

# Grid Energy Storage

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## DOE Update

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IMRE GYUK, PROGRAM MANAGER  
ENERGY STORAGE RESEARCH, DOE

Energy Storage provides Energy

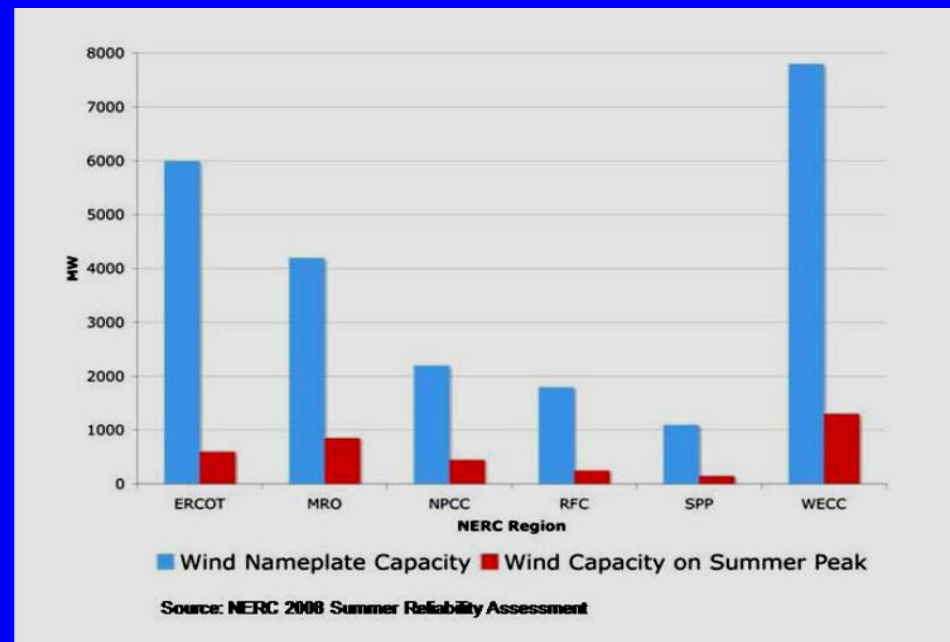
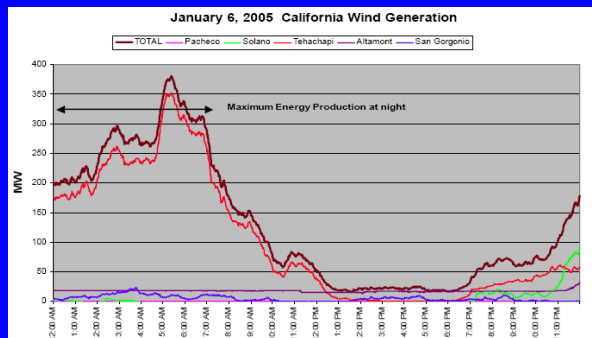
**when** it is needed

just as Transmission provides Energy

**where** it is needed

# 29 U.S. States have Renewable Portfolio Standards (RPS) Requiring 10-40% Renewables

## On Peak Wind - the Reality!



Cost effective Energy Storage yields better Asset Utilization

# Policy Decisions are as important as Technological Progress!

FERC 755: Pay for Performance

California AB2514: PUC to Develop Targets

CA PUC Order: Deploy 50MW Storage!

CA PUC Proposal: 1,325MW by 2020!!

Wyden Bill: 20-30% Investment Tax Credit

## Regulatory Policy will co-evolve with Technology and Deployment

# Energy Storage is becoming a Reality!

## Some Large Storage Projects

27MW / 7MWh	2003	Fairbanks, AL
34MW / 245MWh	2008	Rokkasho, Japan
20MW / 5MWh	2011	Stephentown, NY
32MW / 8MWh	2011	Laurel Mountain, WV
14MW / 63 MWh	2011	Hebei, China
36MW / 24MWh	2012	No Trees, TX
8MW / 32MWh	2014	Tehachapi, CA
25MW / 75MWh	2014	Modesto, CA

## Worldwide (CNESA)

2011 May	370 MW
2011 Aug.	455 MW
2011 Nov.	545 MW
2012 Feb.	580 MW
2012 June	605 MW
2013 Jan.	670 MW
2013 May	690 MW



Beacon Flywheels



AES / A123 - Laurel Mountain



PNL - EastPenn - Ecoult

# **ARRA Stimulus Funding for Storage Demonstration Projects**

Leveraged Funding: \$185M vs. \$585M

4 of 16 Projects completed

+ 7 Smart Grid Projects with Storage

- Show technical feasibility
- Gather cost data
- Stimulate regulatory changes
- Generate follow-on projects

# ARRA – Duke Energy / Xtreme Power

36MW / 40 min battery plant – Remote Operation  
Ramp control, Smoothing, Frequency Regulation  
Linked to 153MW Wind farm at No-Trees, TX

Ribbon Cutting  
March 28, 2013

► ERCOT Pilot

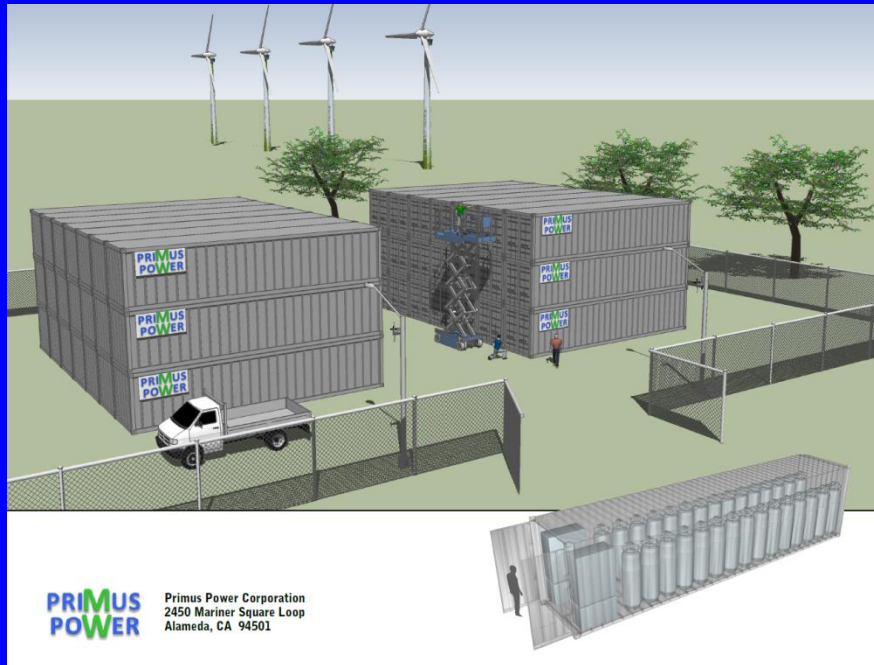


Clean Tech 100 in 2010 / 11

ESNA Best Projects 2013

## ARRA- Primus Power:

25MW / 3hr battery plant for the Modesto, CA Irrigation District,  
Providing equivalent flex capacity of a 50MW - \$73M gas turbine



	Gas Turb	Storage
Cap Cost:	\$75M	\$50M
Ramp:	300 sec	5 sec
CO <sub>2</sub>	66k met. tons	0
Area:	1 acre	¼ acre



2012- 50 Hottest Tech Startups  
2011-GoingGreen Global 200



EnergyPod 250kW / 1MWh

Power Box



# Primus Power / Raytheon

Marine Corps Air Station

Miramar, CA

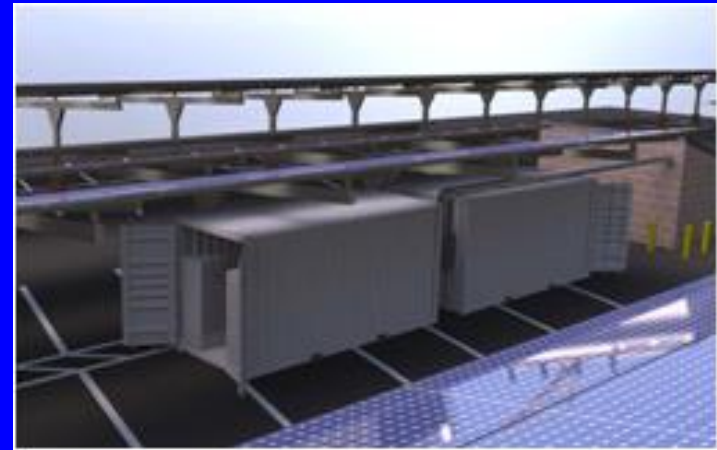
An ESTCP Project

250kW- 4hr EnergyPod™ (ZnBr) for 230kW PV with micro-grid capability. Completion 2014

Mission critical backup power  
Islanding and Peak Shaving capability

**Miramar lost power in September 2011 Great Southwest Blackout**

- Training missions cancelled
- Planes grounded
- 25% of diesel generators had trouble starting



Battery system developed under ARRA

# FREQUENCY REGULATION



DOE Loan Guarantee – Beacon:  
20MW Flywheel Storage for  
Frequency Regulation in NY-ISO  
Commissioned July 2011  
240,000 MWh of FreqReg delivered!



ARRA Project – Beacon  
Hazleton, PA.  
20MW Frequency Regulation for PJM.  
Groundbreaking June 21, 2013

► FERC: PAY FOR PERFORMANCE!

Frequency Regulation using  
Energy Storage is now  
a Commercially viable Business  
in FERC compliant Regions!

# Key Outcomes of 2012 PNNL Study

- For every 10 MW of extra wind capacity approximately 0.8 – 1.5 MW of intra-hour balancing (minute-to-minute variability) need to be added.

Intra-hour balancing power requirements caused by wind variability in WECC area		
20% wind in WECC	Required MW Storage	Percentage of Installed Wind Capacity
AZ-NM-SNV	174.08	12.8
CA-MX	943.65	14.4
NWPP	1,071.26	11.0
RMPA	504.89	8.0

## 2 ARRA Projects using EastPenn Ultra-Batteries



### Public Service NM:

500kW, 2.5MWh for smoothing of  
500kW PV installation;

Commissioned Sep. 2011

### EastPenn, PA

3MW Frequency Reg.  
1MW 1-4hrs Load Management  
during Peak Periods

Commissioned June 2012

Over 700,000 kWh of regulation  
Services delivered to PJM !



Integrator: Ecoult



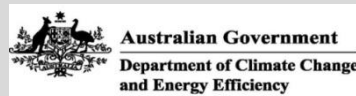
# Hydro Tasmania to install Australia's largest battery on King Island

Installation: Q4 2013

3MW / 1.6MWh

EastPenn Ultrabattery

for renewable integration and a totally green Island!



**EAST PENN**  
manufacturing co., inc.



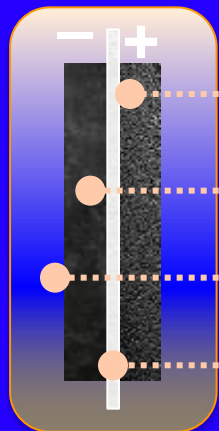
**Deku unigy**  
**UltraBattery**



Integrator: Ecoult

# ARRA – Aquion Energy: Aqueous Hybrid Ion (AHI) Battery

Safe, Reliable, Sustainable, Cost Effective



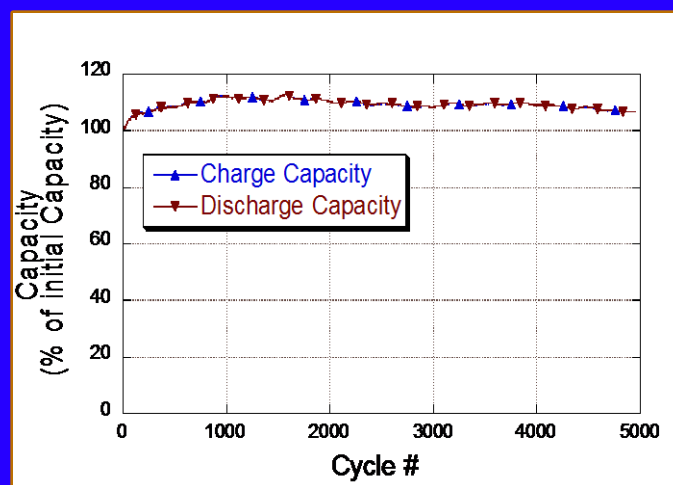
Cathode: Manganese Oxide

Anode: Carbon composite

Electrolyte: Aqueous solution

Separator: Cellulosic material

- Above 85% round trip efficiency
- 5,000+ cycles demonstrated – up to 50°C
- Targeted pricing at scale : <\$250/kWh
- Simple/inexpensive manufacturing
- High volume manufacturing Q4/2013
- ▶ DOE ARRA \$5 M – VC \$75 M
- ▶ Over 120 employees and growing!



Winner, 2011  
World Technology Award

# ARRA - SustainX:

Development of a Totally Green Isothermal  
Compressed Air Energy Storage System Using Hydraulics



1.5MW Engine in place

Isothermal efficiency of 94.9% achieved  
compared to 54% for adiabatic process.



3000PSI 1MWh Storage tanks

Installation: Aug. 2013  
Commission: Dec. 2013

GE Ecomagination Award  
2010/11/12 Global Cleantech

► Coming ventures in  
China, Japan, Korea ?



# Re-Purposed Vehicle Battery Research at ORNL



Factory Acceptance Test at ABB Facility Orlando, FL

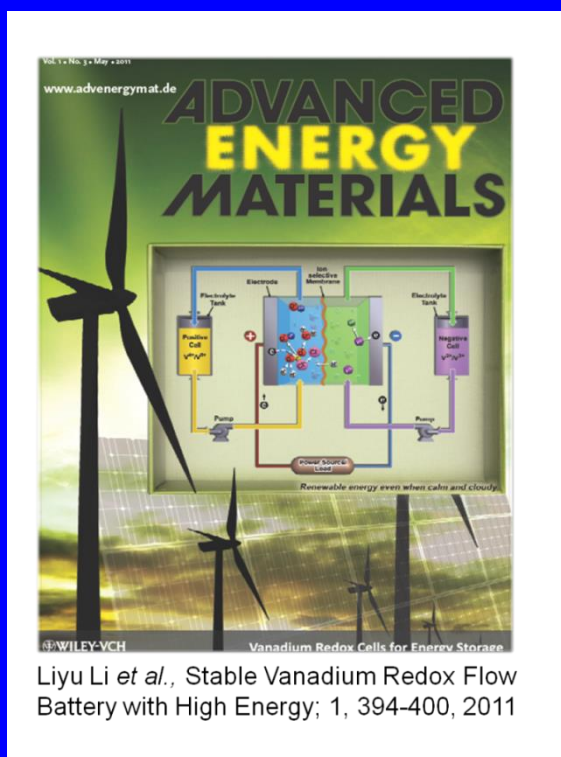
5 GM Chevy-Volt LiMn batteries in 15 strings  
forming a 25kW – 50kWh Storage System

**Energized April 12, 2013**

To be tested in residential load simulation

# Materials Research at PNNL and Sandia

## Mixed Acid Electrolyte (2x Energy density)



PNNL, Nov. 2011

- ▶ Cost
- ▶ Cycle Life
- ▶ Energy Density
- ▶ SAFETY!

2012 Federal Laboratory  
Consortium Award for  
Technology Transfer

**UET** UniEnergy  
Technologies

# SNL Energy Storage System Analysis Laboratory

*Reliable, independent, third party testing and verification of advanced energy technologies from cell to MW scale systems*



Redflow at DETL



Energy Storage Test Pad (ESTP)



Milspray Deka Battery under testing

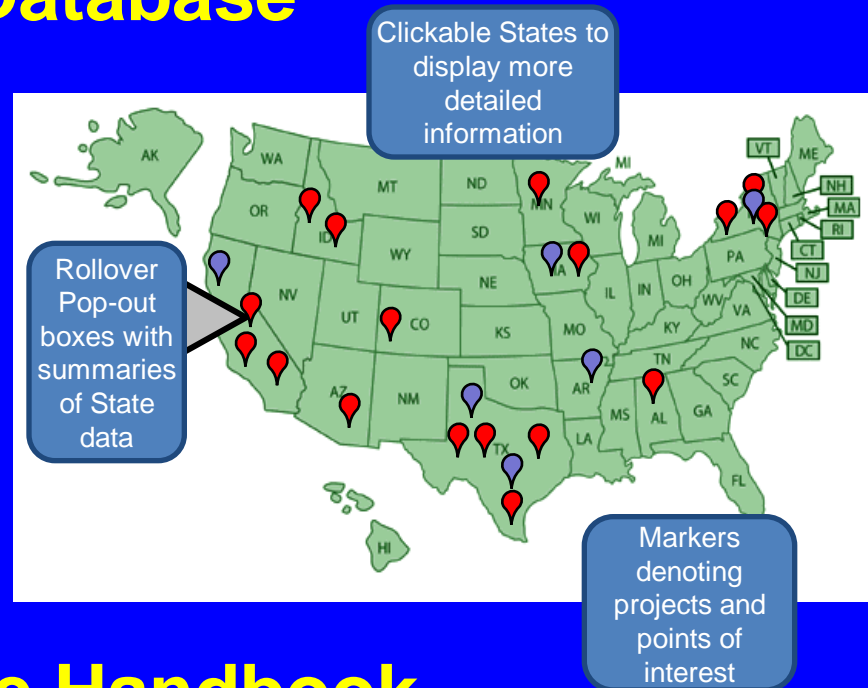
## System Testing

- Scalable from 5 KW to 1 MW, 480 VAC, 3 phase, Both power and energy use tests.
- 1 MW/1 MVAR load bank for either parallel microgrid, or series UPS operations
- Subcycle metering in feeder breakers for system identification and transient analysis
- **Safety Analysis**
- In FY13 tested 3 grid scale systems providing key information to manufacturers. Resulting in system redesigns in all cases

# Energy Storage Projects Database

A publicly accessible database of energy storage projects In the U.S. and world-wide, as well as state and federal legislation/policies. 400+ projects!

[energystorageexchange.org](http://energystorageexchange.org)



## DOE/EPRI Energy Storage Handbook

Partnership with EPRI and NRECA to develop a definitive energy storage handbook: Details the current state of commercially available energy storage technologies. Matches applications to technologies. Info on sizing, siting, interconnection. Includes cost database. Released July '13

[sandia.gov/ess/publications/SAND2013-5131.pdf](http://sandia.gov/ess/publications/SAND2013-5131.pdf)

## **Development of a Protocol to Measure and Report Performance of Energy Storage Technology**

An application specific Protocol providing a uniform way of measuring, quantifying and reporting the performance of EES systems in various applications. Developed by a Working Group of over 100 members. Released Oct. 2012 Basis for new IEEE standard and DoD FOB standard

[pnl.gov/main/publications/external/technical\\_reports/PNNL-22010.pdf](http://pnl.gov/main/publications/external/technical_reports/PNNL-22010.pdf)

## **Evaluating Utility Procured Electric Energy Storage: A Perspective for State Electric Utility Regulators**

A Handbook to provide state utility regulators with an understanding of energy storage systems as a grid asset. Includes a review of many PUC active and closed dockets. Released Nov. 2012

[sandia.gov/ess/publications/SAND2012-9422.pdf](http://sandia.gov/ess/publications/SAND2012-9422.pdf)

## **Regular Workshops with CESA on Storage Topics**

[cleanenergystates.org/events/](http://cleanenergystates.org/events/)

# Energy Storage provides Resiliency to the Grid!

*renewable integration – rooftop PV – military micro grids – VARs  
emergency preparedness – island grids – EV charging – G2V –  
dispatchable solar farms - frequency regulation - etc. etc.*