

Electrical Energy Storage

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Maintaining the Momentum

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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

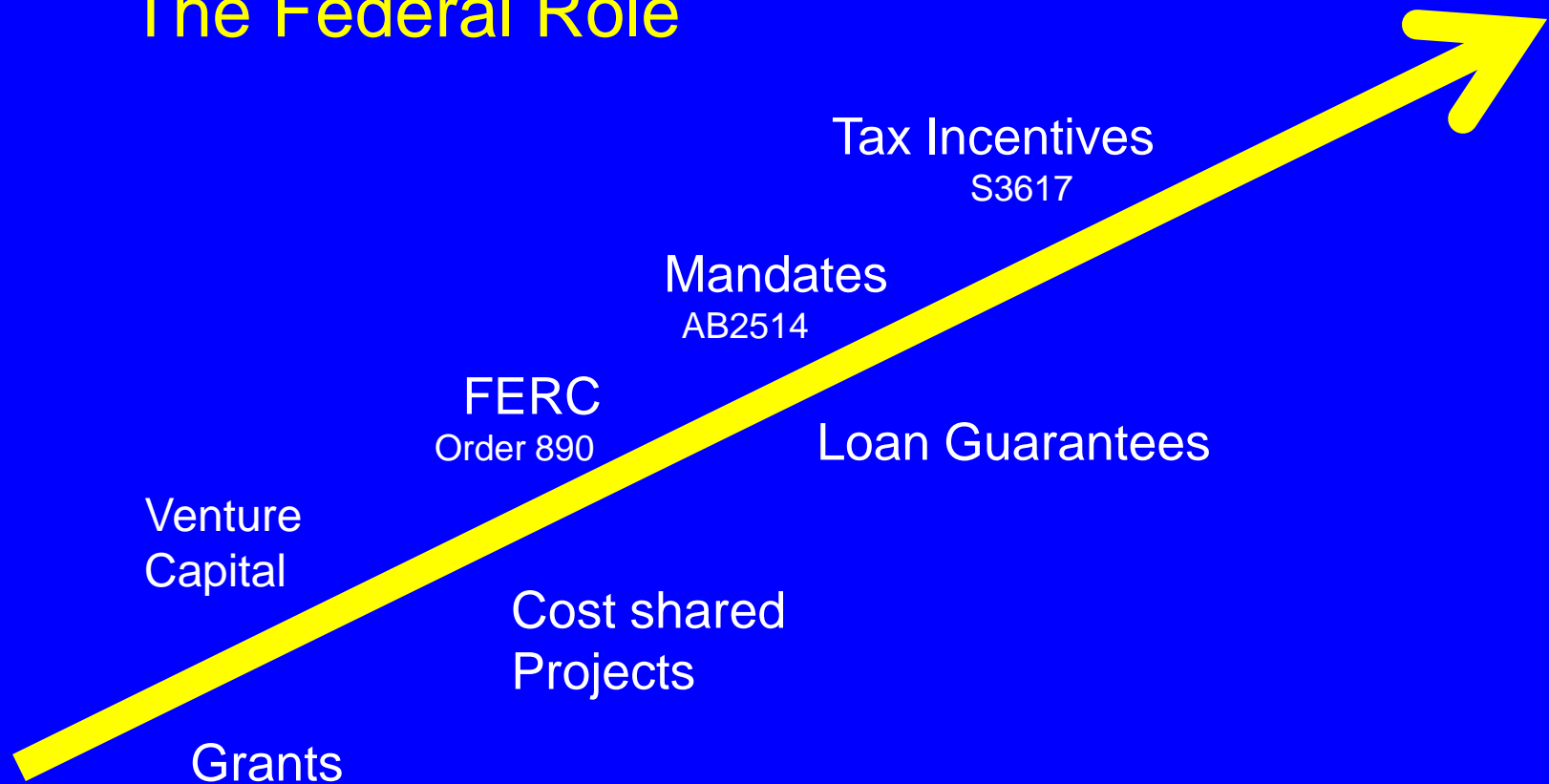
The need for regulation services can dramatically increase as the amount of variable renewable resources is increased. Local storage is among the best means to ensure we can reliably integrate renewable energy resources into the grid.

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.

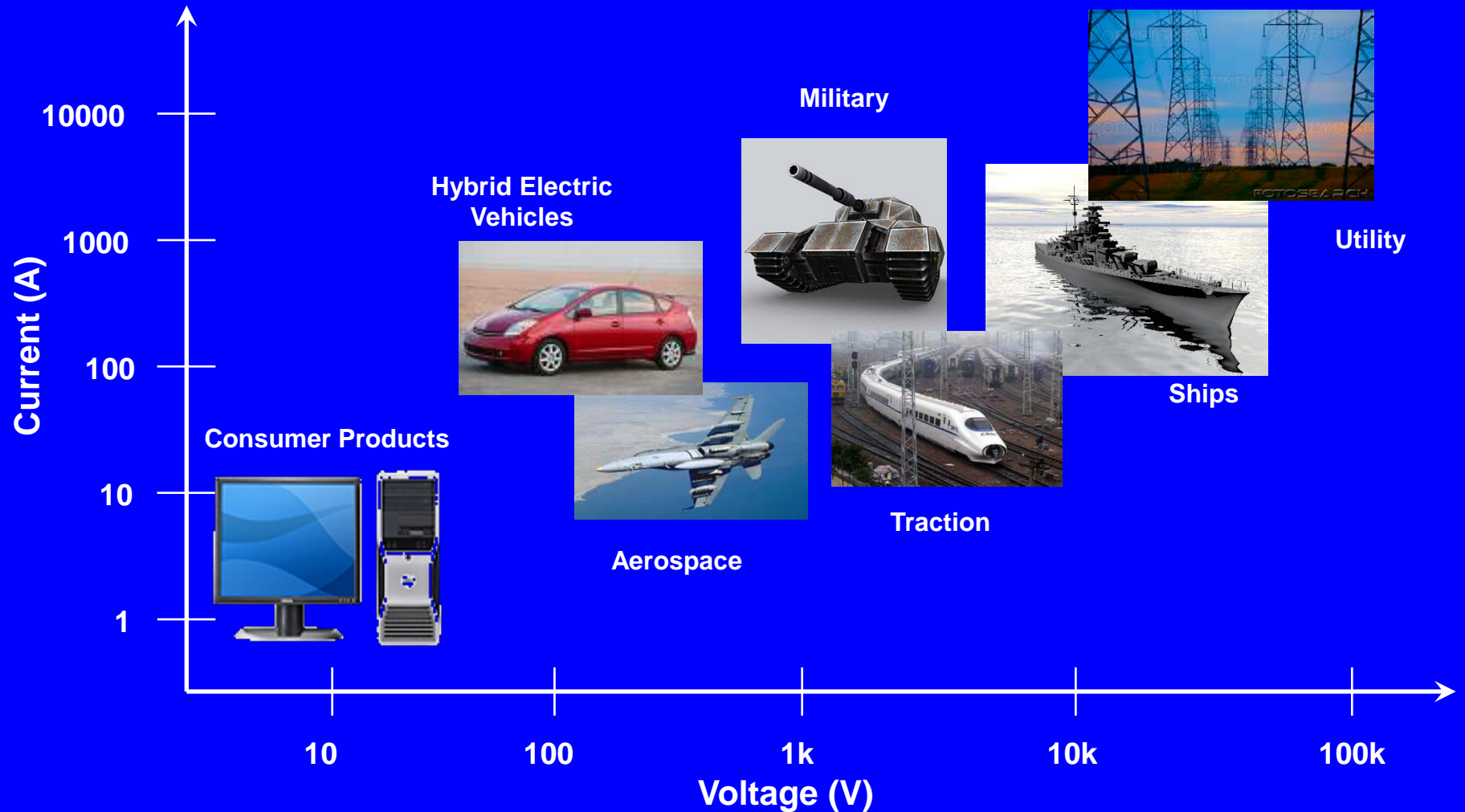
Terry Boston , CEO, PJM, June 2010

The Federal Role

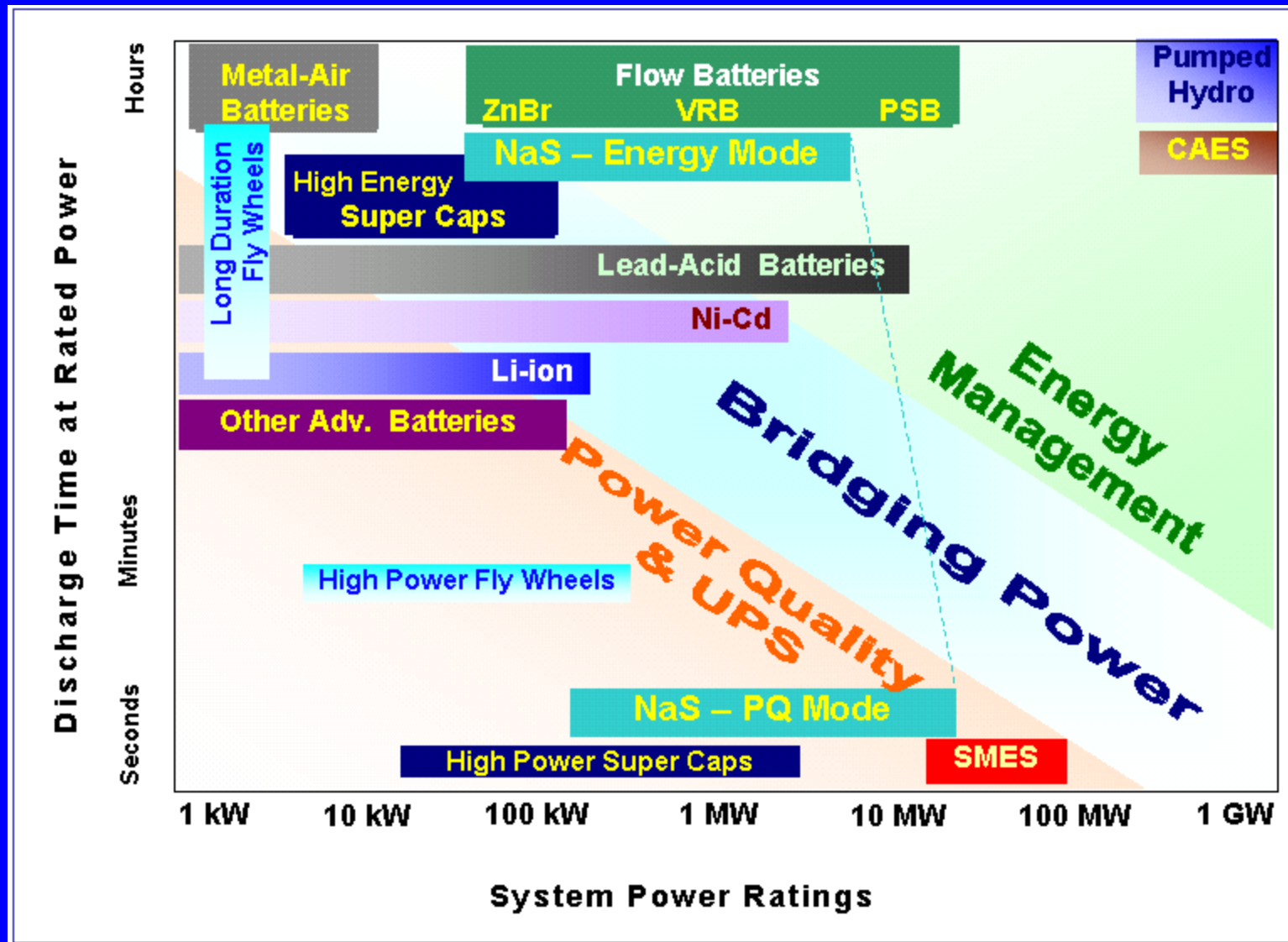


Research Development Demonstration Niche Market Mass Market

Scales of Power



Storage Technologies and Regimes of Application



Historically, the DOE Energy Storage Program has had MOUs with CEC and NYSERDA supporting a Considerable Number of joint Projects.

DOE has also worked on Demonstration Projects directly with Utilities

With the \$185M ARRA Stimulus Program no separate individual Projects have been initiated recently

ARRA has created considerable Interest among Utilities And Renewable Developers but ARRA Funding has closed

A new Approach is needed to maintain the momentum of the Energy Storage Investment – Collaboration with the States!

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)

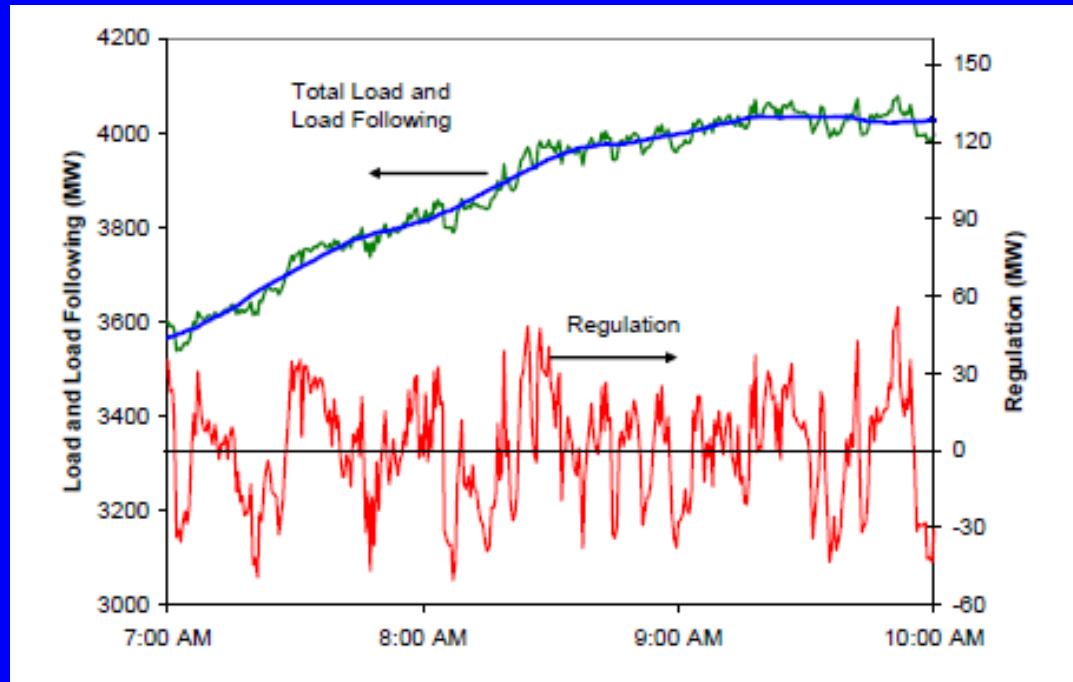
Technology Development (5 projects)

533MW - \$585M Costshare!

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

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 !!!!!



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



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

**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



Coming: Pay for Performance!



DOE Loan Guarantee – Beacon:
20MW Flywheel Storage for
Frequency Regulation in PJM
8MW on Line!

DOE Loan Guarantee – AES / A123:
20MW Lithium Ion Battery for
Frequency Regulation in NY-ISO
8MW on Line!

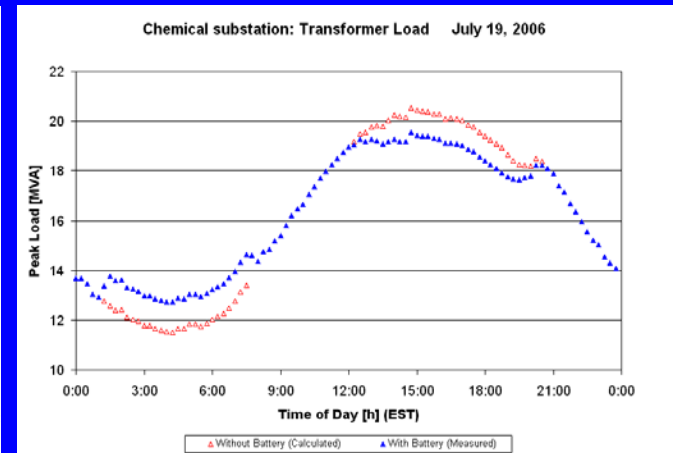


PEAK SHAVING

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



Distributed Energy Storage Projects

Vanadium Redox: City of Painsville, OH

Load leveling for 32MW coal plant; 1MW, 6-8MWh

Lithium Ion, Edison Electric, A123

Community Energy Storage; 20units @ 25kW, 50kWh

Lead/Carbon, EastPenn

Frequency regulation, Peak shifting; 3MW, 1-4MWh

Lead/Carbon, Public Service New Mexico

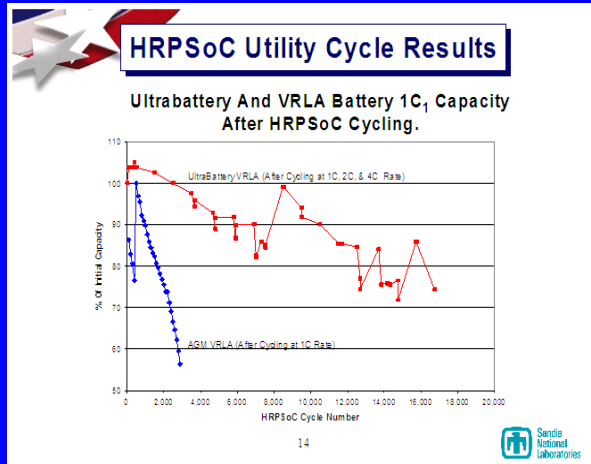
Smoothing of 500MW PV installation; 500kW, 2.5MWh

ZnBr, Premium Power

Peak shaving; 5 systems @ 500kW, 2.5MWh

ARRA - East Penn:

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



Battery Stacks

Testing at Sandia



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

5 Distributed Projects = 9MW in Stimulus Package

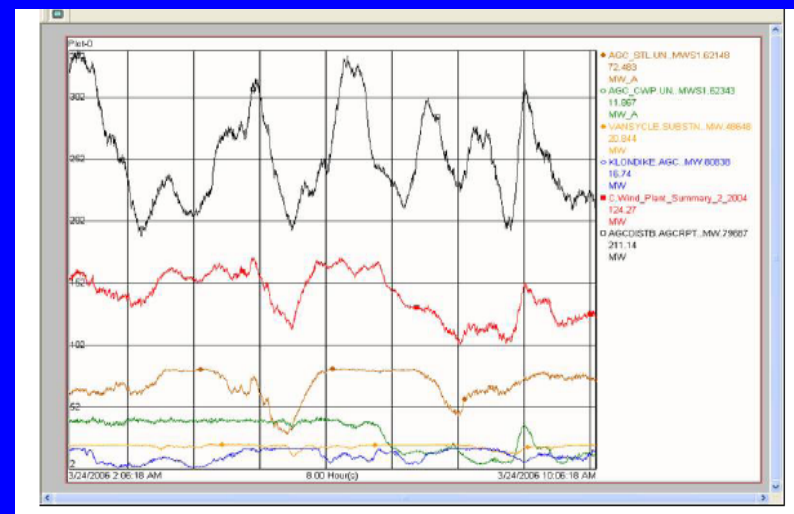
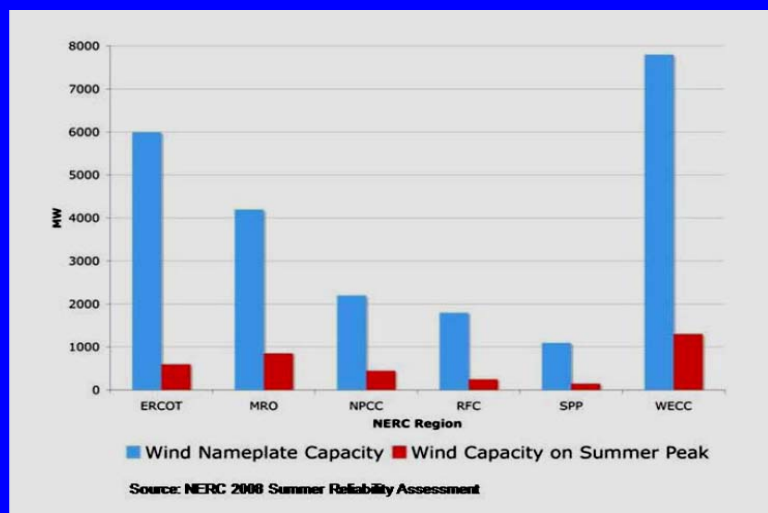
RENEWABLES DISPATCH

SMOOTHING, RAMPING,

and PEAK SHIFTING

increasingly considered

Large Batteries for Wind Integration



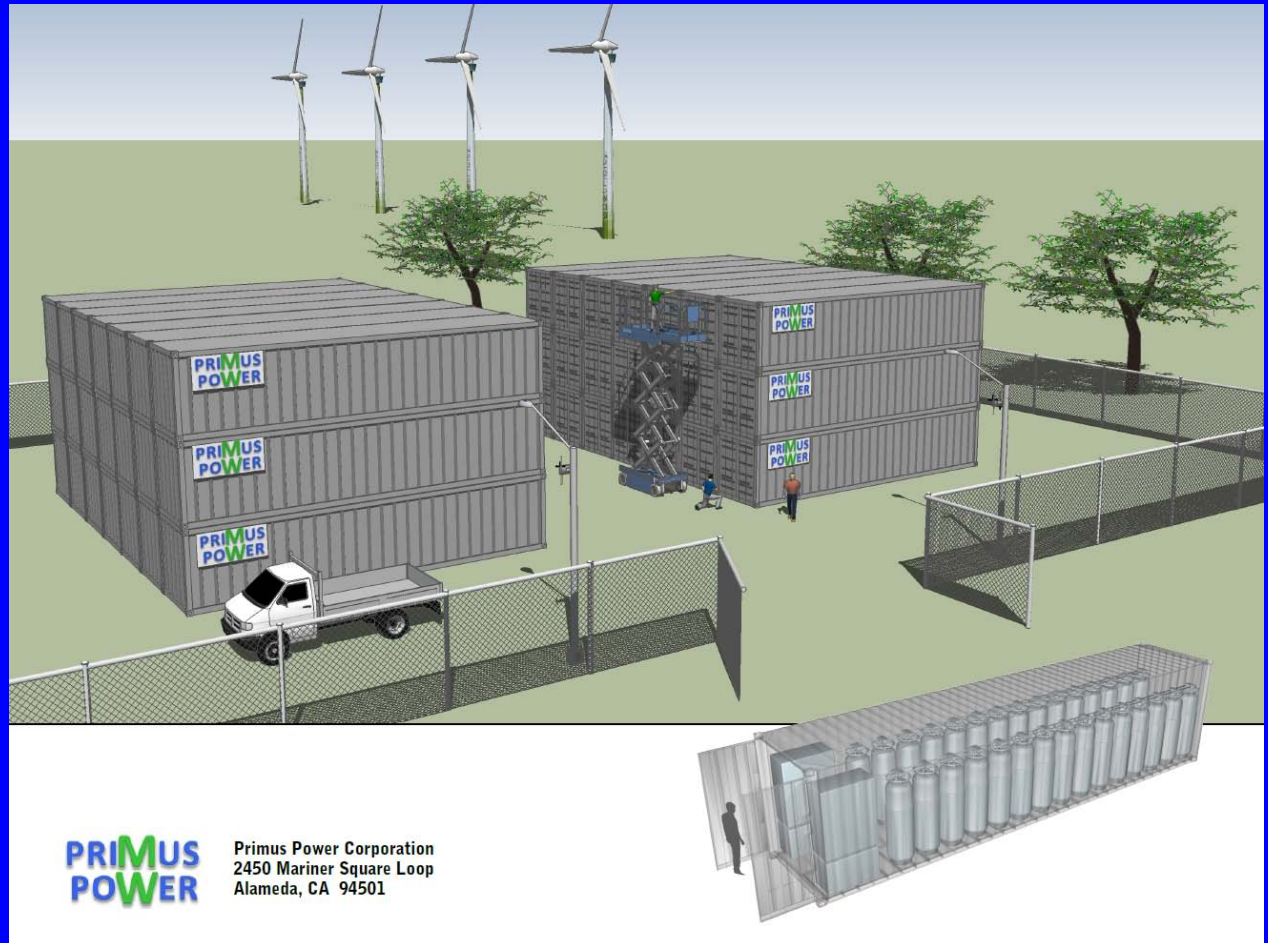
3 Large Battery + Wind Projects =
53MW in Stimulus Package!

ARRA- Primus Power:

25MW / 3hr battery plant for the Modesto, CA Irrigation District,
firming 50MW of Wind, replacing \$75M of Gas fired Generation.



Totally sealed battery module
With a ZnCl electrolyte and
zinc and graphite electrodes



ARRA - Southern California Edison / A123 – Li-Ion:

8 MW / 4 hr battery plant for wind integration at Tehachapi, CA.



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

McIntosh, Alabama, 110 MW



Huntorf, Germany, 290 MW



ARRA - NYSEG:

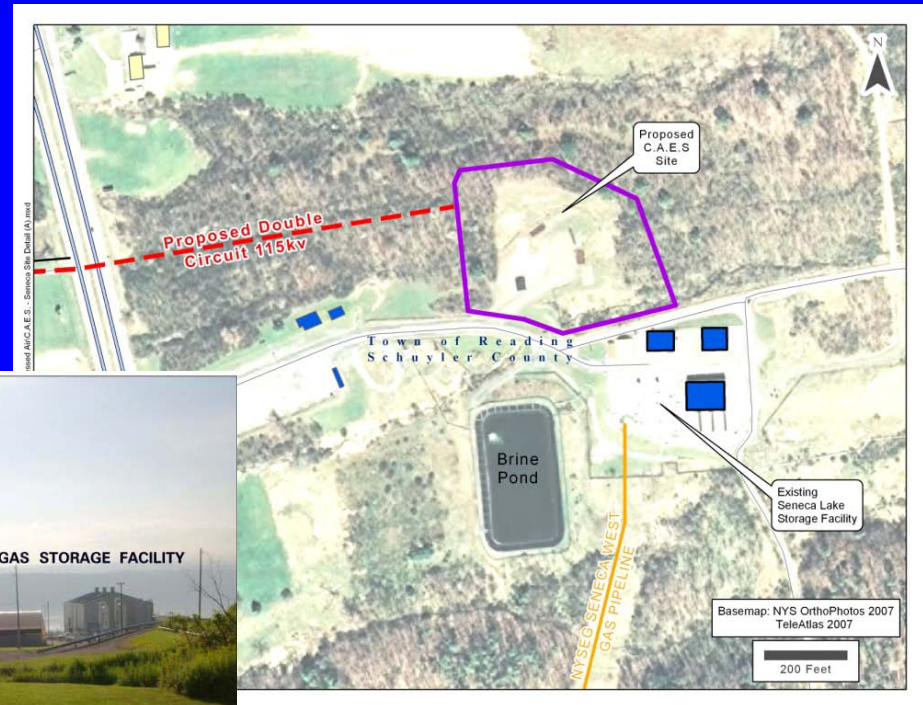
180 MW / 10hr Compressed Air Energy Storage Facility in Watkins Glen, NY

Layered Salt formation

Gas Pipe Line

Transmission Line

Installed Wind Generation

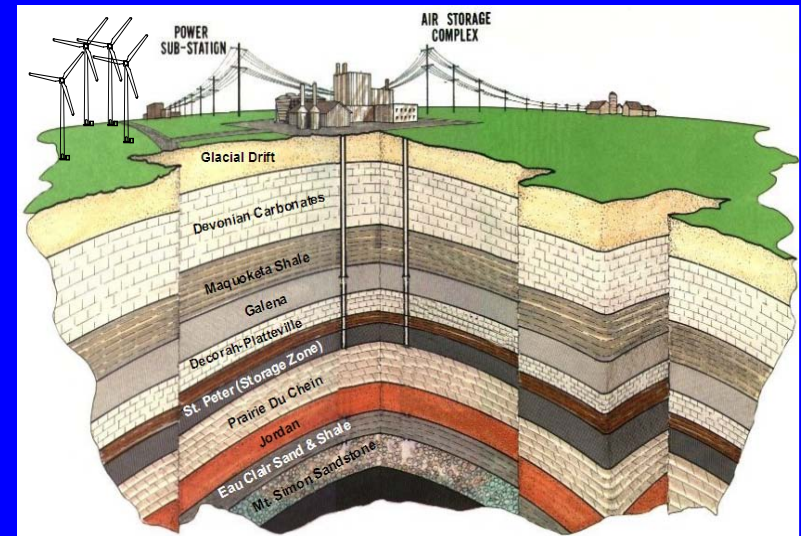


2 CAES Projects = 450MW in Stimulus Package!

COMPRESSED AIR ENERGY STORAGE:

A DOE/ Iowa Muni Project

268 MW Aquifer
Compressed Air Energy
Storage (CAES) using off-
peak Power. 2000 MW of
Wind at play in Iowa.
Planned by Iowa Associated
Municipal Utilities.



Several other CAES projects are under consideration
by EPRI and others

Community Energy Storage



25 kW / 2 hrs
15 year life time

Backup, Platform for Solar,
Utility Dispatchable

ARRA Project puts 20 Li-Ion CES Units on Detroit Edison Grid

Widespread Adoption of EV may reduce the cost of Li-Ion Batteries
Or else, used EV Batteries could be used for Grid Applications

News Flash!

Consortium Initiated
to explore Re-use of EV Batteries for Grid
Storage Applications

DOE – OE, Storage Program

DOE – EERE, EV Program

EPA – Vehicle and Fuel Emissions Lab

ORNL – Sustainable Electricity Program

Nissan, General Motors

5 New Storage Technologies

Sodium Ion Battery: Aquion

Low cost, long life, aqueous sodium ion electrolyte

Flywheels: Amber Kinetics

Low cost bulk energy storage; 50kW, 50kWhr

Iron Chromium Redox: Enervault

PV Smoothing and peakshifting; 250kW, 1 MWhr

Low cost Li-Ion: Seeo

Nanostructured polymer electrolyte

Compressed Air Energy Storage

Hydraulic pump and motor; 1MW

ARRA - Enervault: 250kW/4hr Fe-Cr Flow Battery for PV

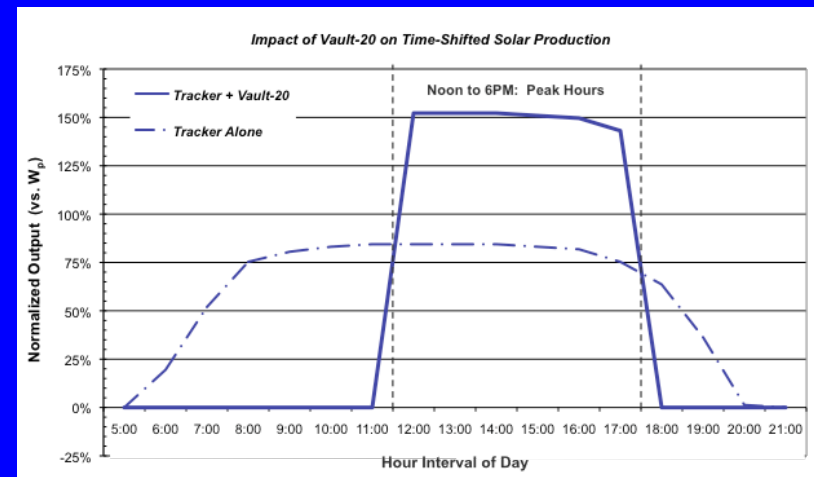
PV: 300 kW
Storage: 250 KW
Peak output: 450kW
Storage Cost: +16%
Storage Value: +84%



Tracking PV in Almond Grove



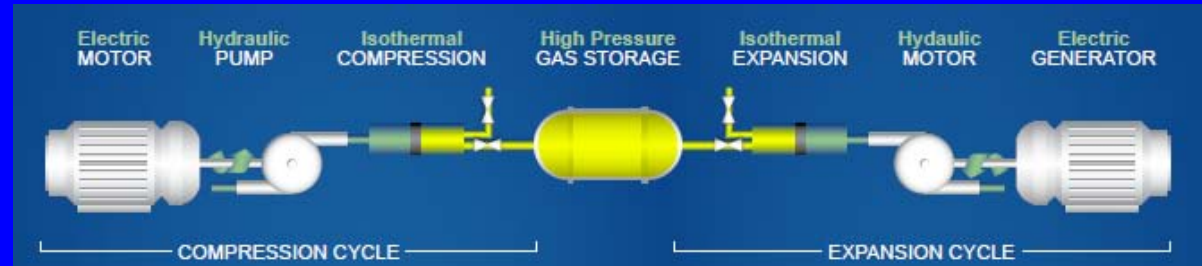
Flow Battery Prototype



Leveraging PV with Storage

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.

DOE Energy Storage Program

Aggressively Furthers

Market Pull and Technology Push:

Demonstrations and Research

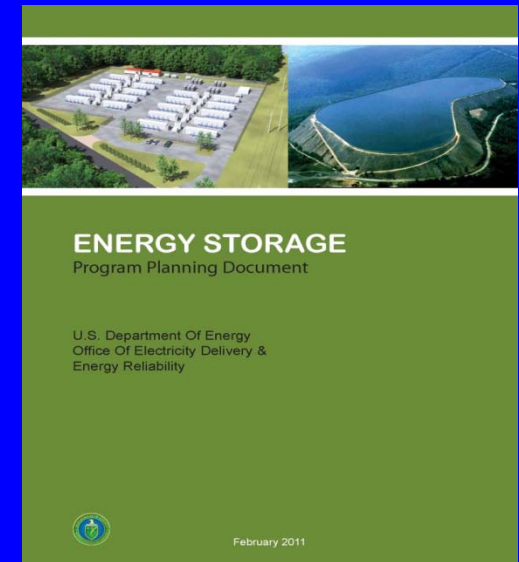
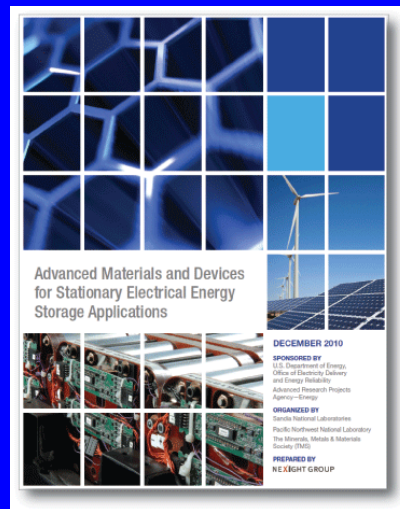
Stakeholder Workshops and OE Program Plan



Utility Requirements
With EERE-PV

*Under the Auspices
of the Materials Society*

Material Needs
With ARPA-E



OE Energy Storage Program Plan

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

EESAT, Oct. 16-19, San Diego

