Emerging Storage Technologies, (PNNL, SNL, ORNL)

**Non-Aqueous Flow Batteries** (e.g. ferrocene, alkylamines)
- Higher operating voltage than aqueous (no H₂O electrolysis) enables higher energy density flow systems
- Low electrolyte conductivity diminishes power capability

**Na-ion**
- Both aqueous and organic (Li-ion analog) electrolytes offer potential for lower cost materials systems.
- Limited by suitable high capacity, low degradation anode materials.

**Mg-Ion**
- Divalent ion increases theoretical energy density; Mg metal anode with low potential for dendrite formation.
- Low capacity cathode materials and electrolyte/cathode materials.

**Li-S**
- High energy density (2X Li-ion)
- Safety and long term operation of Li metal anode, long term stability of cathode.

**Solid State Li-ion**
- Replacement of flammable Li-ion electrolyte improves safety.
- Poor electrolyte conductivity limits power, additional manufacturing step for electrolyte.
DOE-ARRA Storage Installations:

- **2011, NM:** 500kW, 2.5MWh with PV
- **2013, TX:** 36MW with Wind
- **2014, CA:** 250kW for Peak Shaving
- **2014, PA:** 20MW for Frequency Regulation
ARRA - Southern California Edison / LG Chem – Li-Ion:
8 MW / 4 hr battery plant for wind integration at Tehachapi, CA.

Tehachapi: 4,500MW Wind by 2015!

Construction of Facility and Commissioned: Sept. 2014
Integrator: ABB

8MW / 32MWh Storage Plant
States are beginning to provide Incentives for Storage

California: 1.3GW Mandate
Hawaii: 200MW Storage Solicitation
New York: 2100$/kW at Peak

The DOE State Initiative for Storage will partner with the States to develop effective local Projects for Grid Energy Storage
Vermont Public Service Dept. – DOE
Green Mountain Power

Solicitation issued by VPS. Joint funding by VPS, DOE-OE, GMP

GMP: Rutland, VT
4MW / 3.4MWh of storage
Integrated with 2MW PV
Integrator: Dynapower

Groundbreaking: Aug. 12, 2014

Situated on Brown Field Area

Ancillary grid services, peak shaving during high load periods

System can be islanded to provide emergency power for a resilient microgrid serving a highschool/emergency center.
Washington State Clean Energy Fund:  
Solicitation for $15M for Utility Energy Storage Projects  

Selected Projects with UET V/V technology:  
- Snohomish PUD (2MW / 6.4MWh) – PNNL -- U of WA  
- Avista (1MW / 3.2MWh) – PNNL -- 1 Energy -- WA State  

UET V/V technology was developed at PNNL with DOE-OE funding  

PNNL will participate in these Projects with benefit optimization studies.
Oregon State Initiative:

Energy Storage Workshop, March 22, 2014, Portland
Organized by DOE-OR, OR-PUC, and DOE-OE

Energy Storage Pilot Projects Request for Comments, July 2014 by DOE-OR in collaboration with DOE-OE

RFP by DOE-OR in preparation
Grid Energy Storage Safety Initiative

DOE identified *Validated Safety* as a critical need for the success of grid energy storage.

The ability to validate the safety of energy storage systems will:

- Decrease human and financial risk,
- Minimize installations costs,
- Accelerate acceptance of new storage technologies.

To address this need DOE is engaging key energy storage stakeholders:

- DOE OE Energy Storage Safety Workshop, February 2014
- DOE OE Webinar on Energy Storage Safety, April 2014
- DOE OE Safety Panel – ESA annual meeting and conference, June 2014
The OE Energy Storage Program aims at a wide Portfolio of Technologies and a broad Spectrum of Applications. Storage will contribute to a safer, greener, and more resilient Grid.