Grid Scale Energy Storage, for Resilience, Stability, and a Greener Grid

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Energy Storage Program Mission and Strategy

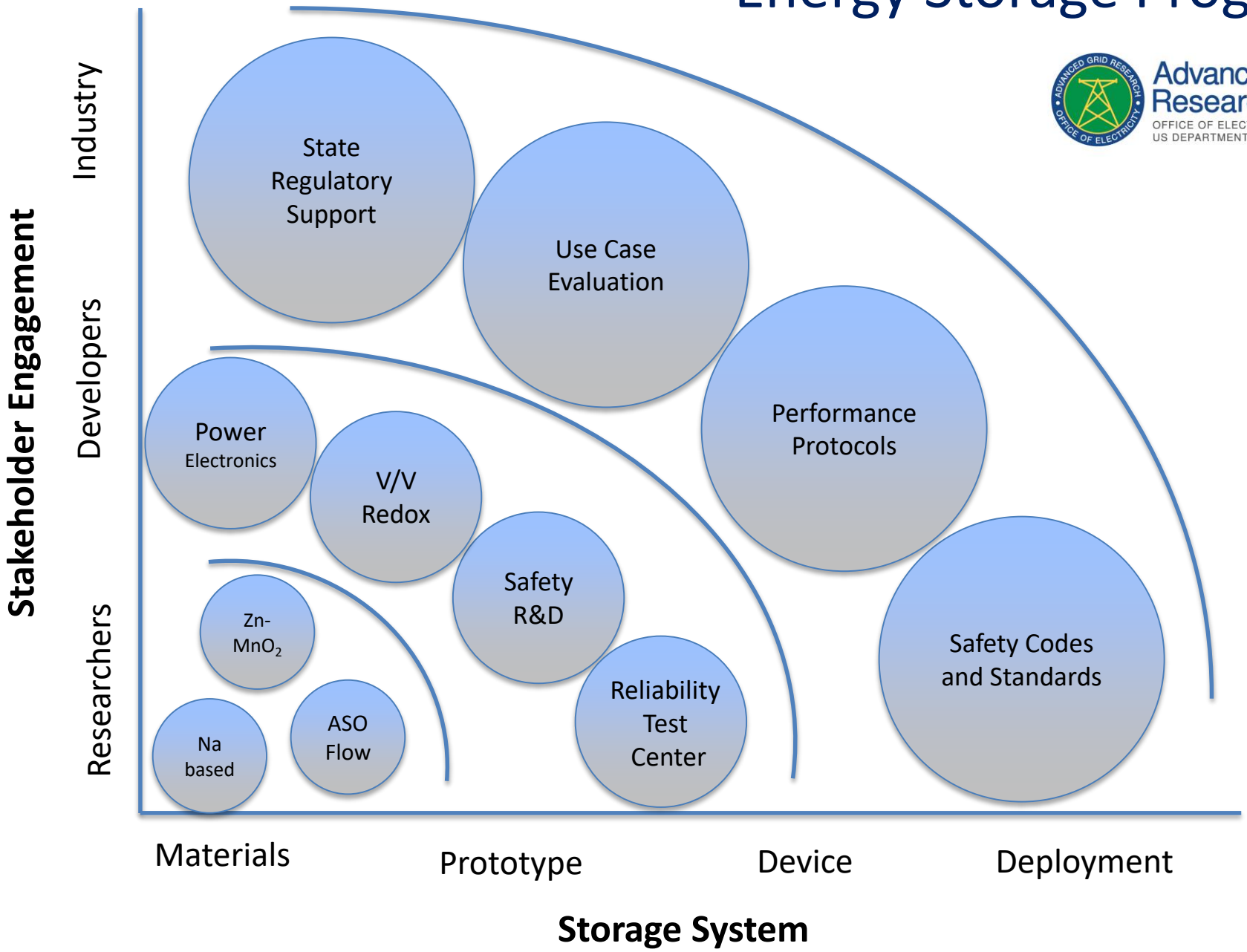
Broad Range of R&D, Deployment, and Analysis Efforts
Materials – Devices – Systems – Analysis – Standards – Policy

Teaming with Sandia, PNNL, ORNL, ANL, LANL
to work with Industry, States, and Utilities.

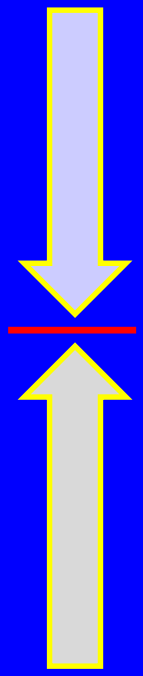
10 R&D 100 Awards, 2 EPA Green Chemistry Awards

Energy Storage Program

Advanced Grid Research
OFFICE OF ELECTRICITY
US DEPARTMENT OF ENERGY



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: Resilience, Sustainability, Grid Stability

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.

Sterling, MA: Microgrid/Storage Project

Sterling Municipal Light Department.

$1.5M Grant from MA Community Clean Energy Resiliency Initiative (Dept. of Energy Resources). Further Funding fromDOE/Sandia.

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

Sterling, MA, October 2016

Sterling, MA, December 2016

Storage Economics in Action!

Sandia Benefit Estimate:

Simple payback 6.7 years

Capital cost: $1.7M/MW,

R. Byrne, Sandia

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

Total Capital Cost: $2.7M@2MW/2hr; Monthly Maintenance: $400!!

2016 Dec. till **2017** Nov.
Actual Savings:

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

S. Hamilton, Sterling

2017 GTM Grid Edge Award !

Carina Kaainoa

April 2019: 1 million Avoided Cost!

Visitors: Germany, Switzerland, Denmark, Sweden, England, Ireland, Australia, Japan, Malaysia, Taiwan, Brazil, Chile, …. Thailand

Cordova, Alaska, Municipal System

Cordoba, Grid Isolated

6MW Run of RiverHydro Power

Total Generating Capacity:

6MW + 1.25MW Hydro; 2x 1MW Diesel

0.5MW Deflected as Spinning Reserve

Hydro: $0.06/kW; Diesel: $0.60/kW

Ribbon Cutting with Sen. Murkowski

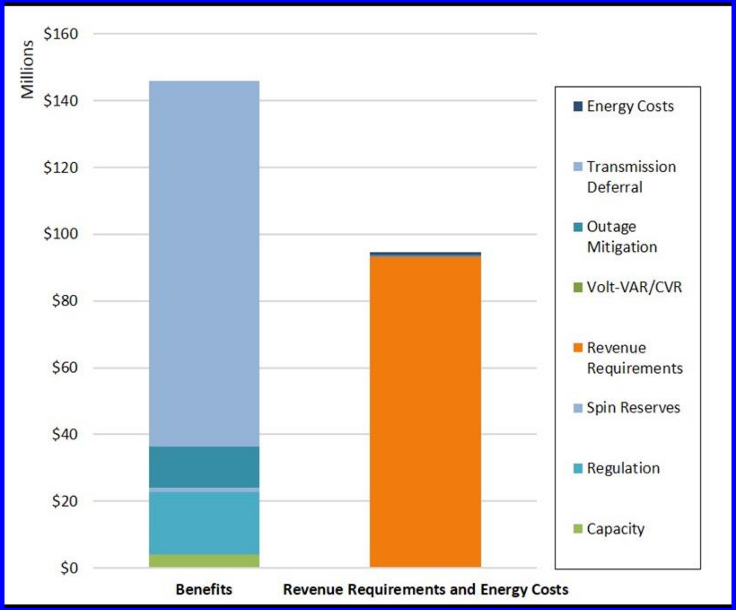
1 MW / 1 hr Li-ion Storage

Commissioned June 7, 2019

- Frequency Regulation – Replace Diesel
- Load following – Make Hydro Dispatchable
- Emergency Supply - Resilience

Nantucket – National Grid, Tesla, PNNL/DOE

71 MW Submarine Cables



Analytics: Balducci et al. PNNL

$110 million Deferral Value + $36 million Operational Benefits

Installation: 6MW/8hr Storage + 6-10 MW Generator to yield required 91MW Peaking Capacity

PNNL evaluated technical and financial benefits of energy storage:

- Financial benefits of ES
- Technical impact on distribution system
- Control strategies to maximize financial benefits while achieving resiliency goals.

Ribbon Cutting: Oct. 8, 2019. Return on Investment: 1.55

In addition to transmission deferral, other potential economic benefits could include:

- ISO-NE demand response program participation
- ISO-NE ancillary service markets
- ISO-NE forward capacity and reserve markets
- Energy arbitrage, Outage mitigation

National Scope - Local Relevance!

- ABQ Public Schools: demonstrate economic & resilience benefits of ES available to public schools 13 high schools, 140 campuses.
- Project with Picuris Pueblo, NM to install storage in combination with solar for “Energy Independence”.
- Iowa: Develop 6-8 hour backup for existing/planned renewables
- 3 projects involving Rural Co-ops and Military Reservations.
- Matanuska Electric Association Alaska: Grid Resilience project
- Puerto Rico: 5 town consortium to form Central Mountain micro-grid powered by 250MW solar and hydro with 75 MW storage backup

Emergence of Storage Ecologies

California: Mandate, CEC, Industry

New York: BEST, NYSERDA, CCNY

Northwest (WA, OR, AK): PNNL, WA Clean Energy, PUCs, Senate,

New Mexico: Sandia, Congressional Support, Projects

Massachusetts: DOER, Projects, National Grid, Universities

Congressional and State Support, Regulatory Structure,
National Laboratories, Universities, Utilities, Real Projects

States with Big Plans!

CA: 1,325 MW by 2020; + 800MW
MA: 200MW by 2020 → 1,000MWh
NJ: 600MW by 2021; 2,000MW by 2030
NY: 3,000 by 2030

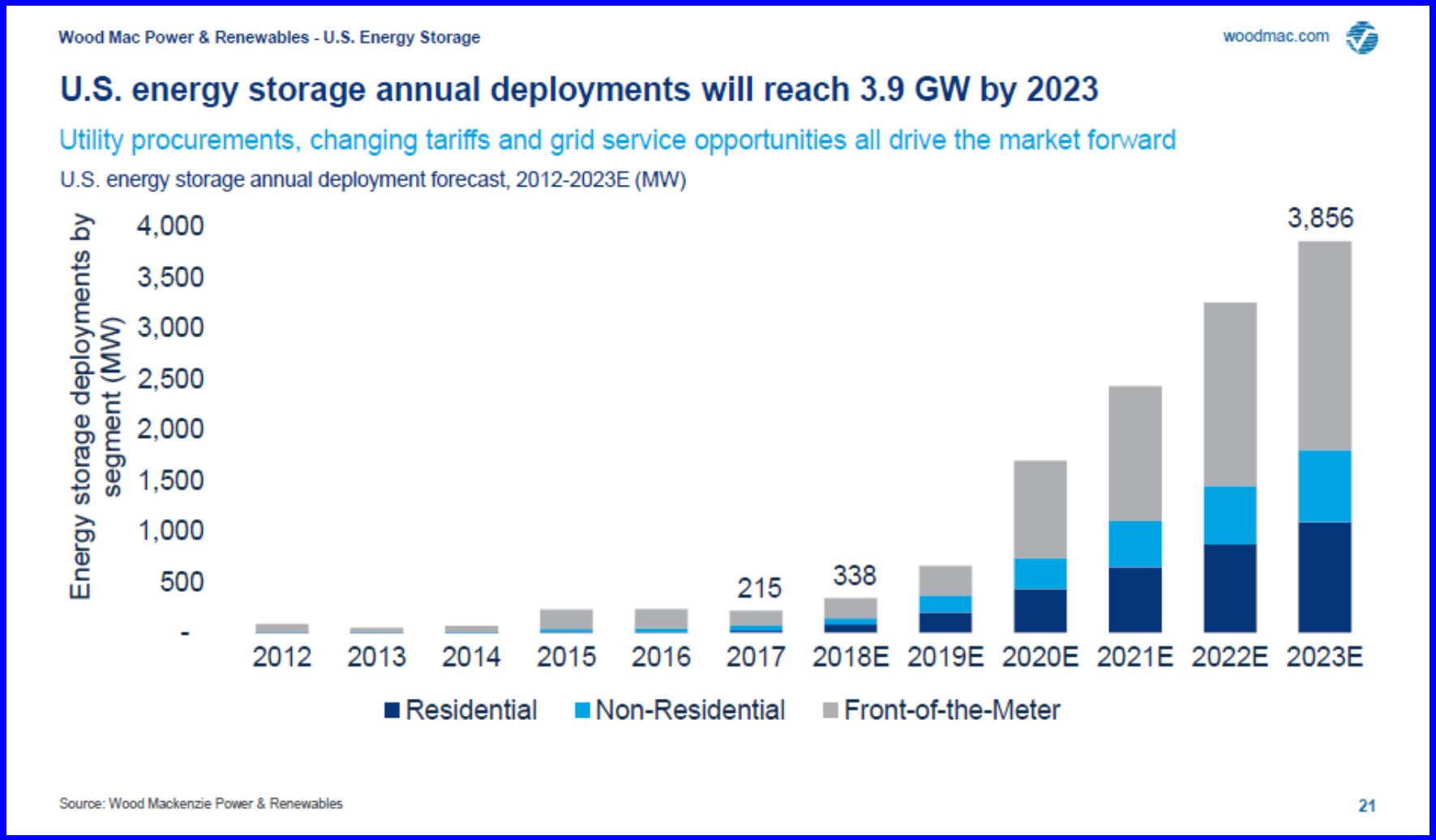
AZ: 3,000 by 2030 prop; APS: 850MW
ME: 300MW by 2025 prop.
NV: 380MW @ 4hrs at solar farm on Fed Land

DOE Tech Assistance, SNL/PNNL

SE ES Symposium: AL, AR, FL, GA, KY, MD, NJ, VA
NM: Half-day workshop: Tech, Econ, Policy
MI: 1 day workshop with MI Pub Serv.
AZ Pub Serv IRP Workgroup: Best practices
CEC workshop: chem, test, perf metrics, fire haz.
ME: ES commission, Storage Overview

NV PUC: 1 day Workshop; policy, valuation, modeling, interconnection, commissioning, safety
New Engl. Conf. of PUCs: CT, MA, ME, NH, RI, VT

Energy Storage has become a Resounding Success!



Incumbent Lithium Ion Technology:

Ecological and Sociological Issues

Safety, Reliability,

Re-Use, Recycling, Disposal

Li-ion Batteries?

PRO:

Low cost, market ready

Familiar Technology

CON:

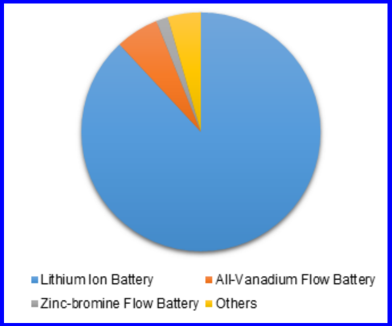
Cycle life <<20years

Capacity Fade

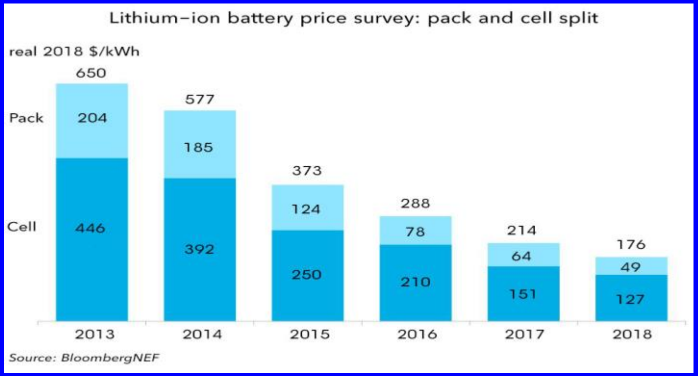
Safety Issues

No U.S. Manufacture

No Recycling!



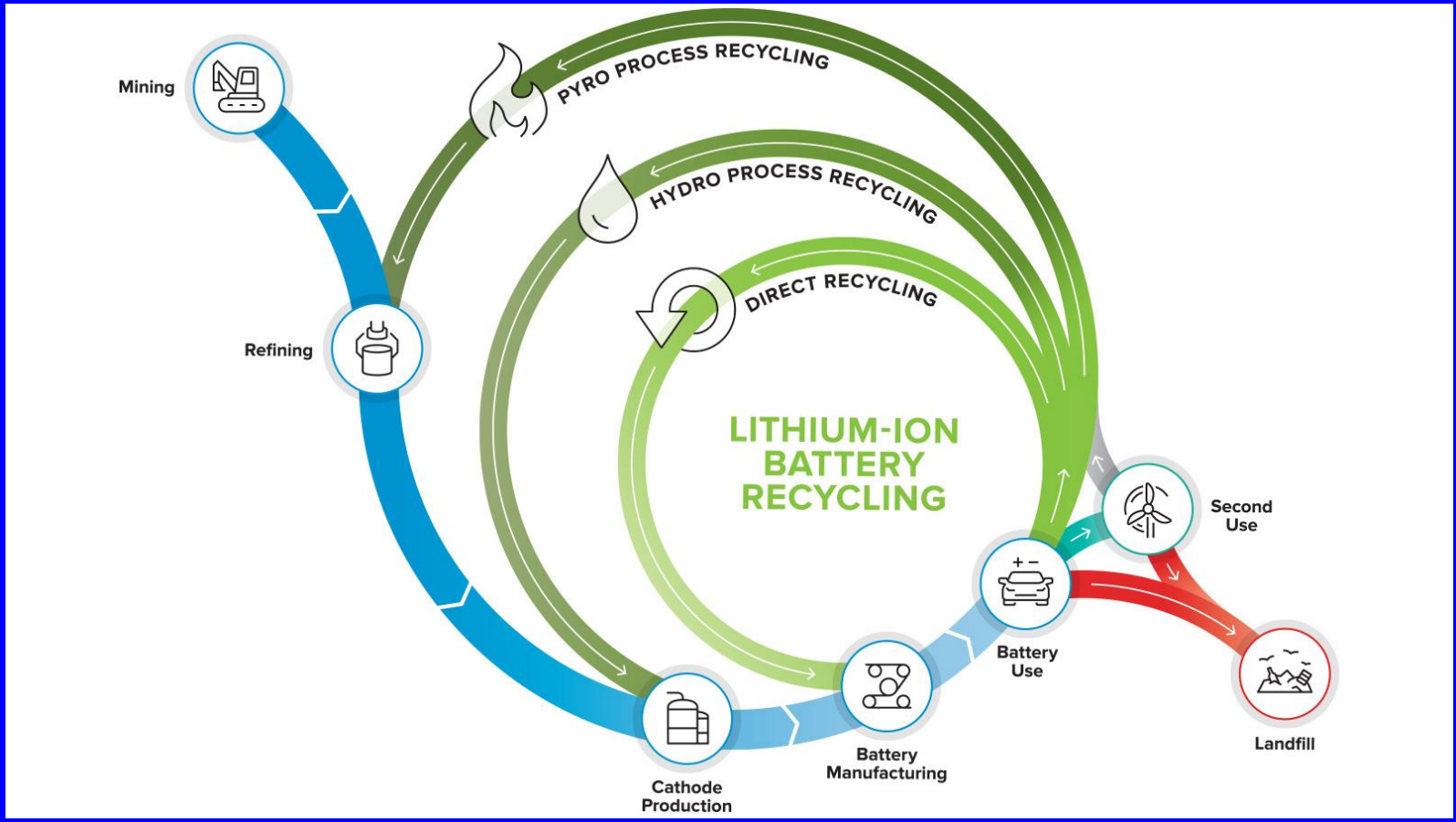
Market Dominance



15 MW scale Fires in Korea during 2017 (27 MW) Arizona, 2018!

225 Aviation Incidents

Recycling Lithium Batteries?



Argonne

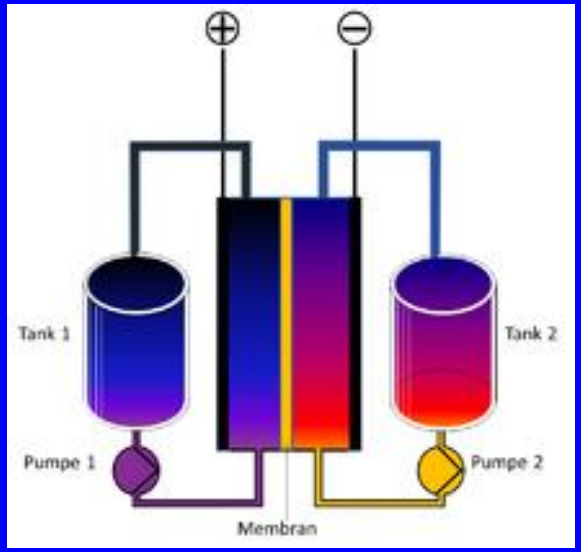
Materials Research on Safety, Reliability, Recycling and new Technologies

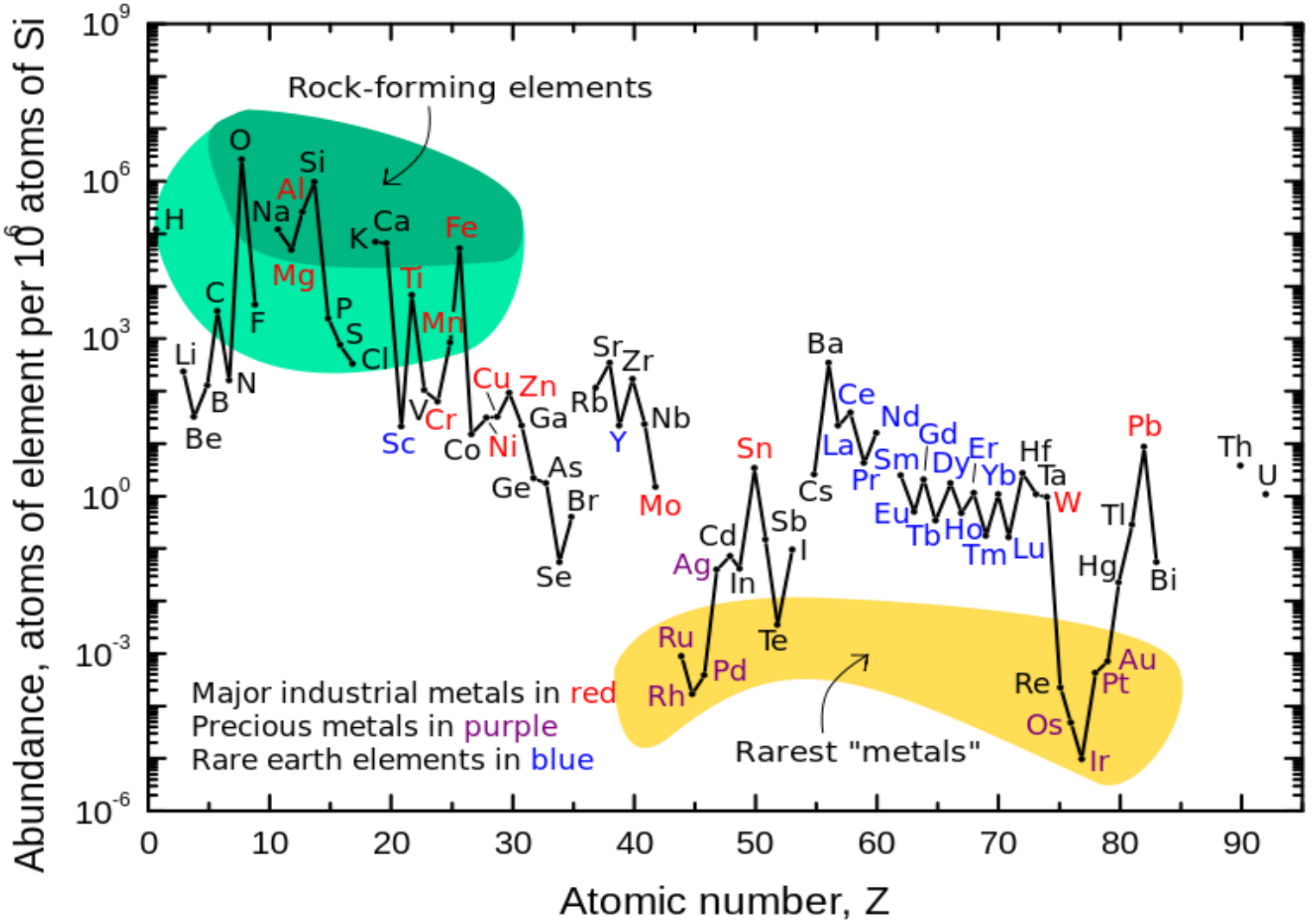
Flow Batteries decouple Power from Energy:

- Power is produced by a rechargable Electrochemical Cell
- Energy is stored in Tanks of electrolyte

This is analogous to a car:

- Power comes from the Engine
- Energy is in the gasoline Tank





We want low Cost !

Cost <u>Goals</u> for Focus Technologies

Manufactured at scale

Li-ion Batteries (cells only)	$100/kWh
V/V Flow Batteries (stack+PE)	$300/kWh
Zinc Manganese Oxide (Zn-MnO_2) 2 Electron System	$ 50/kWh
Low Temperature Na / Na-ion based Batteries	$ 60/kWh
Aqueous Soluble Organic (ASO) Redox Flow Batteries (stack+PE)	$125/kWh
Advanced Lead Acid	$ 35/kWh

On the Horizon:

Non-Lithium Technologies / “Better” Lithium: Innolith (Alevo)
Vanadium Redox, Zinc-Bromine, Zinc-Manganese,
Iron-Chlorine (ESS), Ambri, Sodium (NGK)

Non-Battery Technologies:
Cement Blocks, Railroads (Colorado), CAES
Thermal Systems (Ice, PCMs, Aesthus, Malta, Liquid Air)

Vehicle to Grid – Fleets: School bus. Postal, Military

Long – Duration, Long Term Storage (8hrs, 12hrs, days)
Business Case? “Frozen” Electrolytes, Hybrid Systems,

Hydrogen, Ammonia, etc.

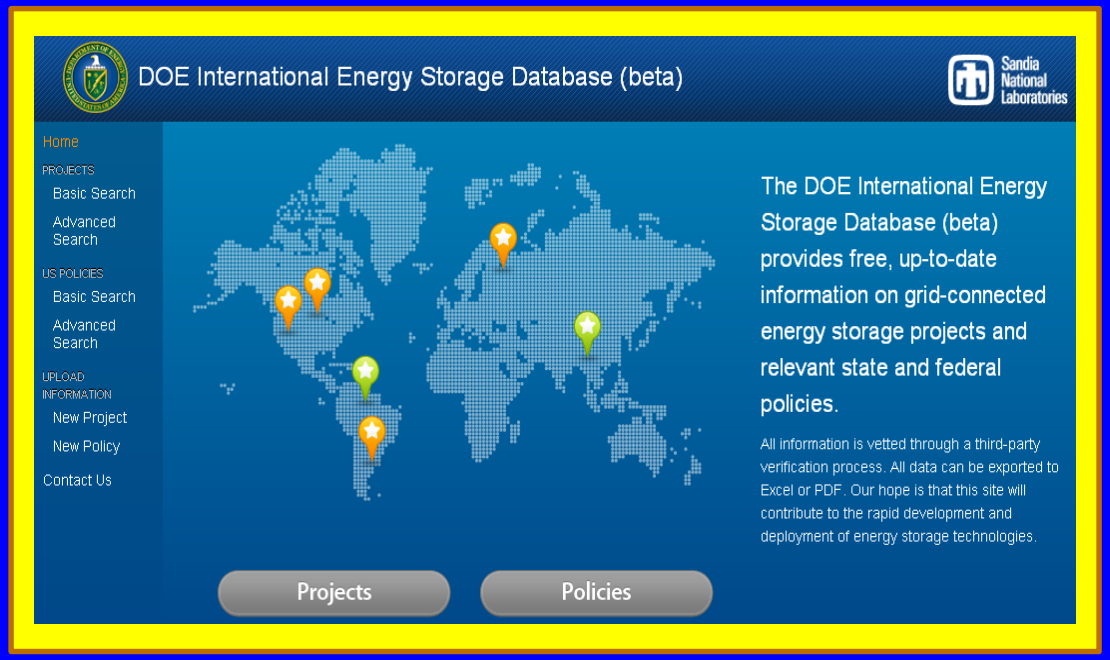
Energy Storage Technology Advancement Partnership ESTAP

Regular Webinars
In collaboration with CESA

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

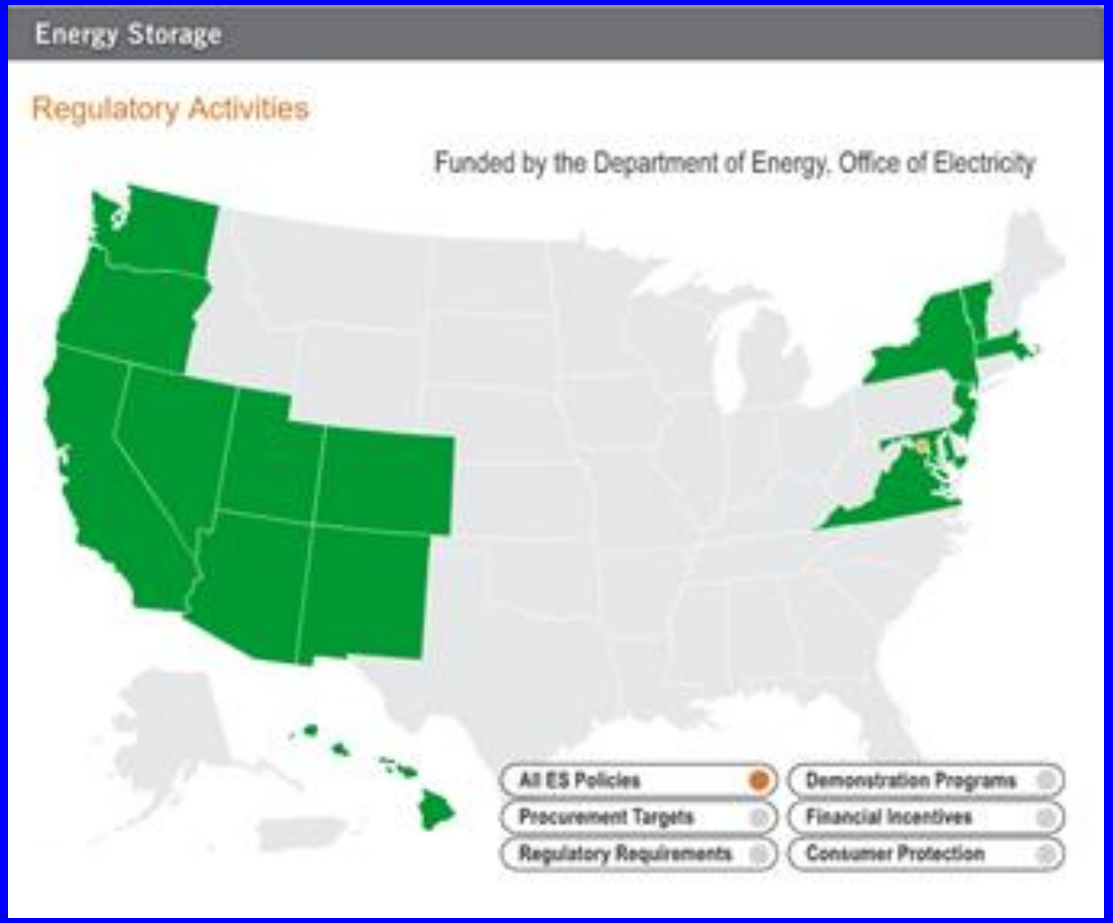
DOE International Energy Storage Data Base

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



sandia.gov/ess-ssl/doe-global-energy-storage-database

Energy Storage Policy Data Base



https://energystorage.pnnl.gov/regulatoryactivities.asp

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!