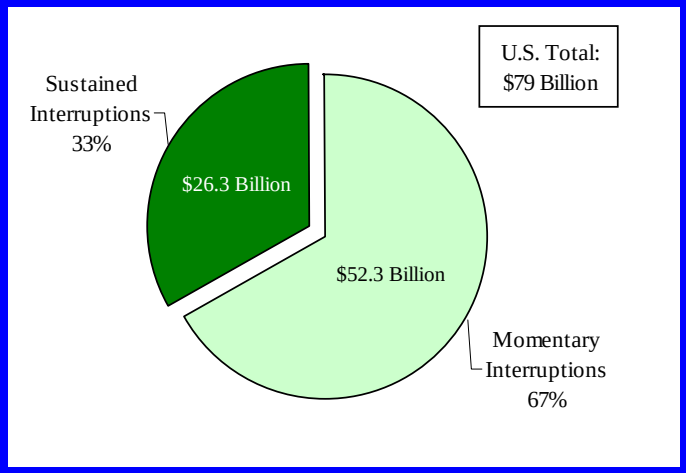
Scales of Power



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

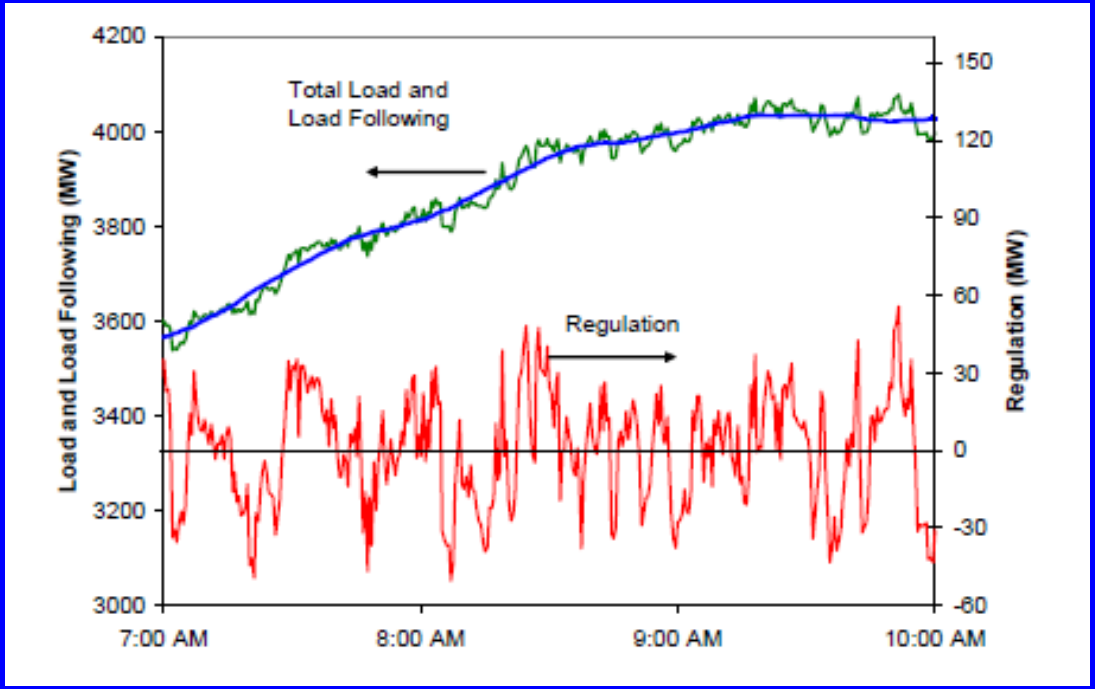
40 MW in Fairbanks, Alaska

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 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

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

ARRA - Beacon Power:

20MW Flywheel Storage for Frequency Regulation in PJM

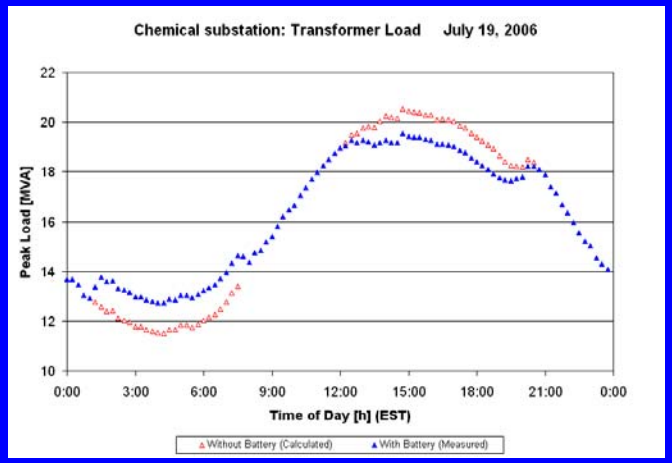
20 MW Flywheel System in NY State initiated with DOE Loan Guarantee
2 more 20 MW systems proposed (flywheels and Li-Ion)

PEAK SHAVING

ENERGY MANAGEMENT

UPGRADE DEFERRAL

Near commercial



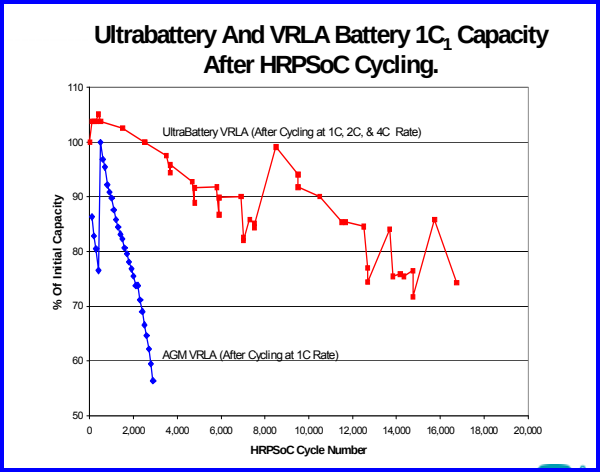
Charleston, WV Appalachian Power Substation – AEP / DOE Project, June 2006

1.2 MW / 6hr NaS Battery for Substation Support

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

ARRA - East Penn:

3MW Frequency Regulation + 1MW / 1hr Demand Management Using new Lead-Carbon Technology



Testing at Sandia

Battery Stacks

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

5 Distributed Projects = 9MW in Stimulus Package

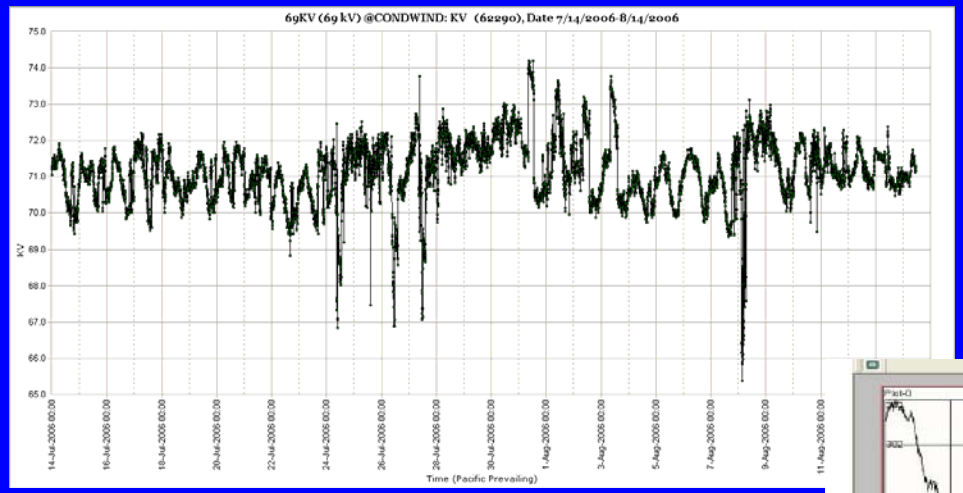
RENEWABLES DISPATCH

SMOOTHING, RAMPING,

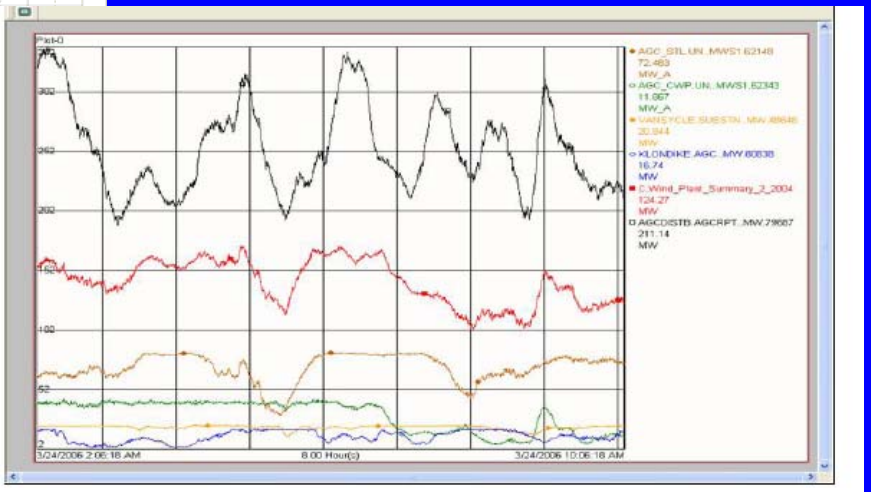
and PEAK SHIFTING

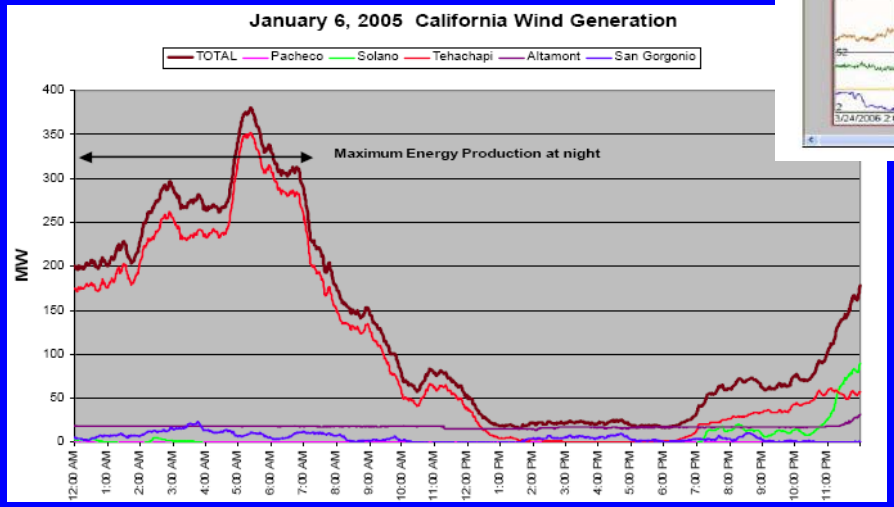
increasingly considered

Grid Voltages near Condon, OR, Windfarm



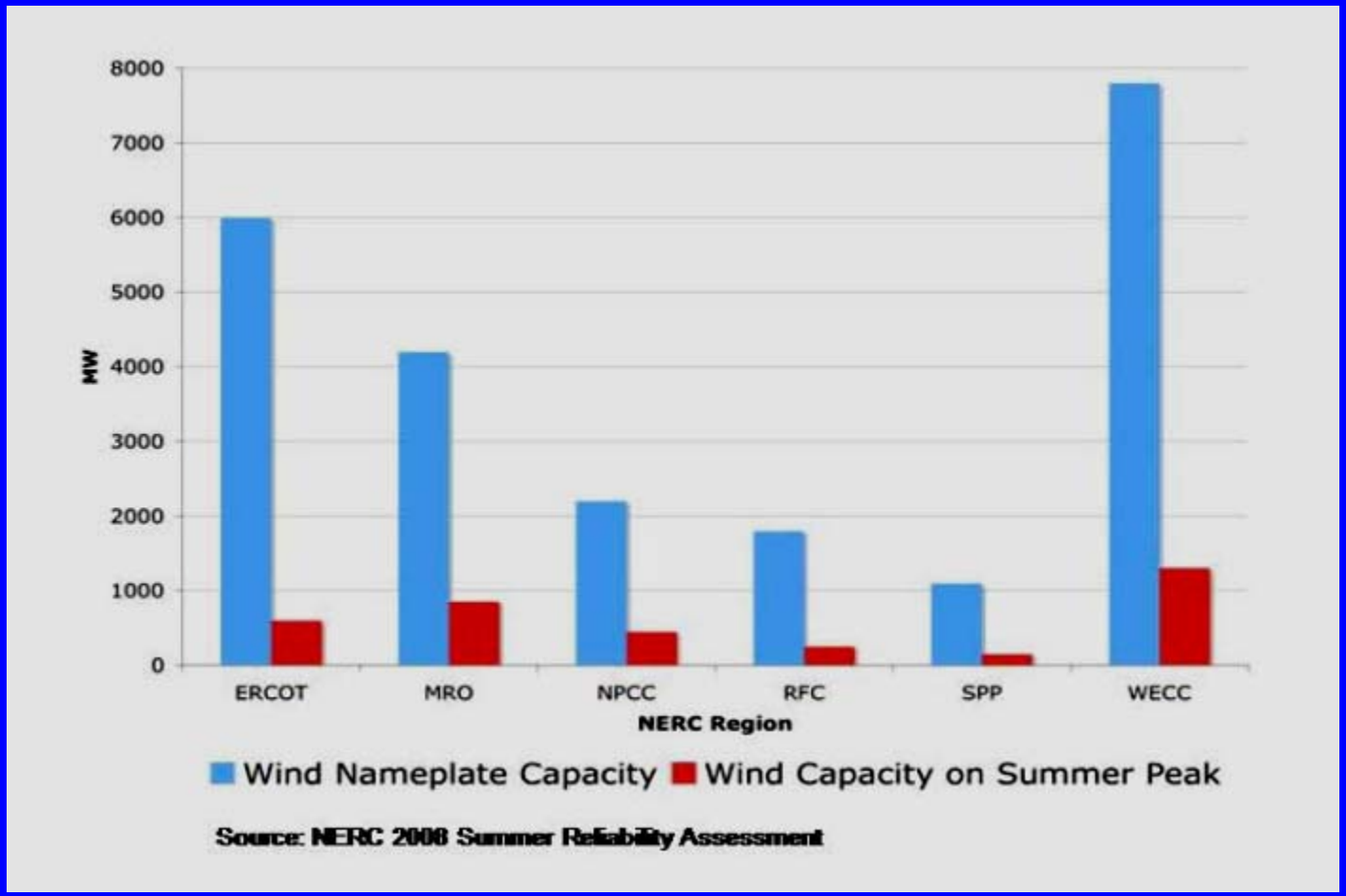
Wind Ramps in BPA Territory





Diurnal Pattern in California & Texas

On Peak Wind - the Reality



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!

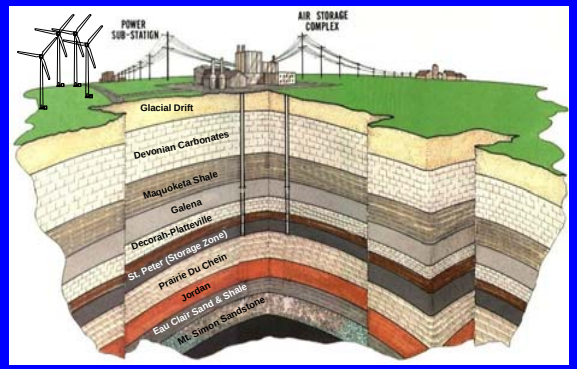
Compressed Air Energy Storage CAES

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

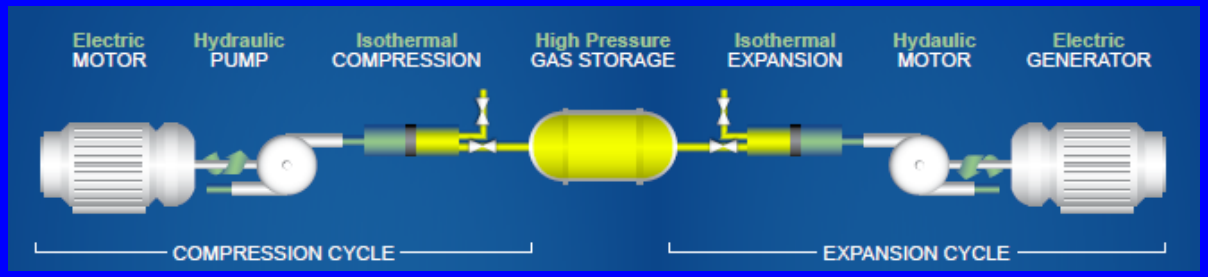
Transmission Line

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

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

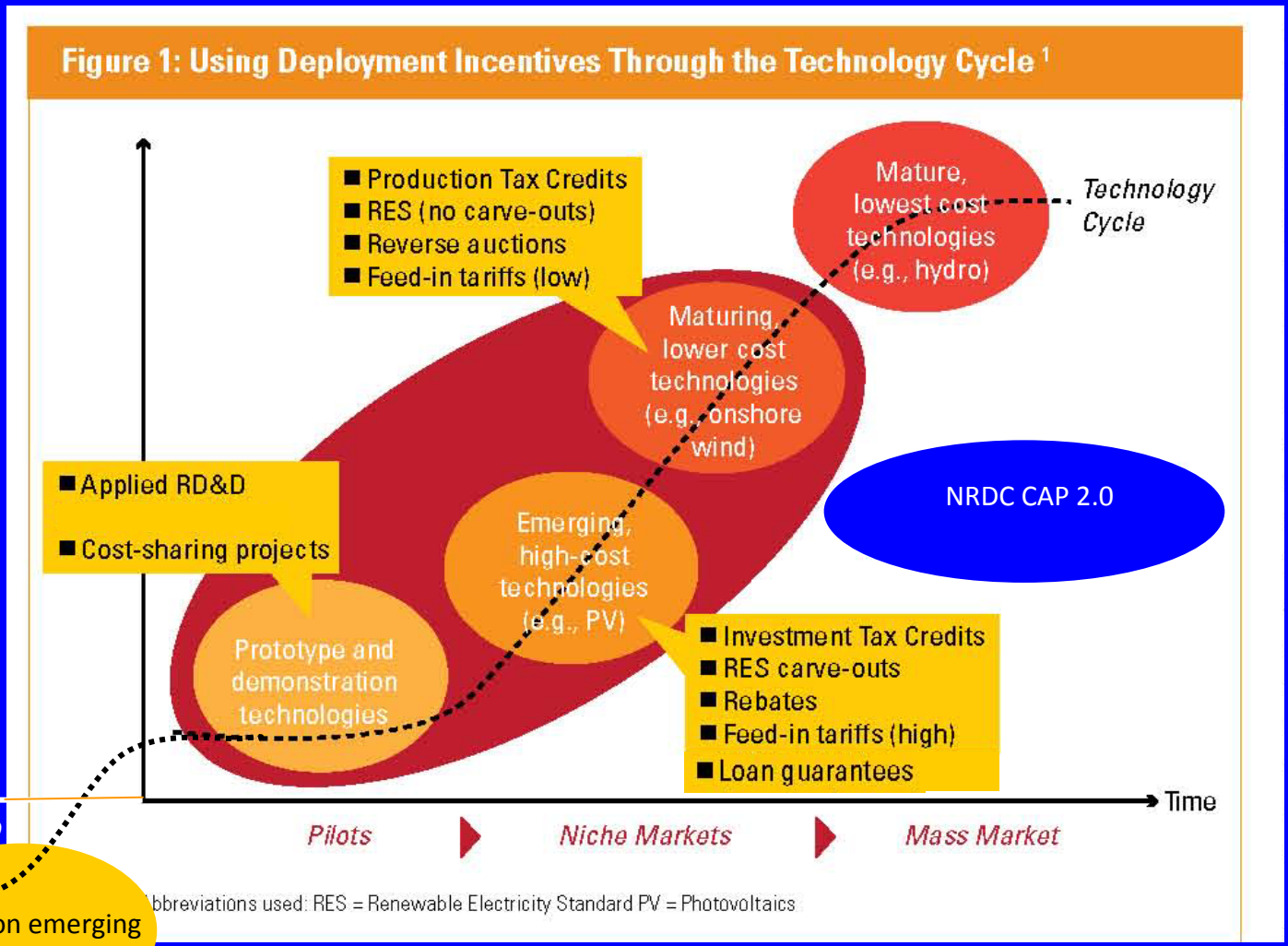
ARRA Stimulus Funding for Storage Demonstration Projects ($185M)

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



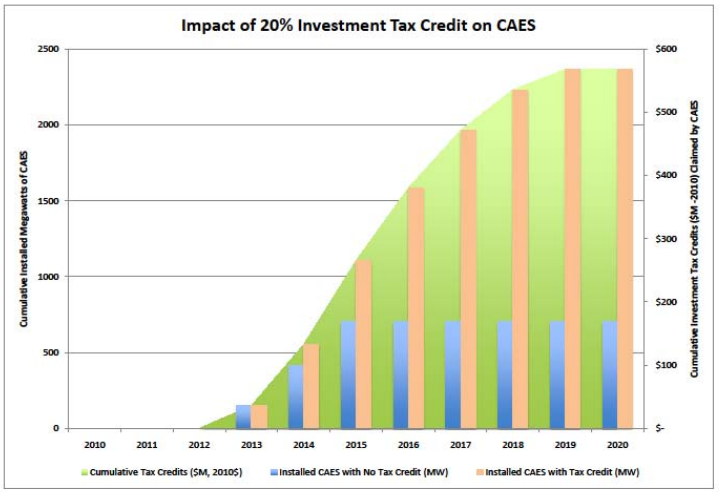
NRDC CAP 2.0

R&D on emerging technologies

Federal R&D Grant Programs
X Prize Awards

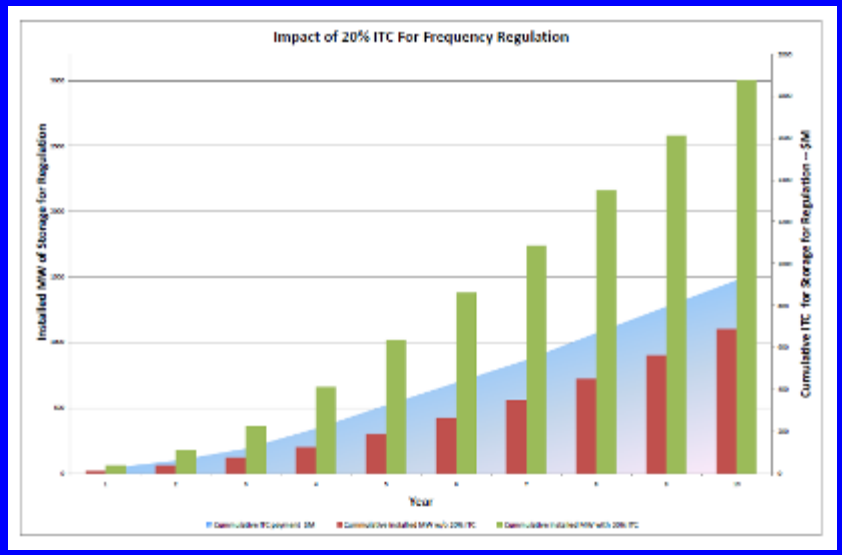
A. Jackson, U.S Senate Staff

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