Resiliency through Storage Microgrids: Recent DOE Projects with the States

IMRE GYUK, PROGRAM MANAGER
ENERGY STORAGE RESEARCH, DOE

Teaming with PNNL, SNL, ORNL:

Materials – Devices – Systems – Analysis

Focused on Commercialization !

170+ peer reviewed publications
85+ Patents, 7 R&D 100 Awards
Fed. Lab Consortium Award for Tech Transfer

Projects at major Universities

Work with Korea, Japan, Singapore, Australia

Energy Storage provides Energy

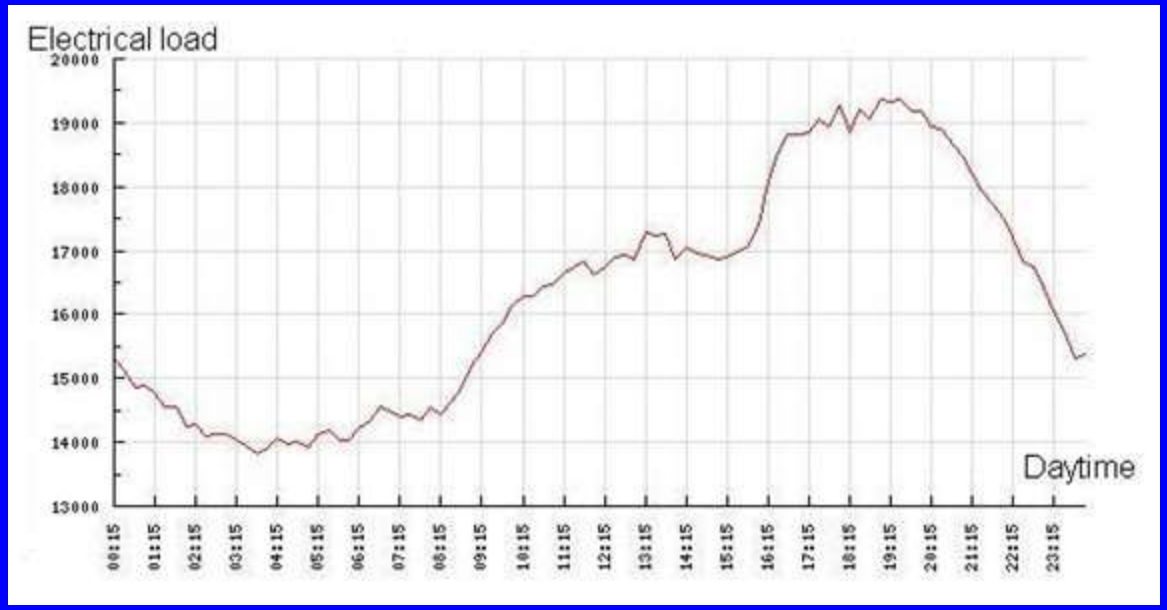
when it is needed

just as Transmission provides Energy

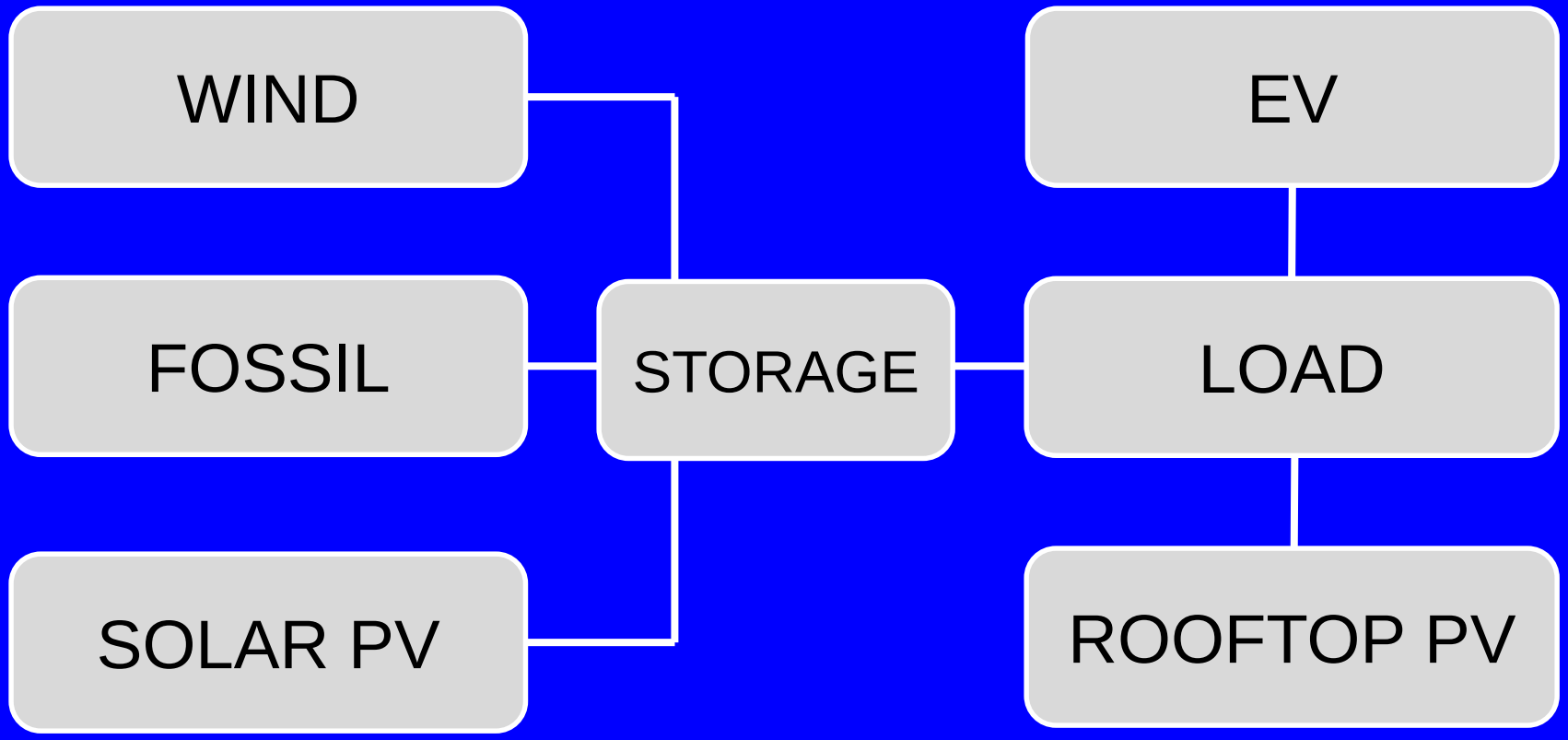
where it is needed

The deterministic grid

GENERATION — TRANSMISSION — LOAD



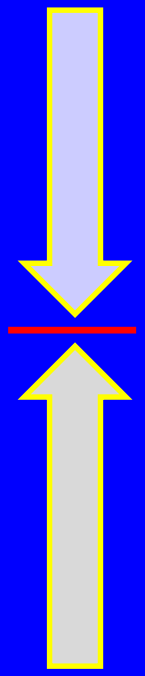
The grid has now become stochastic!



A Portfolio of Technologies:

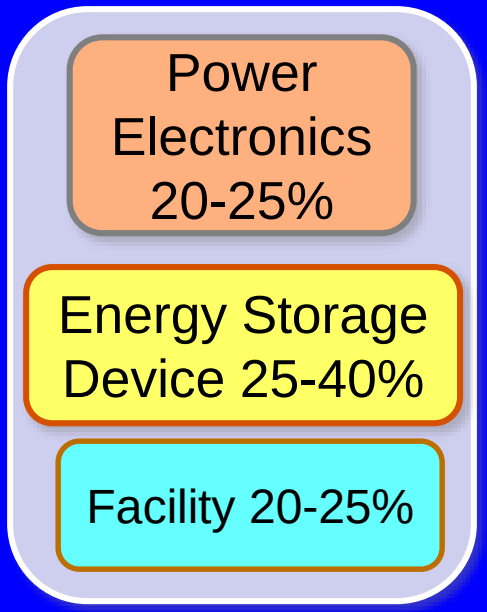
Pumped Hydro	
Compressed Air (CAES)	PG&E, Iowa
Aquifer CAES	
Advanced Isothermal	
Batteries	
NaS	AEP, PG&E
Flow batteries	
ZnBr	Primus
Vanadium Redox	UET
Lead Acid	
Lead carbon	EastPenn
Aqueous hybrid ion	Aquion
Lithium Ion	SouCalEd, AES
Flywheels – Energy	Amber
– Power	Beacon
Electrochemical Capacitors	

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



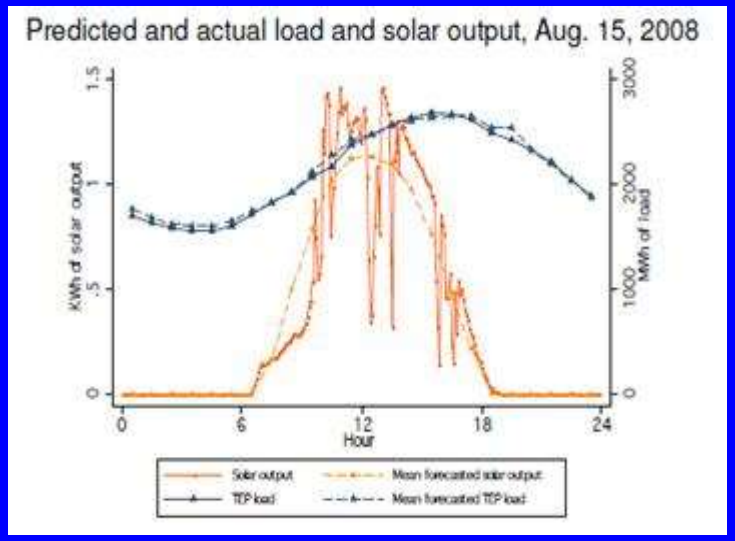
LCOE depends on Application! Policy is important!

Partnering with States and Utilities on meaningful Projects

Storage for Renewable Integration:

ARRA – Public Service NM:
500kW, 2.5MWh for Smoothing and Peak Shifting of a 500kW PV installation; Using EastPenn Lead-Carbon Technology

Load & PV Output in Tucson, AZ



Commissioned Sep. 24, 2011 Integrator: Ecoult

Tasmania

King Island Hybrid System
Hydro Tasmania – Ecoult/EastPenn

Peak Load: 2.5MW
Wind: 2.5 MW
Diesel: 6 MW
Battery: 3MW-1.6MWh
Demand Management

>65% Renewable Energy:
A Green Island!

ARRA - Southern California Edison / LG Chem – Li-Ion:

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

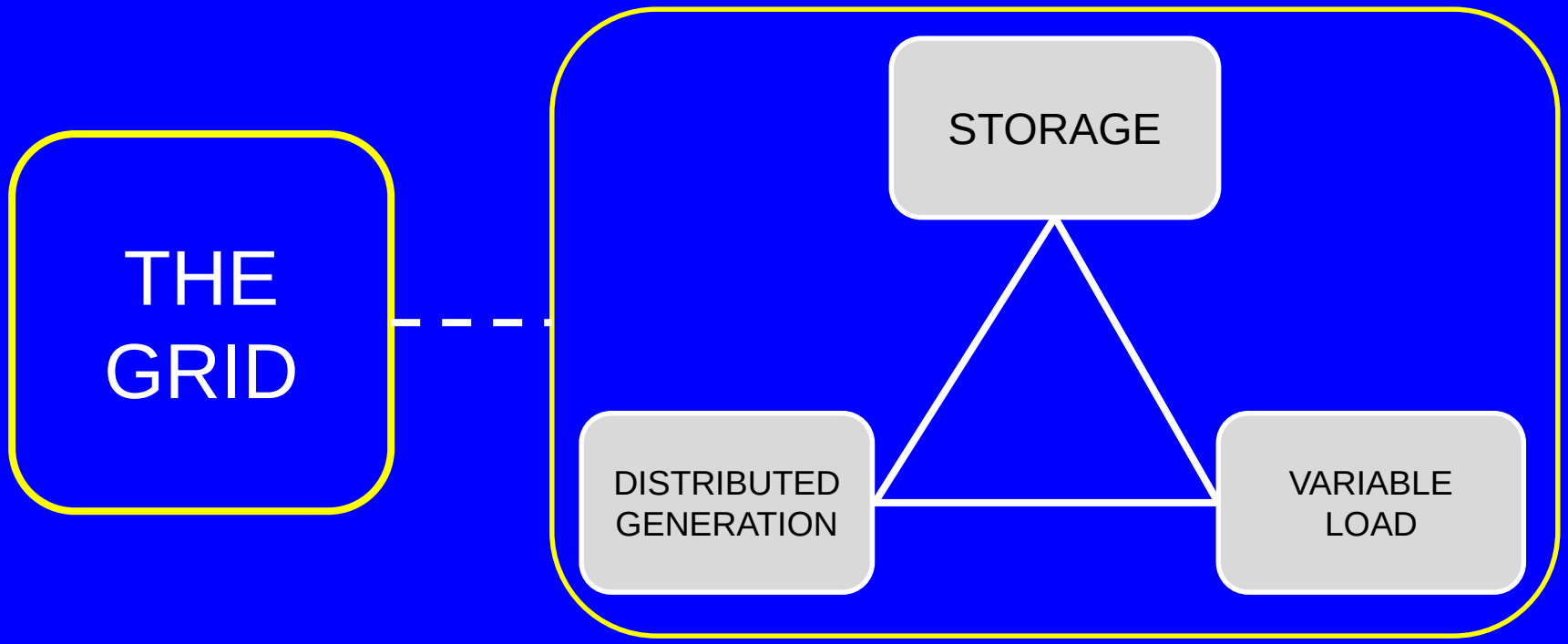
Tehachapi: 4,500MW Wind by 2015!

Commissioned: Sept. 2014
Integrator: ABB

→ Prequel for CA 1.3GW Mandate!

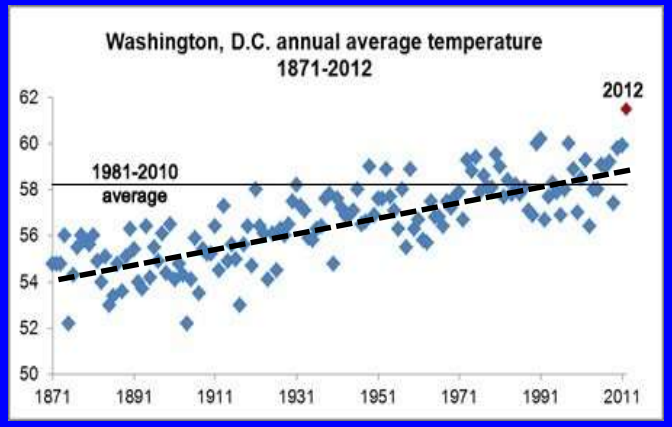
8MW / 32MWh Storage Plant

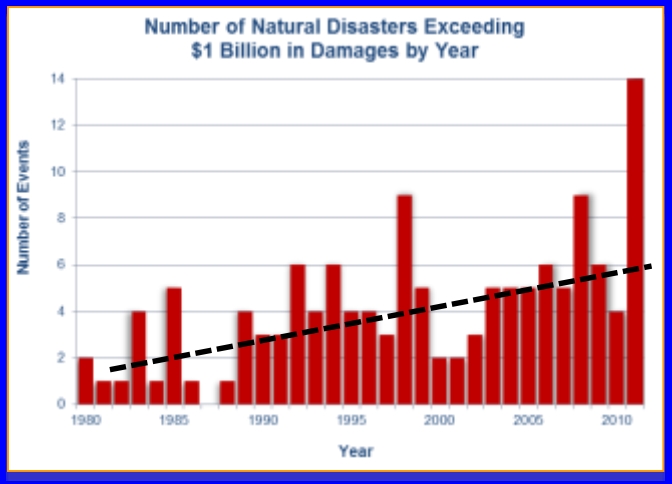
An Autonomous Micro-Grid



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!!

Vermont Public Service Dept. – DOE - Green Mountain Power

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

Groundbreaking: Aug. 12, 2014
Commissioning: Sep. 15, 2015

Storage: Reduces demand charges by peak shaving (8/12/16 ISO-NE peak!)
PV: Green power for the grid. Situated on Brown Field area.

System can be islanded to provide emergency power for a resilient microgrid serving a highschool / emergency center.

Referenced as model in VT Energy Strategic Plan. New projects underway!

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

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

Vanadium technology with 1.7x Energy density developed at PNNL for DOE

Ribbon Cutting
Avista, April 2015

2nd Solicitation: DOE Teaming with Avista on Transactive Microgrid

Eugene Water and Electric Board (EWEB) Grid Edge Demonstration Project – Eugene, OR

- Significant engagements with OR prior to project.
  - 03-14 – Storage Workshop with OR-DOE and OR-PUC
  - 05-15 – Storage Bill passed; 5MW or 1% by 2020
  - 07-15 – NW PUC storage workshop organized by OE / PNNL
  - 09-15 – Joint Solicitation issued with $250,000 grant from OE/Sandia
  - 11-15 – Project selected:

Eugene Water & Energy Board Microgrid

- 500kW + 125kW PV + diesel gen sets at 3 aggregated sites
- Resiliency for critical infrastructure
- Aggregation of energy storage to provide grid services (e.g.)
  - Peak shifting, AGC control, Volt-VAR control, Transmission congestion relief, Capacity / resource adequacy.
- EWEB working with Sandia and PNNL:
  - Define and monetize value of use cases
  - Evaluate design of planned microgrids.

Equitable Regulatory Environment!

Reducing institutional and regulatory hurdles for an environment where the opportunities for deployment and the services provided by energy storage are recognized, implemented and appropriately valued requires coordination across federal, state and municipal entities

- Pacific Northwest utility regulatory commission workshop on energy storage with commissioners and staff from WA, OR, ID, and MT.
- Southwest regional utility regulatory commission workshop with NM, UT, AZ, CO, NV PUC's. With support from NARUC,

Sterling MA - NEC
MA-DOER: Microgrid/Storage Project

Sterling Municipal Light Department

$1.5M Grant from Community Clean Energy Resiliency Initiative.

1MW/2hr storage to provide resiliency for Police HQ and Dispatch Center

In conjunction with existing 3.4 MW PV

DOE-OE providing funds and technical support towards expansion to 2MW/3MWh

- Backup for police station / dispatch center
- Cost savings through capacity reduction
- Revenues from demand charges and arbitrage
- Integration of intermittent PV

Northampton, MA
MA-DOER: Microgrid / Storage Project

- Brings multiple assets together to improve resiliency
  - *Biomass, PV, Diesel*
  - *Energy Storage*
- Islands 3 abutting campuses during outage.
  - Northampton Dept. of Public Works
  - Smith Vocational & Agricultural High School.
  - Cooley Dickinson Hospital
- Energy storage benefits:
  - Demand charges
  - Black start capability for biomass facility during extended outages
  - Reduce diesel during an outage and improve resiliency.

With DOE support, PNNL will model microgrid operations in order to evaluate financial benefits and optimally scale all energy assets during design phase.

ARRA – Vionx: Two Grid-scale Flow Batteries in MA

500 kW / 6 hrs Worcester Project
Under Construction – Wind Integration

- Foundation 50% complete
- All 8 Battery Containers delivered to site prepped for install once foundation is finished
- Installation targeted to be complete 16/Q4

500 kW / 6 hrs Everett Project
Solar PV Integration

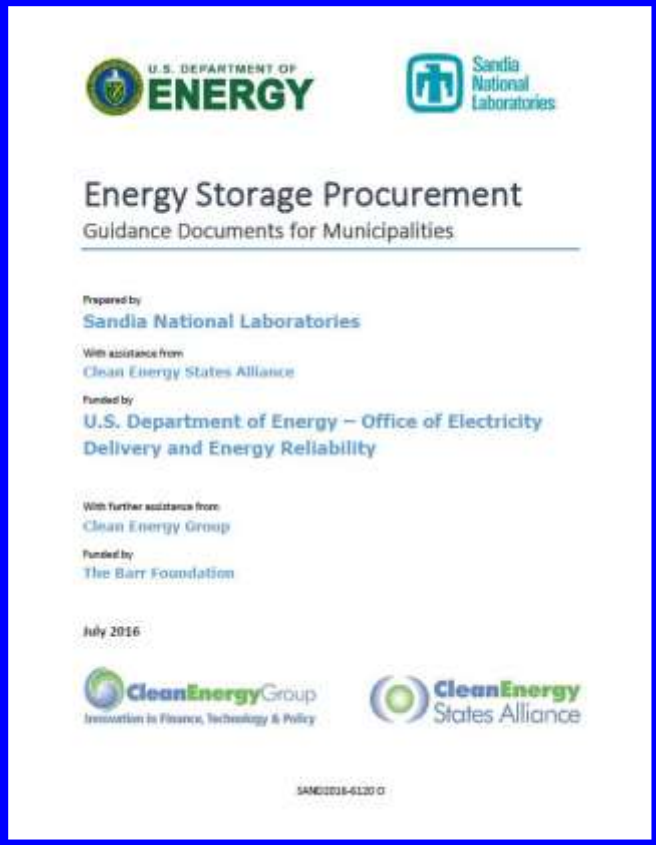
- Permits in process (Chpt 91/ Build)
- All 8 Battery Containers are going through final inspection
- Installation to be completed 16/Q4

VIONX ENERGY™ United Technologies SIEMENS 3M nationalgrid

Energy Storage Procurement, Guidance Document for Municipalities

This document was a response to requests from Massachusetts municipalities, engaged in energy storage procurement, for assistance in drafting RFPs for equipment and services. It is now available for use by any entity procuring storage.

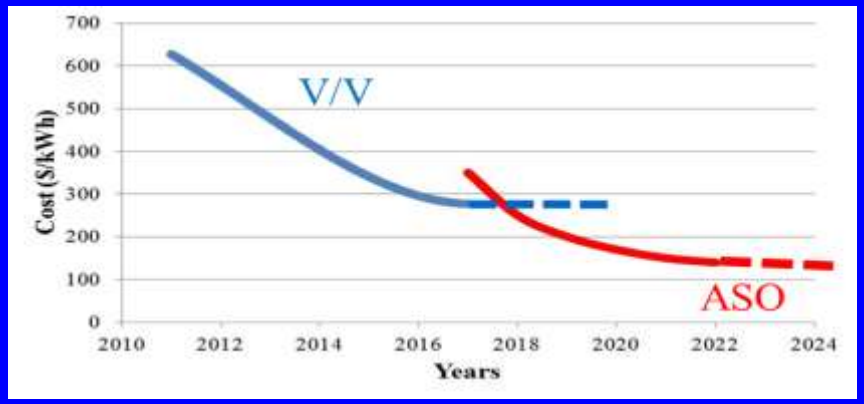
- Developed by Sandia National Laboratories
- Funded by DOE-OE
- Produced in partnership with CESA
- Contains two sample RFPs developed with Sterling, MA, plus a matrix of elements to include in an energy storage RFP



http://www.sandia.gov/ess/publications/SAND2016-6120.pdf

Materials Research For Cost Competitive Energy Storage

Research on Mixed Acid Vanadium Flow Batteries at PNNL has lead to considerable Reduction of System Costs.



- Temperature stability + 80%
- Energy density + 70%
- Projected system cost of $300/kWh for 4 hour system
- Fully commercialized

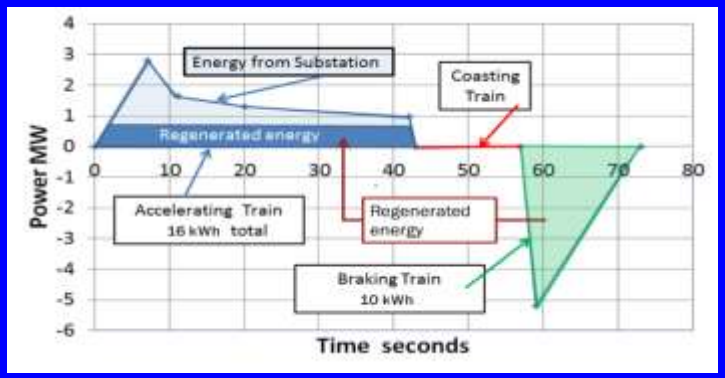
Aqueous Soluble Organics:
Depend on Science,
not the Commodities Market!

- Low cost Material
- Earth Abundant
- Less Corrosive and Toxic

TechConnect 2016, Innovation Award

Helix Power: Regenerative Metro Train Braking

Metro trains have used regen braking since the '80s.



Why is this important?

1. **$10+B market**
2. **Metros are usually highest power usage customer**

i.e. NYC Transit Benefits

- 50% ($115M) annual savings
- 20+% IRR
- 350K tons of CO2 reduction
- Additional ~100MW peak shaving virtual capacity in NYC

Helix Power Technology (MA)

- Flywheel stores 1MW – 90 seconds
- 1 million full cycles in 20 years
- Can operate continuously at full power
- 10x-100x faster than batteries
- 50% of Train Energy can be recycled!

Building Strong Partners

- DOE --$450K grants for market study, prelim. design, risk reduction
- NYC Transit / ConEd
  - develop requirements
- NYSERDA - $2.5M award for flywheel Development; raising $3M cost share
- Starting relationships:
  -- MA-PUC, MassCEC and MBTA

The Bigger Picture:
Creating an Industry!

Grid Energy Storage Safety Initiative

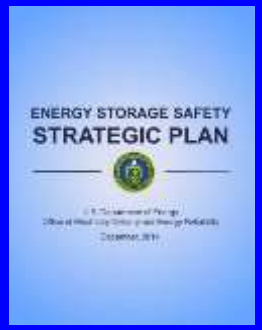
DOE identified *Validated Safety* as a critical need for the success of grid energy storage.

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
- PNNL Publication: Inventory of Codes and Standards
- *Strategic Energy Storage Safety Plan* – December 2014
- Established 3 ES Safety Working Groups – March 2015



Regular Webinars by Storage Experts
arranged by DOE and
the Clean Energy States Alliance

Energy Storage Technology Advancement Partnership (ESTAP)

cesa.org/projects/energy-storage-technology-advancement-partnership/

Measuring System Performance; Market Update; Procurement Guidance; State of the Industry; Flow Batteries; Safety Strategic Plan; Upgrading Distribution Resilience; Economics of Energy Storage; Oregon-DOE Storage Solicitation; Making an existing PV System into a resilient Microgrid; Connecticut and Massachusetts Storage Solicitations; Microgrid Technologies; Commissioning Energy Storage; East Penn and Ecoult Battery Installations; Smart Grid, Grid Integration, and Renewable Energy …….

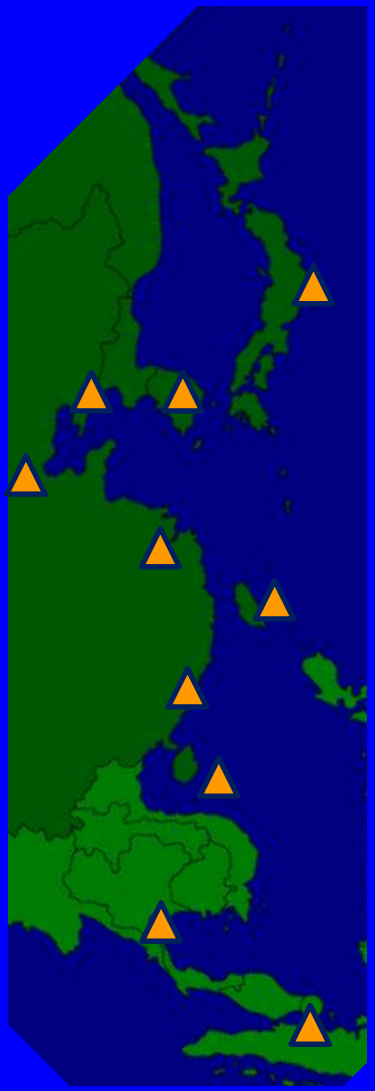
International Collaborations:

Korea: MOU with KETEP/POSCO on Low Temperature NaS Batteries

Singapore: CRADA with EMA to establish ES Test Bed

Japan: MOU with NITE on ES Safety Codes and Standards

Australia: Global ES Data Base



▲ Invited Presentations

DOE International Energy Storage Data Base

energystorageexchange.org supported by Strategen

Over 1550 energy storage projects from 60+ countries.

50 energy storage technologies are represented

Partnerships with Australian Energy Storage Alliance

Policy Database in Development

With new Technologies
Cost will go down, Safety and Reliability will increase

With every successful Project the Value Propositions will continue to increase!