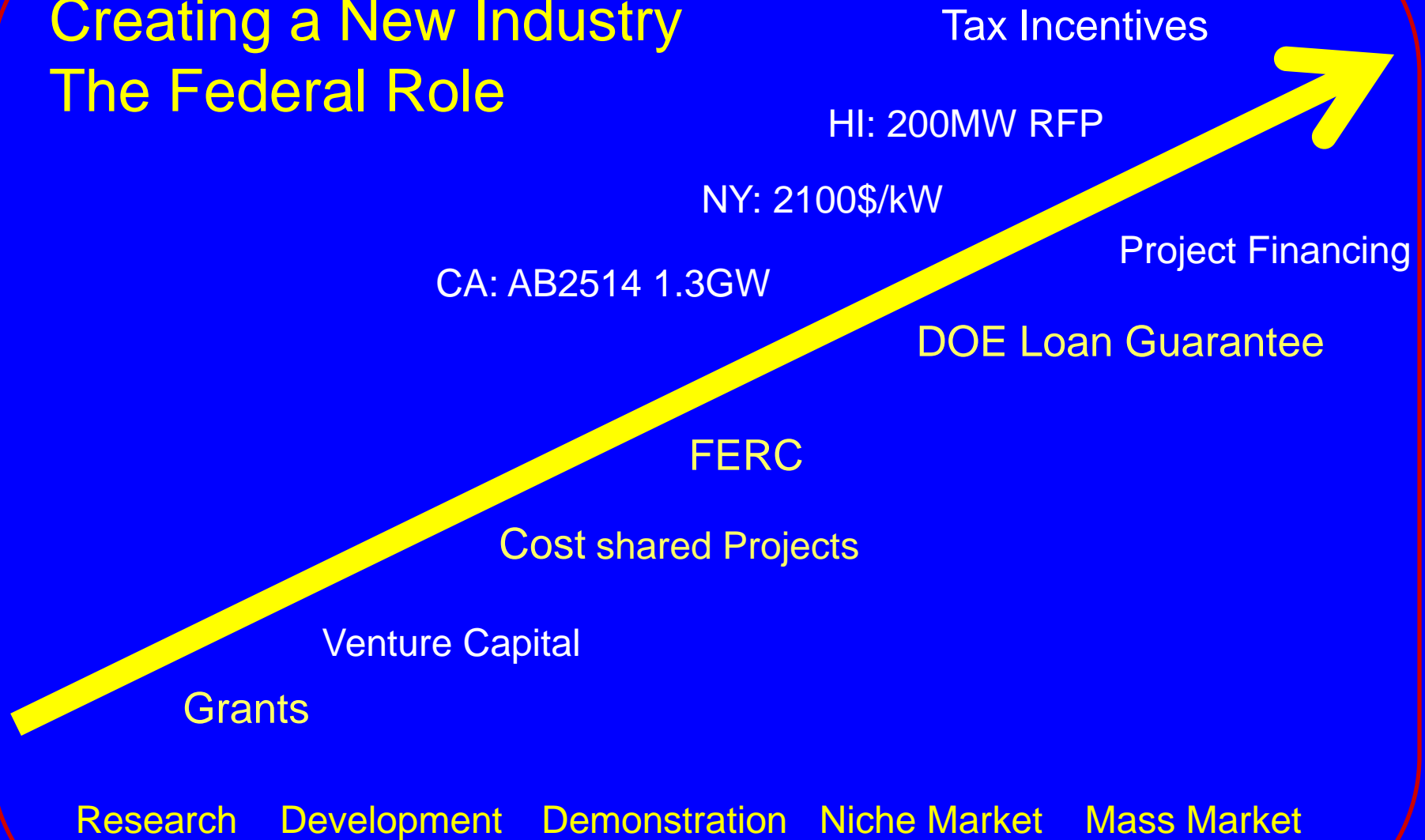


DOE Energy Storage: Projects, State Initiatives, and Evaluation Tools

**IMRE GYUK, PROGRAM MANAGER
ENERGY STORAGE RESEARCH, DOE**

Creating a New Industry

The Federal Role



ARRA Stimulus Funding for Storage Demonstration Projects

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

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

Power Systems for Frequency Regulation or Renewable Smoothing



ARRA Project – Beacon

Hazleton, PA.

20MW Frequency Regulation for PJM.

Commissioning of full 20MW Aug. 2014

- This project provided the basis for FERC to establish “PAY FOR PERFORMANCE”!



ARRA – Duke Energy / Younicos

With 153MW Wind at No-Trees, TX

36MW / 40 min battery plant

Smoothing, Frequency Regulation

Energy Systems for Peakshaving, Loadshifting, or Ramping

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!

Commissioned: Sept. 2014
Integrator: ABB



8MW / 32MWh Storage Plant

ARRA - Primus Power

25 MW • 4 hour ZnBr battery plant for the Modesto Irrigation District in CA,
Providing equivalent flex capacity of a 50 MW • \$73M natural gas engine set

	Gas turbine	Storage
Capital cost	\$73M	\$50M
Ramp	300 sec	1 sec
CO ₂	66k metric tons	0
Area	1 acre	¼ acre



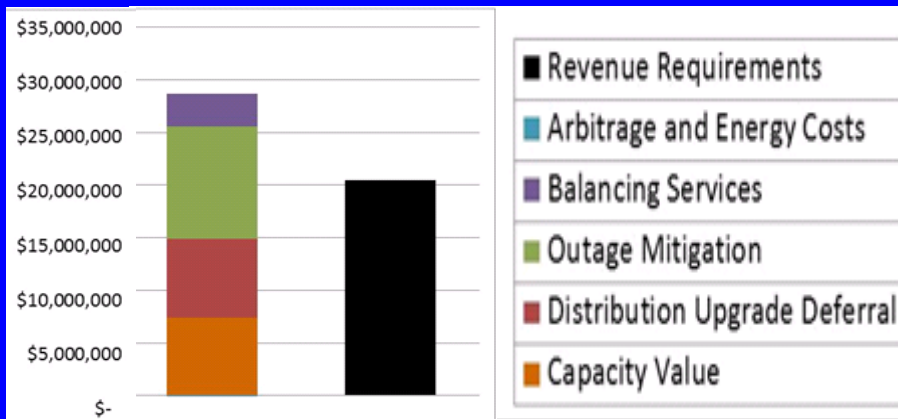
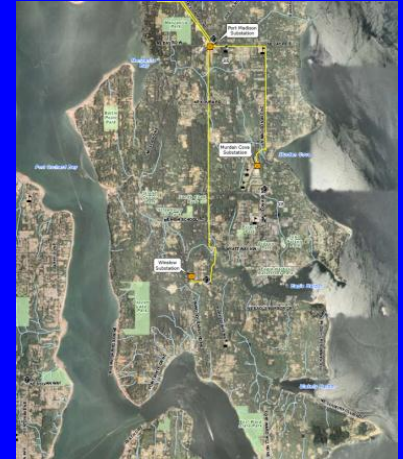
2012- 50 Hottest Tech Startups
2011-GoingGreen Global 200



BPA / DOE / Puget Sound Grid Project:

PNNL Analysis Program selects cost-effective site and scale to optimize Value Stream

Primus Power, developed under ARRA funding to install 500kW / 2hr ZnBr Flow Battery

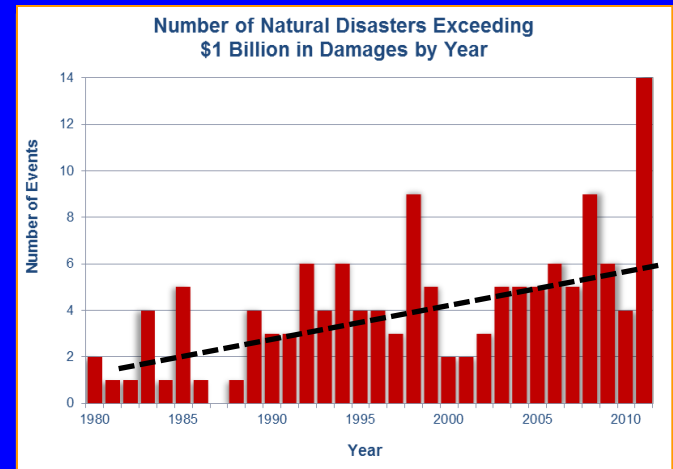
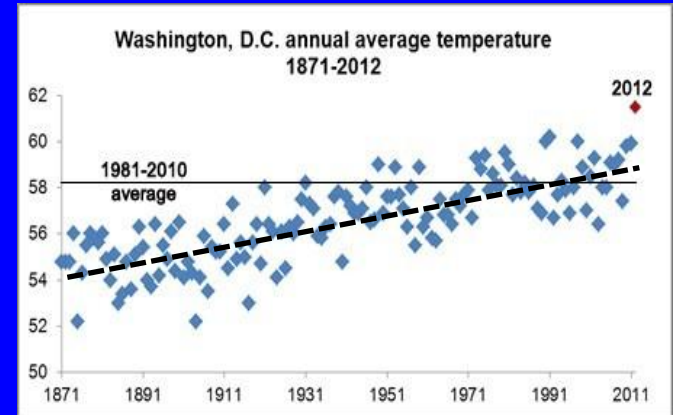


Energy Systems for Resiliency and Emergency Preparedness

DOE / State Initiatives

Energy Storage for Emergency Preparedness

Every \$1 on protection measurements
Can prevent \$4 in repairs after a storm!



Trends indicate the situation
will get worse not better!!

➡ Some 50% of Diesel Generators failed to start during the Sandy Emergency

Storage combined with Renewables allows Microgrids to provide essential Services over an extended Time Period

During non-emergency Periods Storage can provide Demand Management for the User and compensated Services to the Grid

Apartment Buildings – Campuses – Schools – Shopping Centers – Community Centers – Nursing Homes – Hospitals – Police Stations – Gas Stations – etc. etc

Vermont Public Service Dept. – DOE Green Mountain Power

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

Rutland, VT

4MW / 3.4MWh of storage

Integrated with 2MW PV

Integrator: Dynapower

Groundbreaking: Aug. 12, 2014

Expected Completion: April 2015

Situated on Brown Field Area

Storage: 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 vanadium flow battery:

- Avista (1MW / 4MWh) -- PNNL -- WA State U
- Snohomish (2MW / 8MWh) – PNNL -- 1Energy -- U of WA

Avista Commissioning May 2015

Under a DOE / WA MOU, PNNL will participate in both Projects, providing use case assessment and performance analysis.

Vanadium technology with 2x Energy density developed at PNNL for DOE



Hydro Tasmania, Australia's largest battery on King Island

Installed: December 2013

3MW / 1.6MWh system
for renewable integration
and a totally green Island!

EastPenn Ultrabattery System
developed for DOE-ARRA

2013 Australia National
Innovation Award

Integrator: Ecoult



Reduces Diesel >65%



California/CEC

- CA CPUC mandate of 1.3 GW of storage deployed by 2020.
- DOE Working with California Energy Commission (CEC) on multiple projects to determine cost benefit analysis and optimal usage of energy storage.
- MOU being developed with CEC
- SNL and PNNL developing analytic tools to determine value of energy storage deployments in CA, and optimize placement and size of distributed energy storage with PV
- Supported development of CA ES roadmap that identifies roadblocks to ES implementation

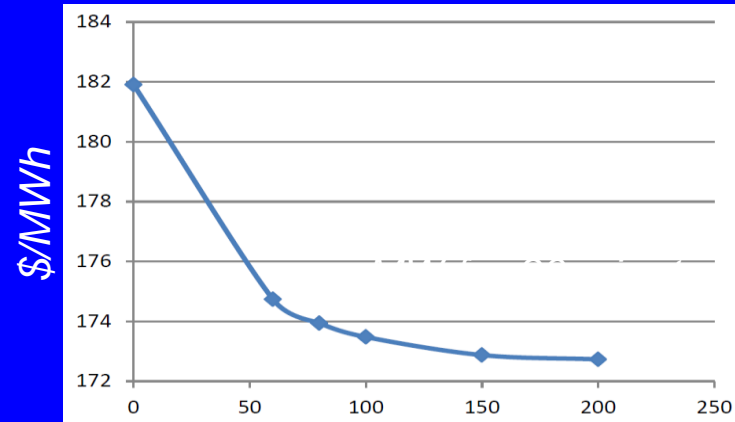


Enervault 250 kW 4-hr Irpn-Chrome Flow battery.
Turlock Ca.

- Review upcoming RFP submittals
- Continue to develop analytic tools to optimize energy storage on the CA grid
- Support development of ES protocols
- Provide evaluation & monitoring support for CEC on upcoming ES installations
- Provide technical consulting for CEC/CPUC

Hawaii Electric Company

- DOE/Sandia and Hawaii Electric Company (HECO) Collaboration to assist in the selection and analysis of 160-200MW, 30 minutes of energy Storage for renewable integration and spinning reserve.
- MOU with HECO to provide ongoing support of ES projects
- Developed the RFP review criteria for HECO and reviewed 10+ energy storage project proposals.
- Developed preliminary ES model to optimize system sizing.
- Provided technical analysis of selected battery technology, power and energy requirements, and costs for winning proposals



MW for 30 minutes (draft)

- Review construction designs
- Review technical specs
- Define commissioning requirements
- Develop Sequence of Operations
- Develop and implement control optimization methodology
- Monitor & evaluate system opera



BERMUDA

INDUSTRY TOOLS

SNL Energy Storage System Analysis Laboratory

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



GS Battery at DETL



Energy Storage Test Pad (ESTP)



Milspray Deka Battery under testing

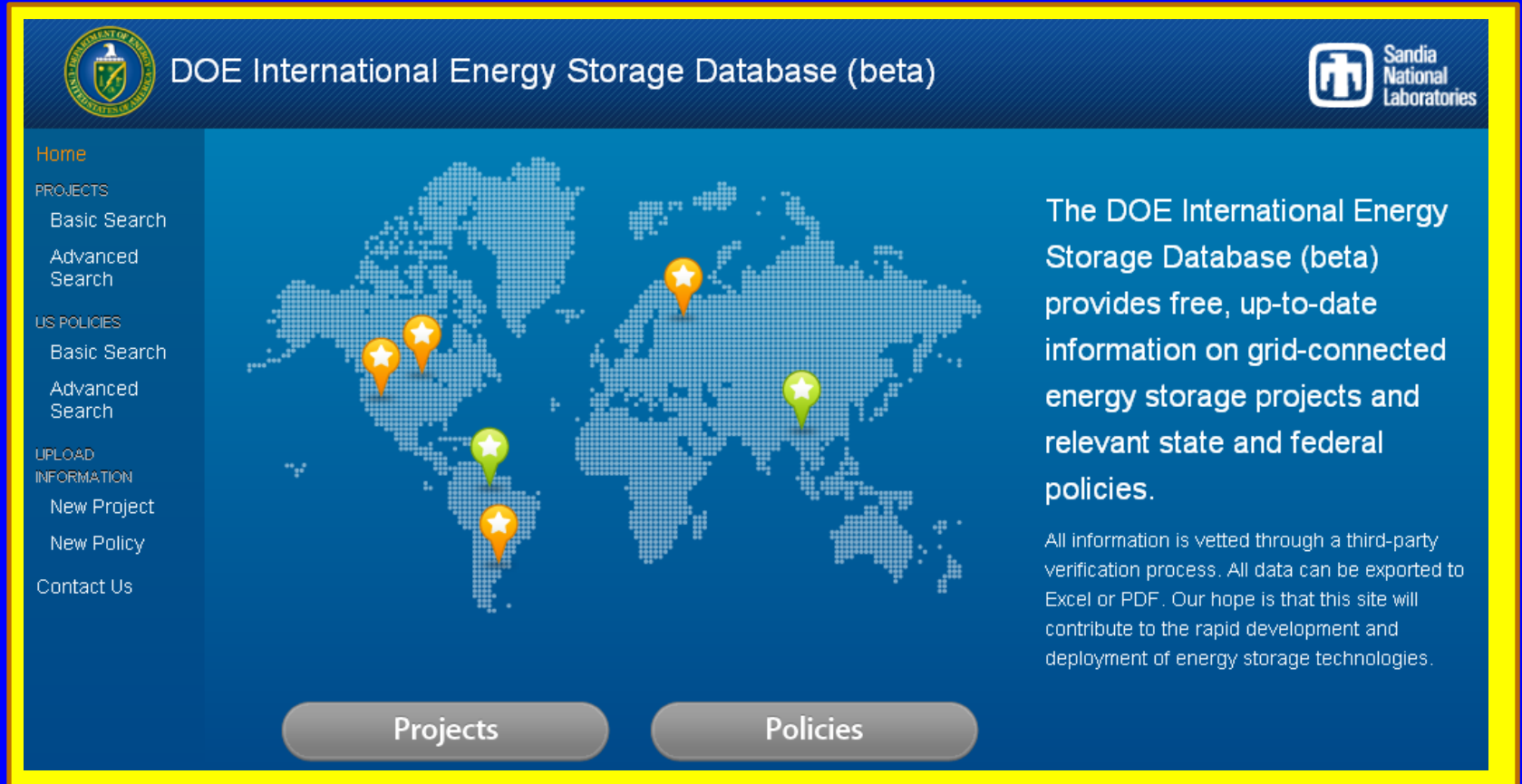
System Testing

- 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**

DOE International Energy Storage Data Base

energystorageexchange.org supported by Strategen

Over 1200 energy storage projects from 58 countries.
50 energy storage technologies are represented



The screenshot displays the DOE International Energy Storage Database (beta) website. The header features the Department of Energy logo on the left, the site title "DOE International Energy Storage Database (beta)" in the center, and the Sandia National Laboratories logo on the right. A left-hand navigation menu includes links for Home, PROJECTS (Basic Search, Advanced Search), US POLICIES (Basic Search, Advanced Search), UPLOAD INFORMATION (New Project, New Policy), and Contact Us. The main content area is divided into two sections: a world map with star markers indicating project locations in North and South America, Europe, and Asia; and a text block describing the database's purpose. At the bottom, two large buttons labeled "Projects" and "Policies" are visible.

DOE International Energy Storage Database (beta)

Sandia National Laboratories

Home

PROJECTS

- Basic Search
- Advanced Search

US POLICIES

- Basic Search
- Advanced Search

UPLOAD INFORMATION

- New Project
- New Policy

Contact Us

The DOE International Energy Storage Database (beta) provides free, up-to-date information on grid-connected energy storage projects and relevant state and federal policies.

All information is vetted through a third-party verification process. All data can be exported to Excel or PDF. Our hope is that this site will contribute to the rapid development and deployment of energy storage technologies.

Projects Policies

Grid Energy Storage Safety Initiative

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

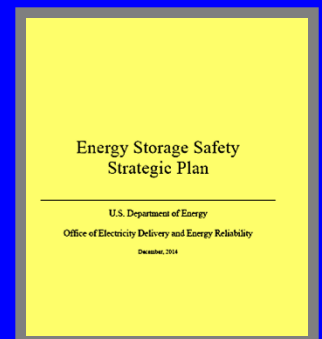
The ability to validate the safety of energy storage systems will:

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

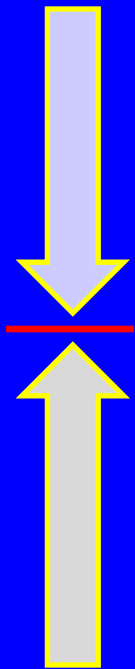


To address this need DOE is engaging key energy storage stakeholders:

- DOE OE Energy Storage Safety Workshop, February 2014
- DOE OE Publications: Inventory of Codes and Standards
- *DOE OE Strategic Energy Storage Safety Plan – December 2014*
- Initiate ES Safety Forum to coordinate safety development



Storage Economics:



The **Cost** of a Storage System depends on the Storage Device, the Power Electronics, and the Balance of Plant

The **Value** of a Storage System depends on Multiple Benefit Streams, both monetized and unmonetized

Power
Electronics
20-25%

Energy Storage
Device 25-40%

Facility 20-25%

LCOE depends on Application! Policy is important!

Energy Storage is Coming of Age!

New Cost Effective Technologies

New Benefit Streams opened

Major solicitations / Mandates in:

California (1.3 GW)

Hawaii (200 MW)

Ontario (50 MW)

Involvement of States: VT, WA, OR, MA

DOE Loan Guarantees Solicitation