

Desarrollo de Almacenamiento de Energía Eléctrica en los EE. UU.

Grid Scale Energy Storage

Business Cases and Pilot Projects

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ENERGY STORAGE RESEARCH, DOE-OE

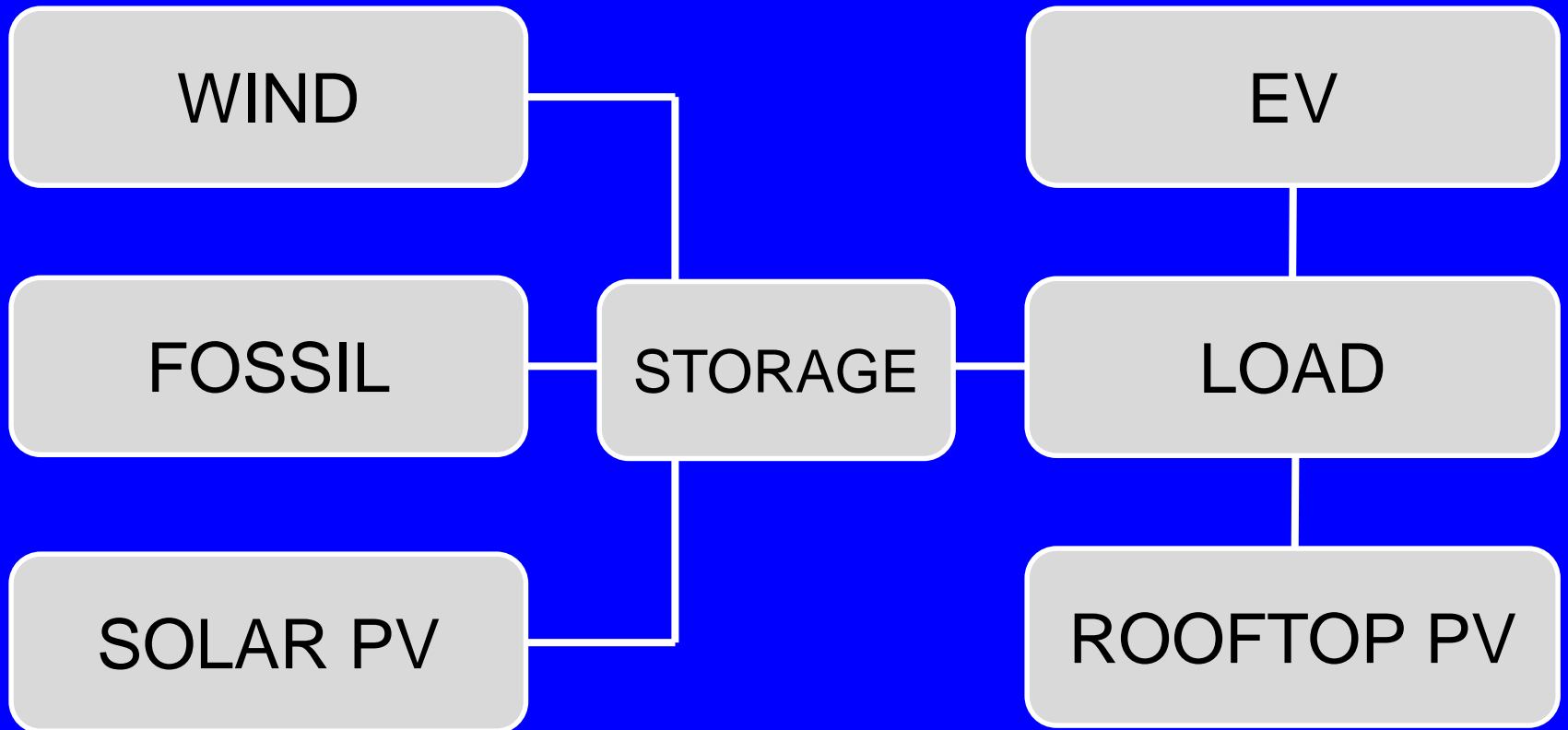
Energy Storage provides Energy

when it is needed

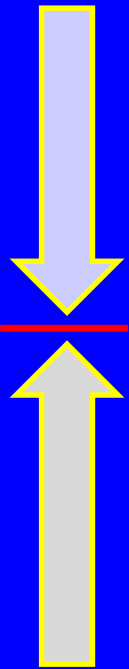
just as Transmission provides Energy

where it is needed

The grid has become stochastic!



Designing a Business Case:



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

Metrics will depend on locality!

Power Electronics
20-25%

Energy Storage Device
25-50%

Facility 20-25%

Arbitrage

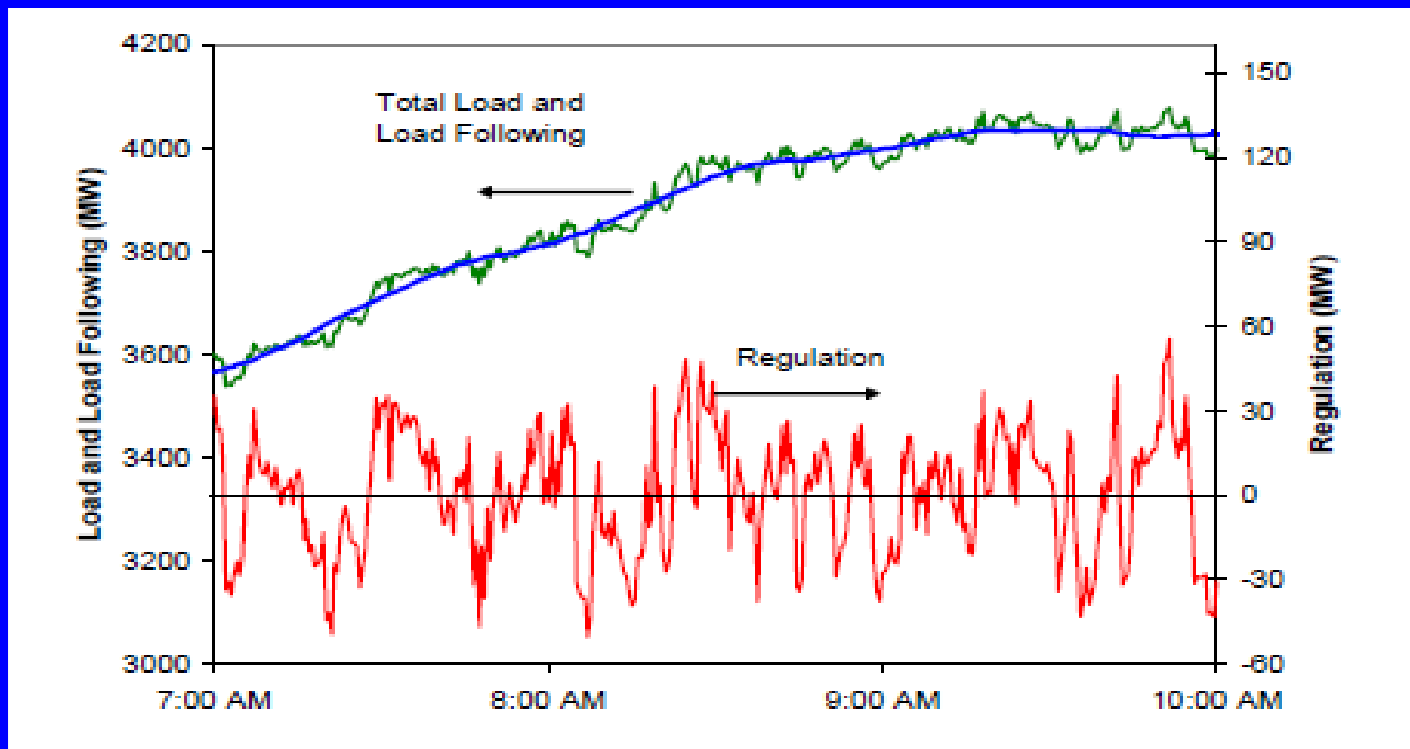
Frequ. Reg.

Dem. Charges
month, year

Resiliency

Building Business Cases

Frequency Regulation





ARRA Project – Beacon

Hazleton, PA.

20MW Frequency Regulation for PJM.
Commissioned Aug. 2014

\$K 5,936/year potential revenue
R. Byrne, SAND 2016-1080C

- ▶ 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

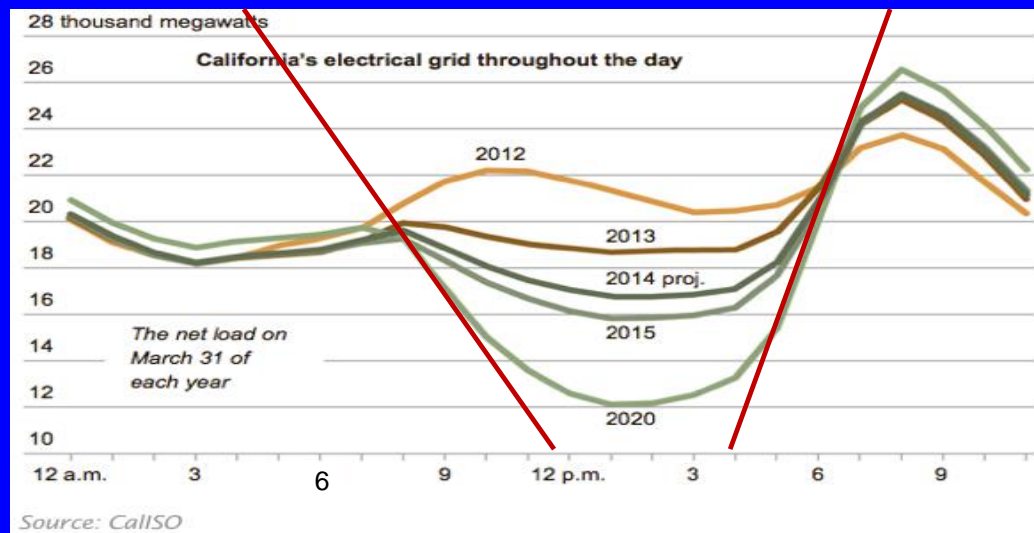
Commissioned March 2013

Regulation with Storage is 2 times as effective!!

2013: FERC's Order 755 Mandated
"Pay for Performance"

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

Energy Storage Systems for Peakshaving, Loadshifting, Ramping



October 2013: California PUC sets target of 1.3GW of Storage by 2020

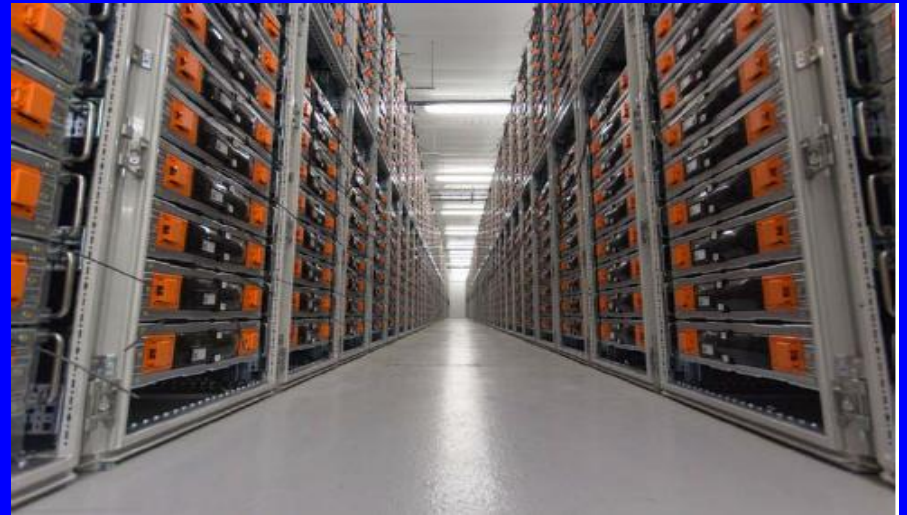
ARRA - Southern California Edison / LG Chem – Li-Ion:

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



Tehachapi Pass Wind Farms

Commissioned: Sept. 2014
Integrator: ABB



8MW / 32MWh Storage Plant

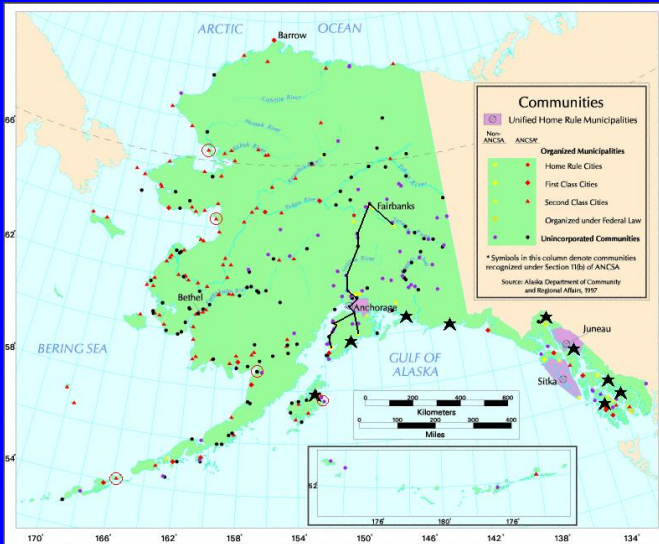
Coming soon:

Energy Storage
as a Transmission Asset

Non-wires Solutions
in Nantucket and San Juan Islands.

Ni-Cd Battery for Voltage Support

World's most Powerful Battery
40 MW in Fairbanks, Alaska!



In 2006: responded to 82 events preventing 311,000 member outages

4 - L'ITALIA ELETTRICA



TERNNA Project Italy

16MW + 24MW

Power
Problem

Energy
Problem



UET V/V
450kW
1440 kWh
Sicily

Coming soon:

Energy Storage for Peak Power!

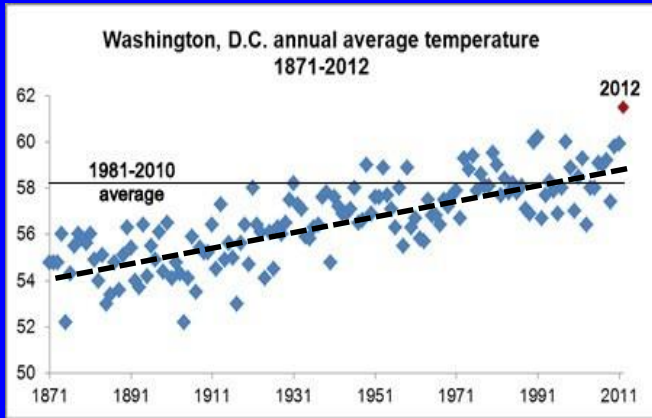
California Public Utility Commission requires utility to use batteries instead of relying on three gas fired plants for peaking.

Jan. 11, 2018

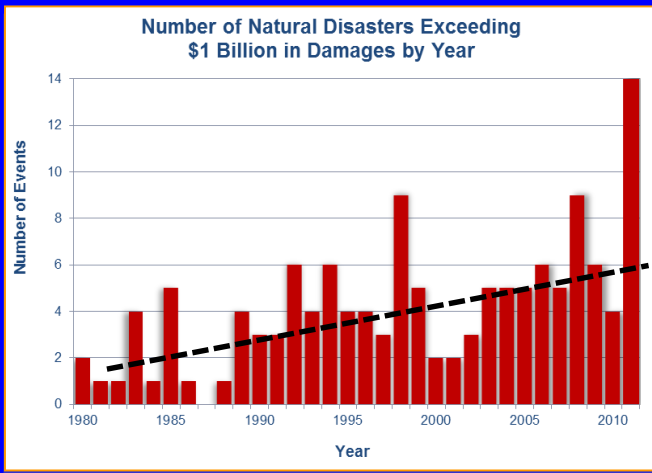
Clear waters
and green mountains!

Resiliency,
Working with the States

Designing for Resilience



Florida, Harvey, 2017



Mexico Earthquake 2017



Puerto Rico, Maria 2017

Every \$1 on protection measures can prevent \$4 in repairs after a storm!

Trends indicate the situation will get worse not better!!

Values such as Resiliency, Military Energy Assurance, or Emergency Preparedness are difficult to Monetize, yet they are often the primary Reason for a Project.

Microgrids with Renewables and Storage provide a good Solution for Resiliency.

But the Business case of a project must rest on Monetizable Benefit Streams.

Vermont Public Service Dept. – DOE - Green Mountain Power

Joint Solicitation issued by VPS/OE
Rutland, VT

4MW / 3.4MWh of storage
Integrated with 2MW PV
Integrator: Dynapower

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

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

Storage: Ancillary grid services, demand charge reduction
PV: Green power for the grid. Situated on Brown Field area

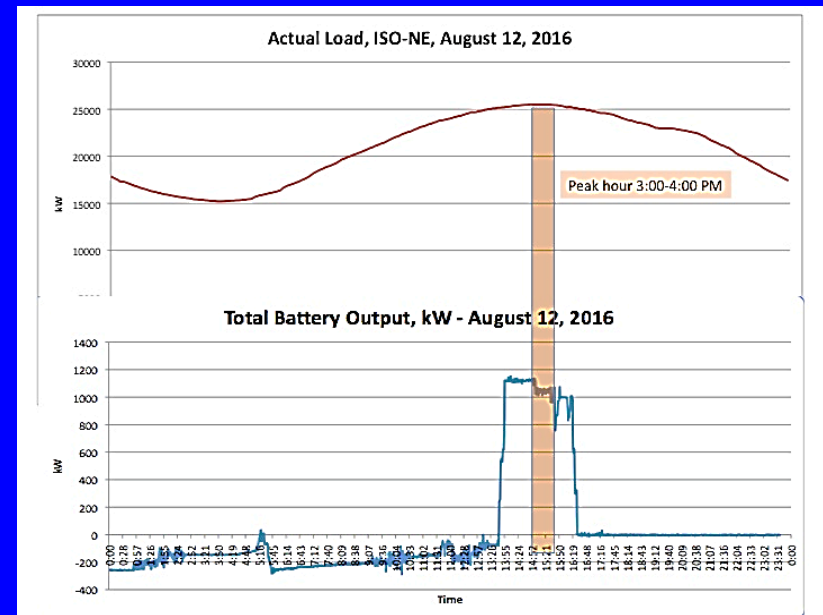


How to make the Microgrid Pay for itself:

Regional Network Service (RNS):
Payments for using transmission lines depend on **monthly peak** load.

Forward capacity market (FCM):
Payments for regional capacity reserves to cover load excursions depend on the **yearly peak** day/hour identified by ISO-NE,

In addition, there are financial benefits from frequency regulation and arbitrage.



Capturing the yearly peak,
\$200,000 from PV and storage!

Vermont Follow-on Activities:

GMP Rutland Project referenced as model in VT Energy Strategic Plan!
Legislative hearings on potential storage mandate.

VT Department of Public Service commissioned Energy Storage Study.

- **Panton VT. Project (GMP)**
 - 1 MW storage linked with solar
 - Resiliency and utility cost savings
- **Residential battery aggregation program (GMP)**
 - Up to 2,000 batteries to be installed behind customer meters
 - Resiliency and utility cost savings
- **Burlington International Airport Microgrid (BED)**
 - 1 MW / 4 MWh battery with 500 kW solar array on airport's parking garage
 - System will provide resiliency to airport, and cost savings to BED



Sterling, MA: Microgrid/Storage Project



Sterling, MA, October 2016



Sterling, MA, December 2016

Sterling Municipal Light Department.

\$1.5M Grant from MA Community Clean Energy Resiliency Initiative (Dept. of Energy Resources). DOE/Sandia. Clean Energy Group.

2MW/2hr storage with existing 3.4 MW PV to provide **resiliency** for Police HQ and Dispatch Center. Li-ion batteries provided by NEC.

Storage Economics in Action!

Description (1MW/1hr)	\$
Arbitrage (buy low, sell high)	13,321
Reduced Monthly Peak	98,707
Reduced Yearly Peak	115,572
Frequency Regulation	60,476
Total	288,076

Capital cost: \$1.7M/MW,
calc. potential benefits.
Simple payback: 6.7 years

R. Byrne, Sandia



2016 Dec. till 2017 Nov.

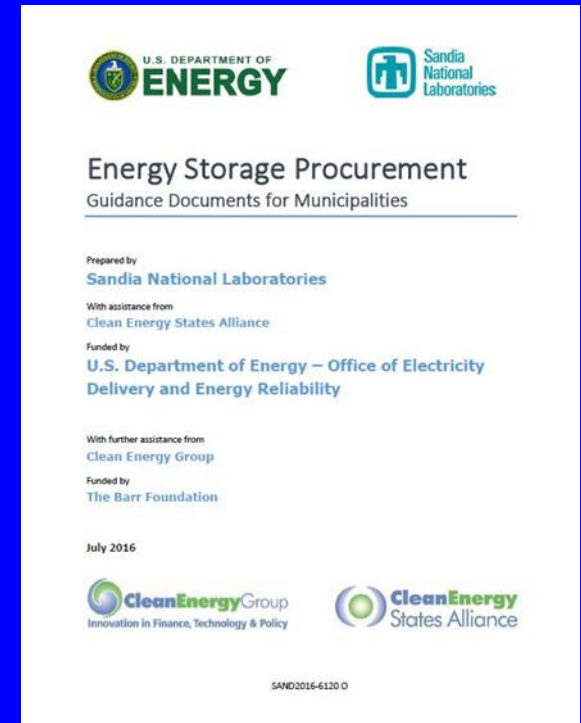
Actual Savings:

- Arbitrage \$11,731
- Monthly Peaks \$143,447
- Annual Peak \$240,660
- Total \$395,839

S. Hamilton, Sterling

Energy Storage Procurement, Guidance Document for Municipalities Dan Borneo (Sandia)

Specific examples of the elements that should be included in a solicitation for the procurement and installation of a battery energy storage project designed to provide backup power during outages and facilitate timely cost recovery.



www.sandia.gov/ess
SAND 2016-8544

2017 GTM Grid Edge Award!

Visitors: Germany, Denmark, England, Japan, Malaysia, Taiwan

Massachusetts Follow on Activities

- MA adopts 200 MWh utility energy storage procurement target
- ACES energy storage grants - \$20 Million
- Peak Demand Reduction Grant Program - \$4.68 Million

- Sterling Community Project: solar + storage
2 MWh energy storage with 1 MW community solar

- 7 more MA municipal utilities have resiliency grants with storage

- MMWEC, which serves 42 municipal utilities in MA,
proposes centralized operation and dispatch services

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

Chattanooga, TN: Partnership with EPB

100kW / 400kWh UET Vanadium Redox Battery



100% fiber-optic community wide communication backbone, delivering 10 Gbits/s. Enables smart grid distribution Automation: 1,200 switches saves \$1.4M in storm.



Storage Energized Sept. 22, 2017

Other DOE-OE Storage Projects:

Chattanooga, TN with EPB

Installation of microgrid based on 100kW/400kWh
V/V flow battery and installed PV. Ceremony Sept. 21, 2017

Birmingham, AL with Southern Research

Utility Test site - 100kW/500kWh. V/V flow battery. Sept 28, 2017

Worcester, MA with National Grid

With wind power – 500kW/ 3MWh. V/V flow battery. Oct. 4, 2017

Eugene, OR, Water & Energy Board

Resiliency Microgrid, 500kW/2hr Storage at a school building

New project funded by KETEP (Hyosung) 1-2MW, 1-2MWh

Cordova, AK, Study with ACEP

Hydropower Smoothing, eliminating diesel back-up

Nantucket, MA with National Grid and Tesla

Transmission Line Deferral. Battery only in use 3 months - analysis to find additional Benefits.

Kona, HI, with NELHA and HELCO

Enabling more solar PV, 100kW/500kWh of V/V Batteries

Decatur Island with OPALCO

WA Clean Energy Fund, 500kW/4 hour V/V system for resilience, Analysis completed (\$3M benefit)

Sandia Analysis for projects in Germany,
JB Andrews, FDA Whiteoaks

The Bigger Picture

Grid Energy Storage Safety Initiative

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

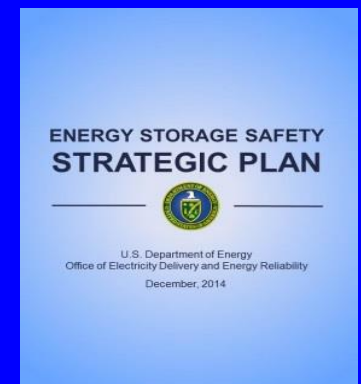
The ability to validate the safety of energy storage systems will:

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



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

- PNNL Publication: Inventory of Codes and Standards
- *Strategic Energy Storage Safety Plan – December 2014*
- Established 3 ES Safety Working Groups – March 2014
- **Energy Storage Systems Safety and Reliability Forum
March 28-29, 2018, Seattle, WA**



Energy Storage – Equitable Regulatory Environment

Reducing institutional and regulatory hurdles for energy storage to provide 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



NorthWest PUC Meeting, July 2015



SouthWest PUC Meeting, May 2016

**U.S. Dept. of Energy, Office of Electricity
Western Electricity Coordinating Council**



November, 2017,
Salt Lake City, UT



Energy Storage Technology Advancement Partnership ESTAP

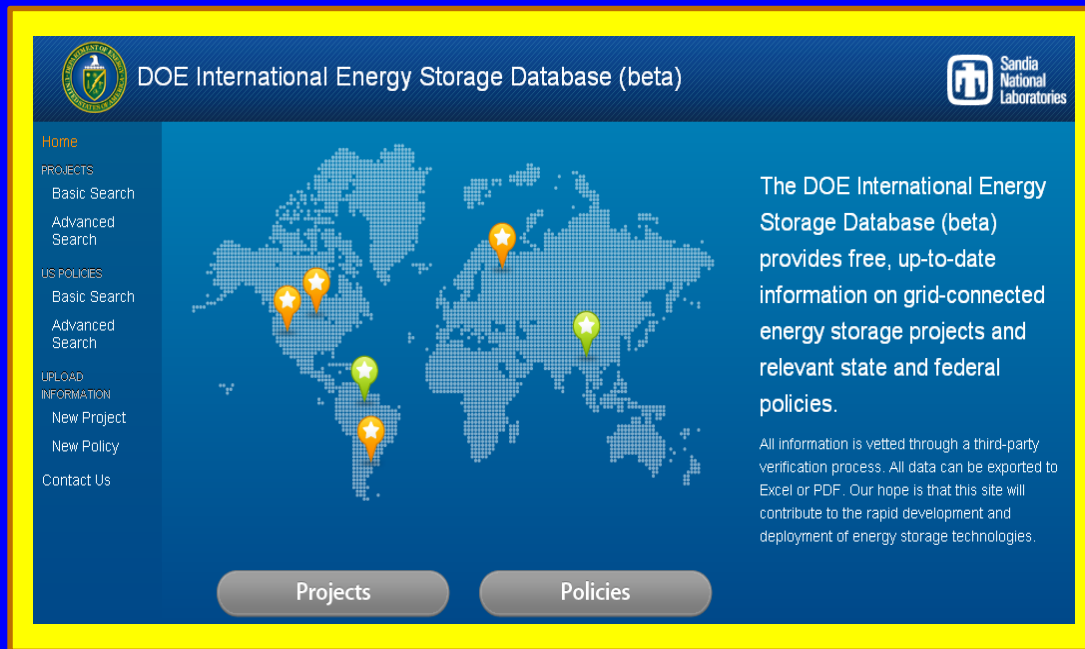
Regular Webinars
In collaboration with CESA

<http://cesa.org/projects/energy-storage-technology-advancement-partnership/energy-storage-events/>

DOE International Energy Storage Data Base

energystorageexchange.org supported by Strategen

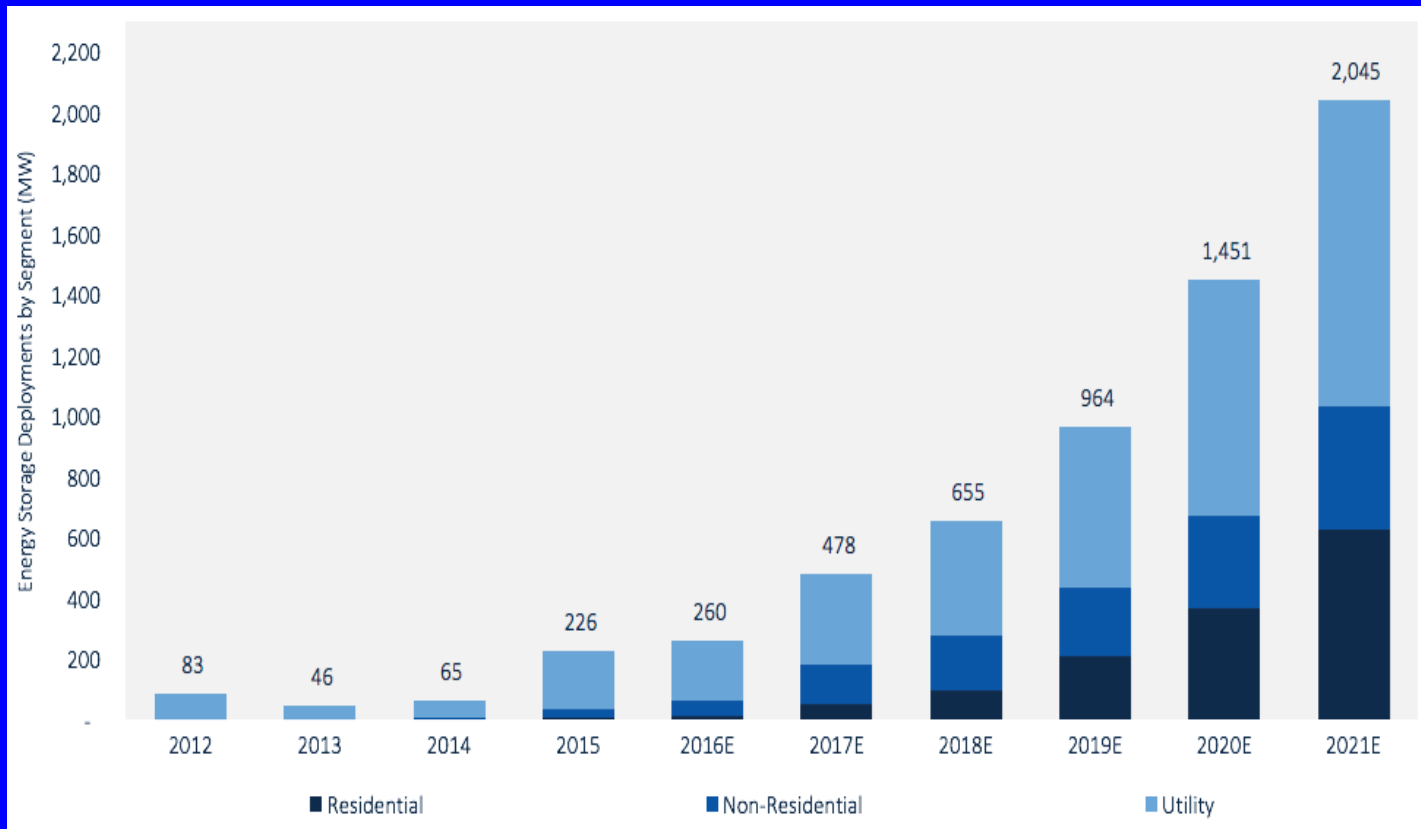
Over 1730 energy storage projects from 60+ countries.
50 energy storage technologies are represented



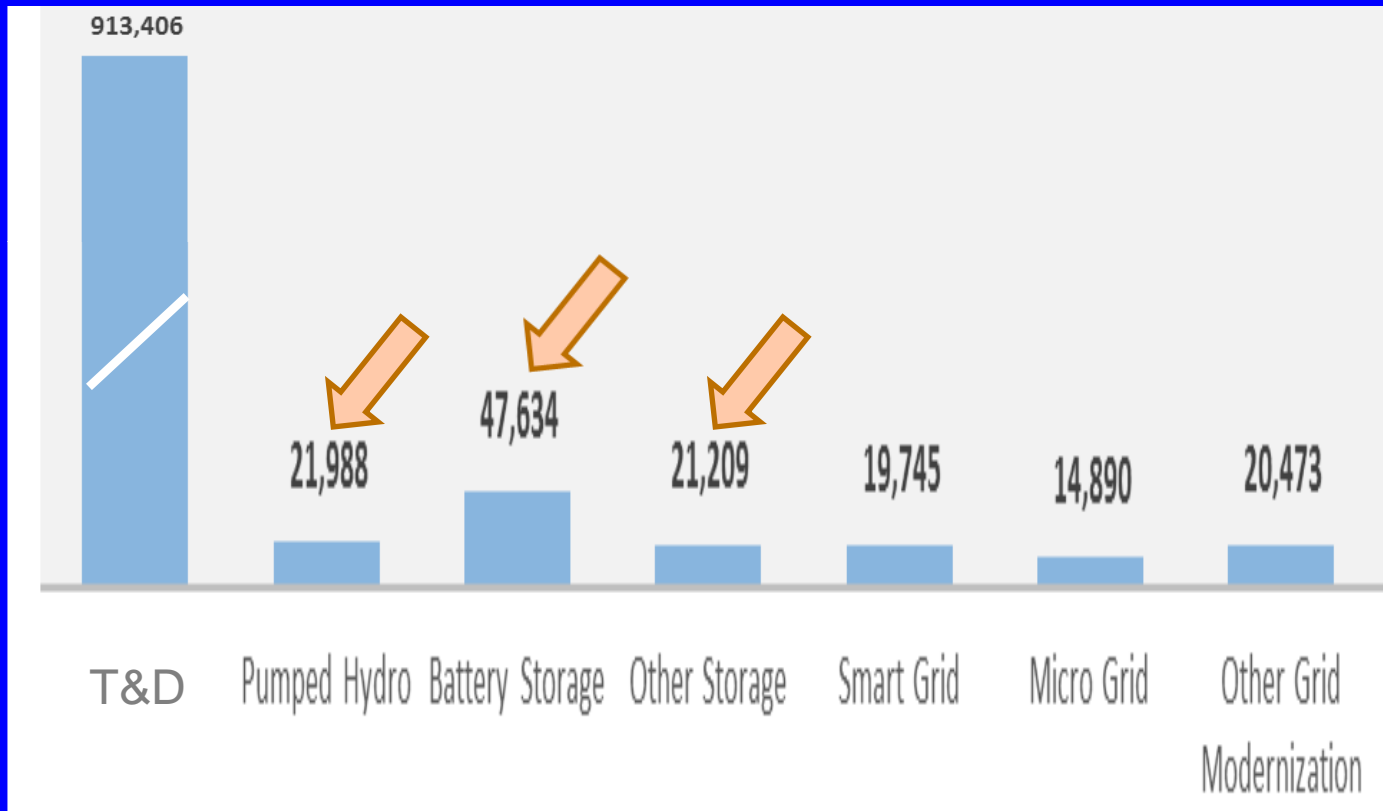
Partnerships with
Australian
Energy Storage
Alliance

Partnership with EIA on Storage Reporting

Annual U.S. Energy Storage Deployments, 2012-2021



U.S. Energy and Employment Report, January 2017



Employment by Transmission, Distribution, and Storage Technologies Q1 2016

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

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

More jobs will be created!!

Energy Storage
should be in
the Toolbox of every Utility!