Progress in Electrical Energy Storage

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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

Transmission

links Generation and Consumer in Space

Storage

links Generation and Consumer in Time

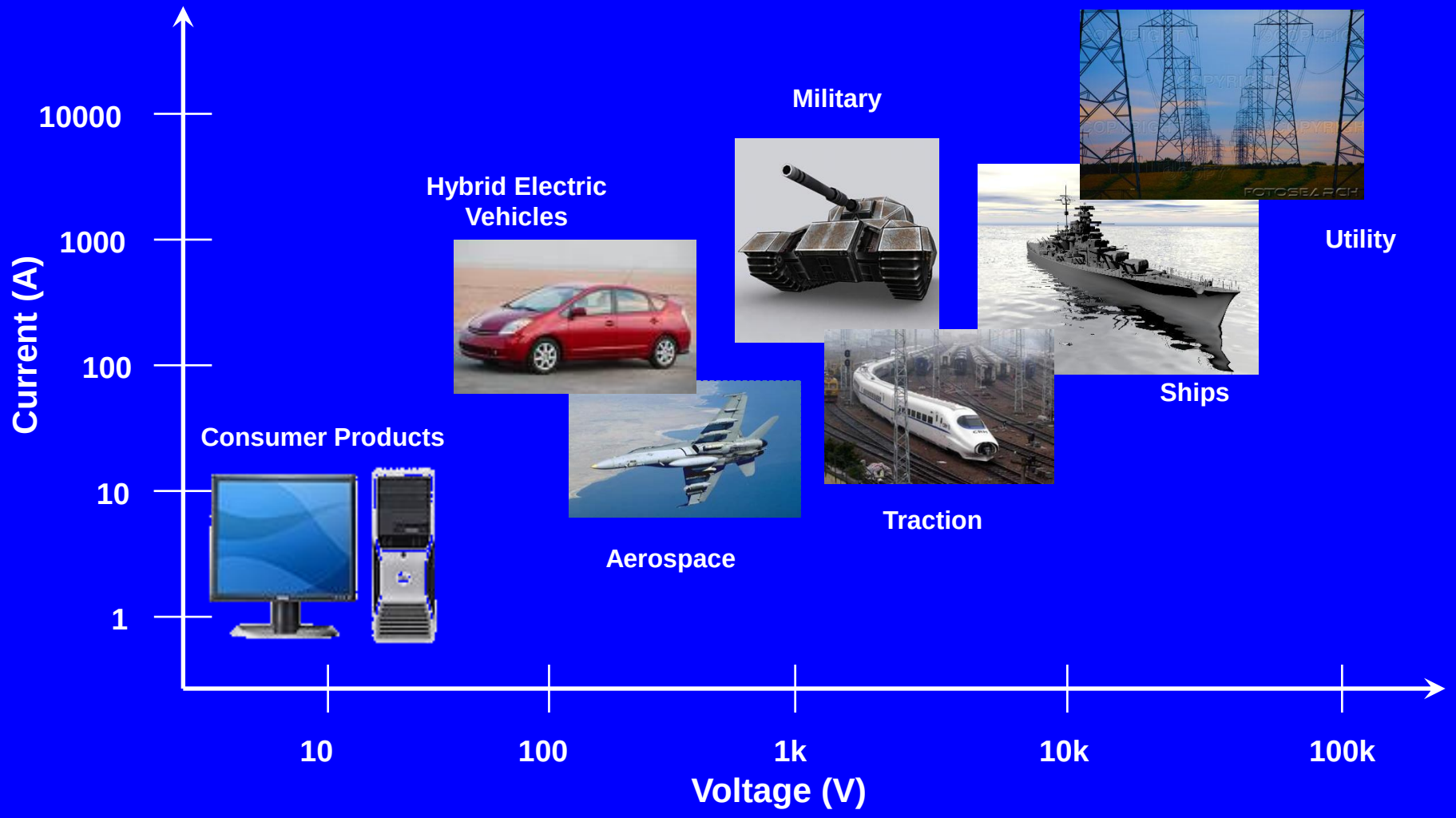
Load and Generation must be balanced on the Grid. Traditionally, Generation was Controlled while the Load was variable.

With Increasing Renewable Penetration Generation has also become variable.

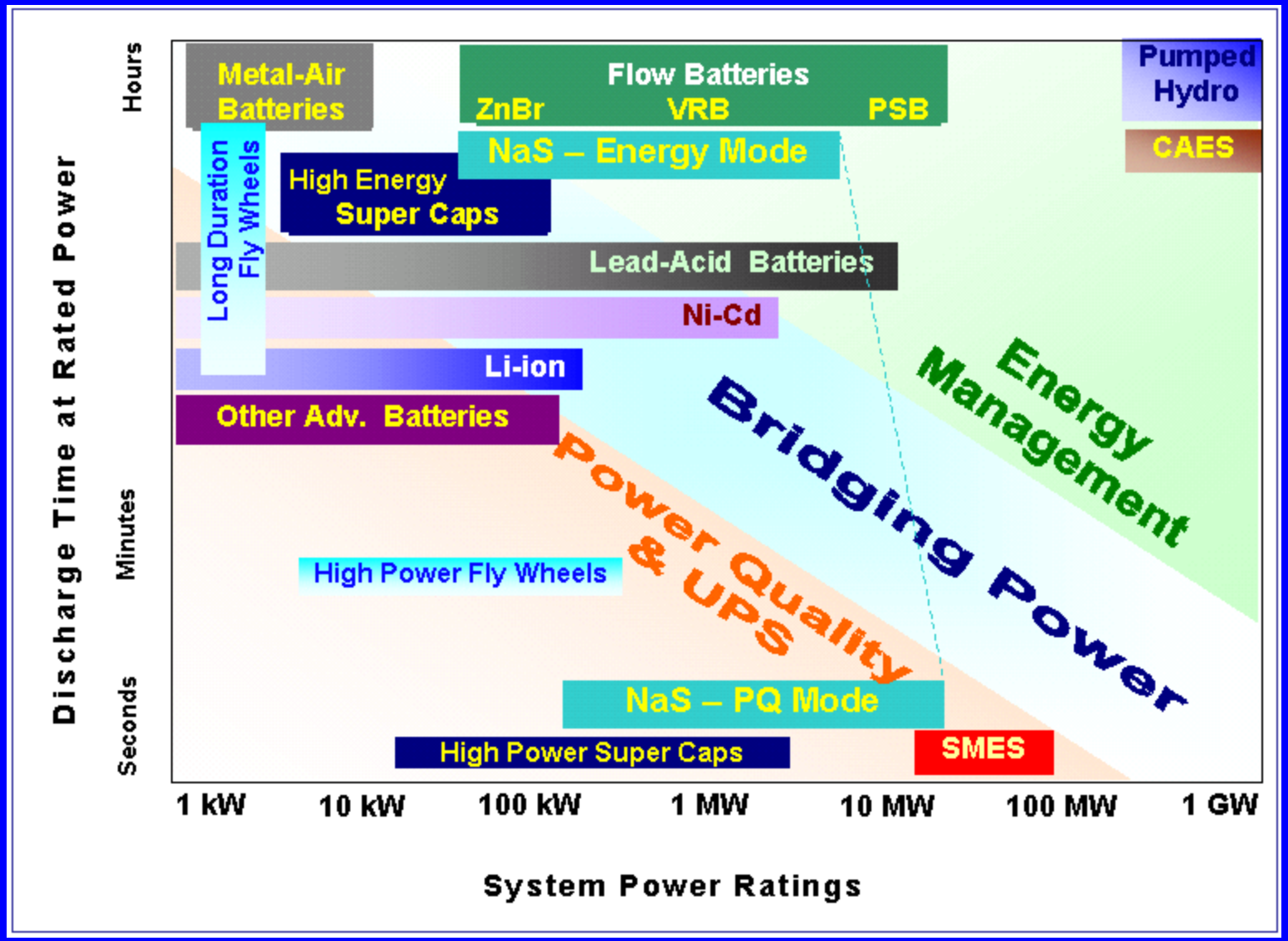
Penetration of Electric Vehicle use inserts a new, and as yet unknown variable

Storage offers a Buffer on all Levels of the Grid

Scales of Power



Storage Technologies and Regimes of Application



A. Nourai

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

A ten-fold Increase in Power Scale!

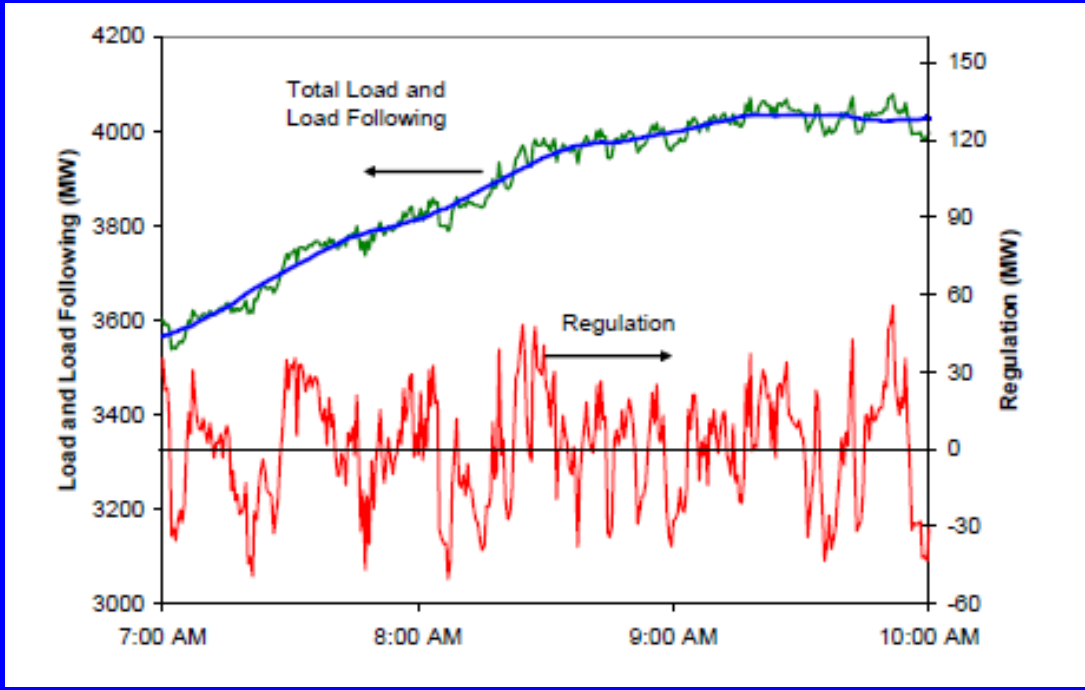
Large Battery System (3 projects,53MW)
Compressed Air (2 projects, 450MW)
Frequency Regulation (20MW)
Distributed Projects (5 projects,9MW)
Technology Development (5 projects)

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!

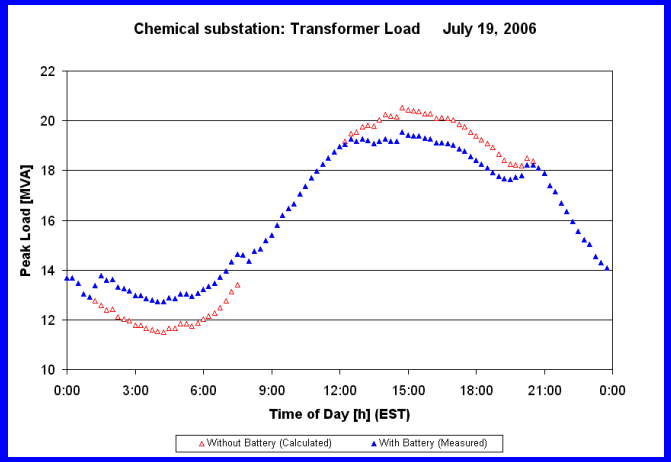
DOE Loan Guarantee – AES / A123:
20MW Lithium Ion Battery for Frequency Regulation in NY-ISO
8MW on Line!

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

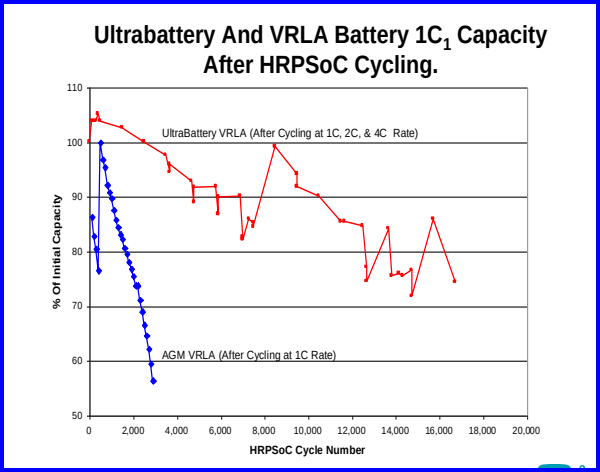
Smoothing of 500MW PV installation; 500kW, 2.5MWh

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



Testing at Sandia

Battery Stacks

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

5 Distributed Projects = 9MW in Stimulus Package

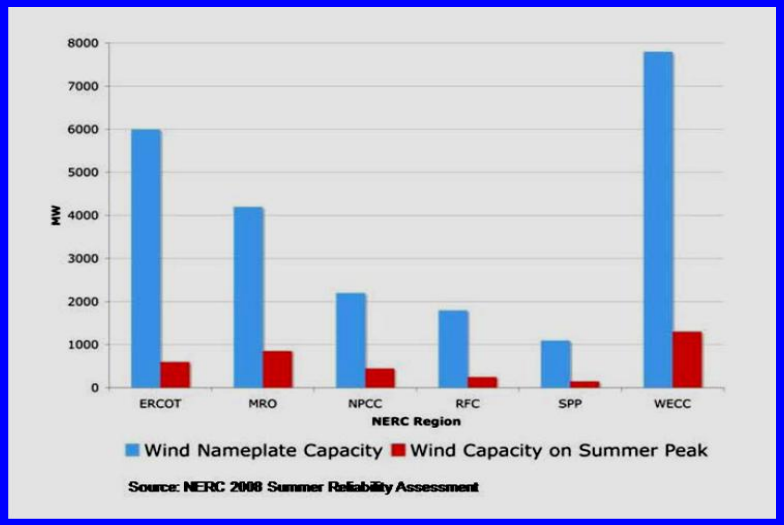
RENEWABLES DISPATCH

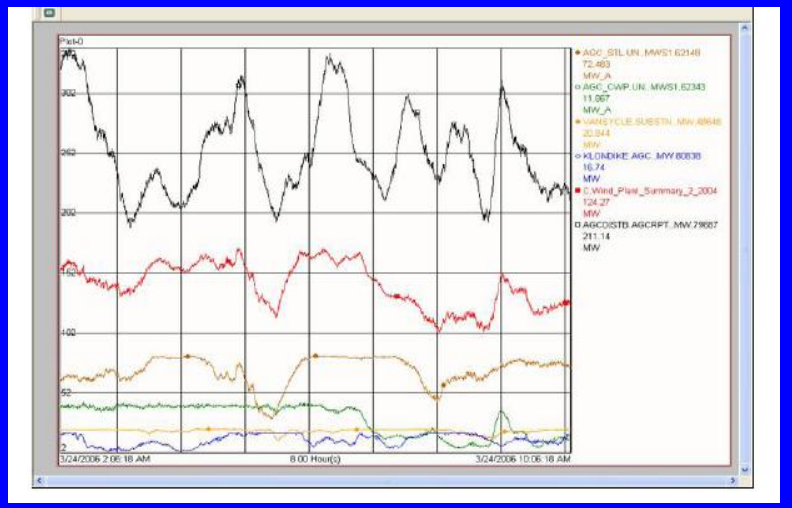
SMOOTHING, RAMPING,

and PEAK SHIFTING

increasingly considered

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

Huntdorf, Germany, 290 MW

ARRA - NYSEG:

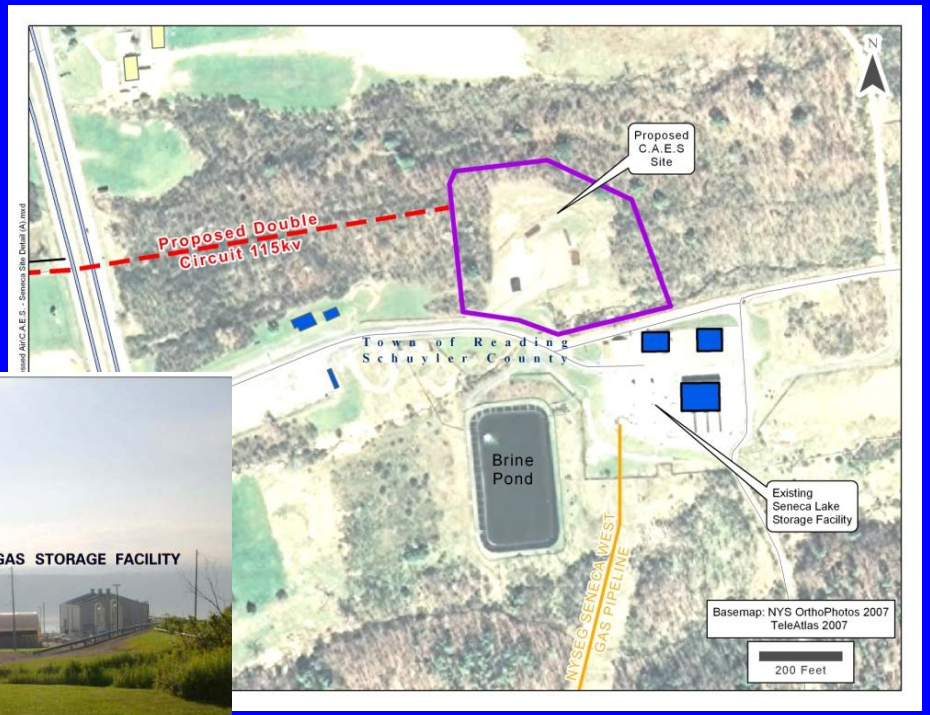
180 MW / 10hr Compressed Air Energy Storage Facility in Watkins Glen, NY

Layered Salt formation

Gas Pipe Line

Transmission Line

Installed Wind Generation



2 CAES Projects = 450MW in Stimulus Package!

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

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

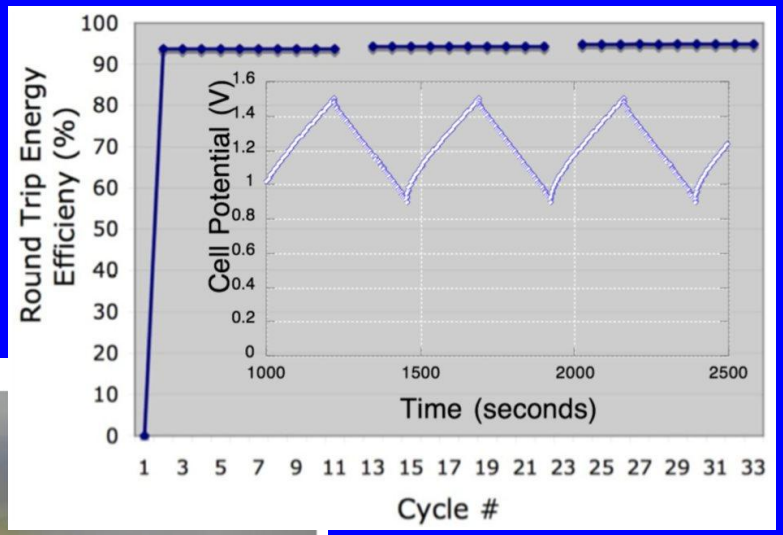
Nanostructured polymer electrolyte

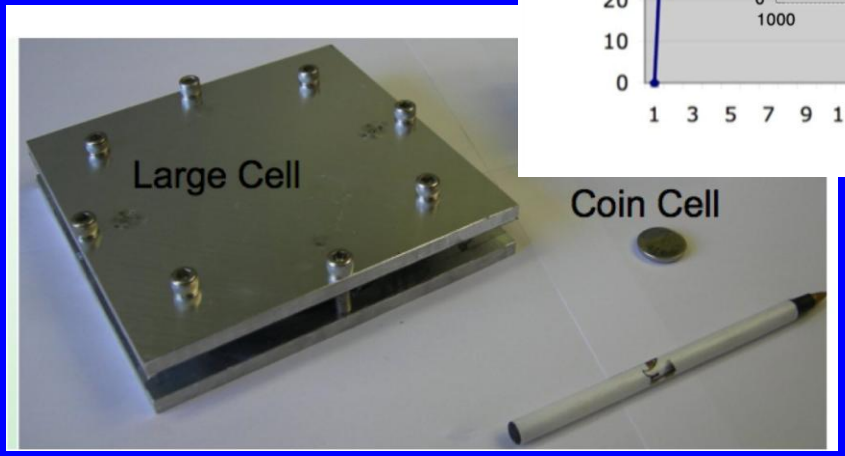
Compressed Air Energy Storage

Hydraulic pump and motor; 1MW

ARRA - Aquion Energy:
Aqueous Sodium Ion Battery

- Cost Goal: <$200/kWh
- Lifetime cost: <$0.10/kWh
- Ubiquitous, low cost precursors
- Inexpensive manufacture
- Roundtrip Efficiency >85%
- 5000 cycles demonstrated





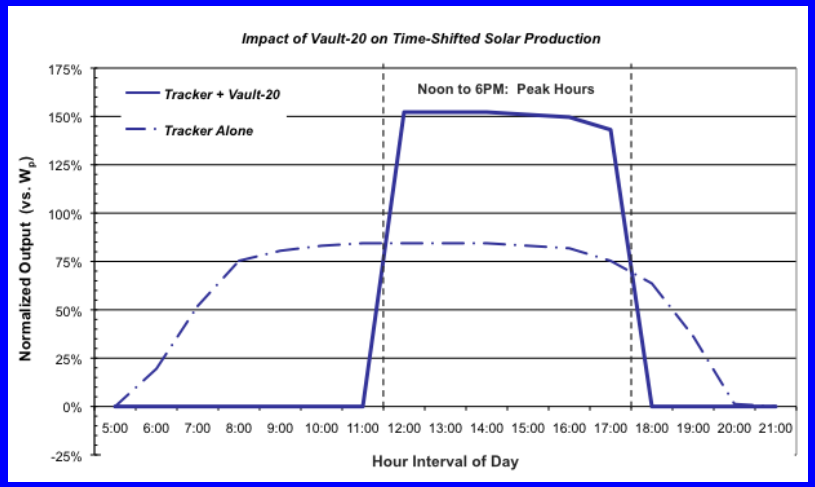
ARRA - Enervault:

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

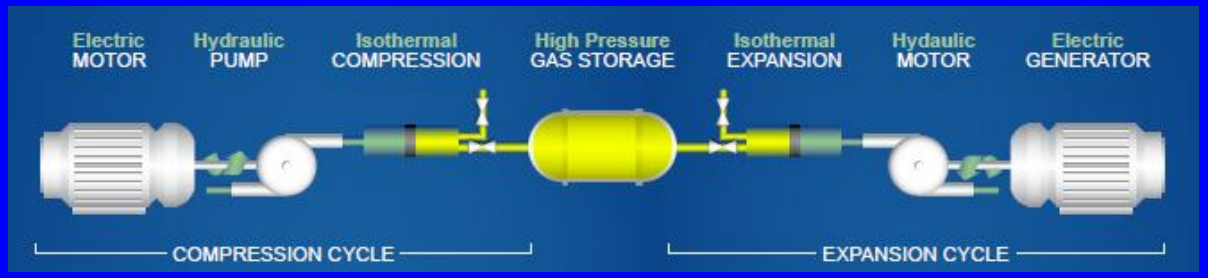
Flow Battery Prototype



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.

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, CA