

# Grid Scale Electrical Energy Storage: Creating Ecosystems!

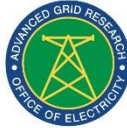
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IMRE GYUK, DIRECTOR,  
ENERGY STORAGE RESEARCH, DOE-OE

# Office of Electricity, Priorities:

- Puerto Rico and U.S. Virgin Islands  
Restoration and Resiliency Efforts
- North American Energy Systems Resiliency Model
- **Mega-Watt Scale Grid Storage**
- Revolutionize Sensing Technology Utilization
- Operational Strategy for Cyber and Physical Threats

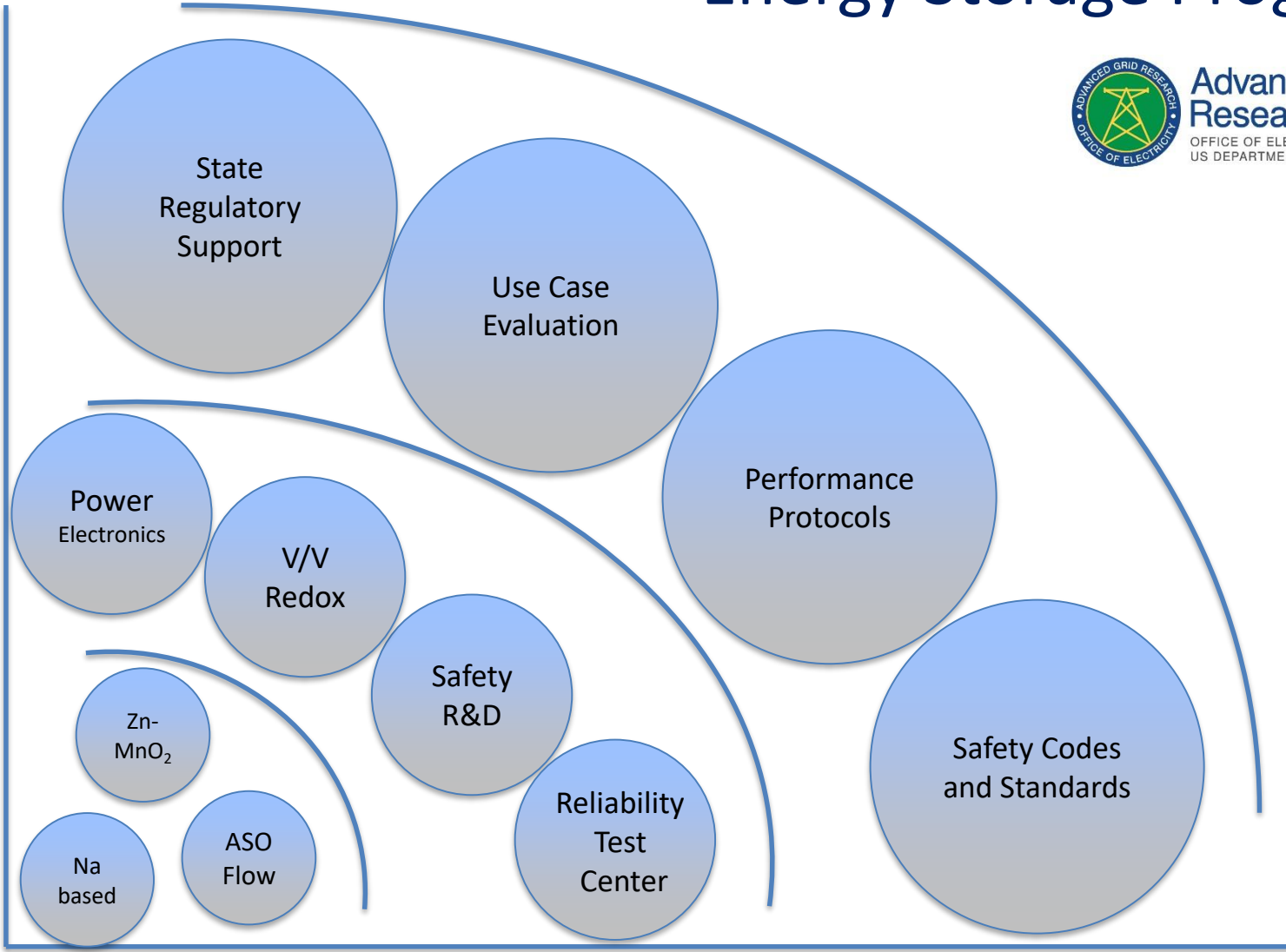
# Energy Storage Program



**Advanced Grid Research**  
OFFICE OF ELECTRICITY  
US DEPARTMENT OF ENERGY

**Stakeholder Engagement**

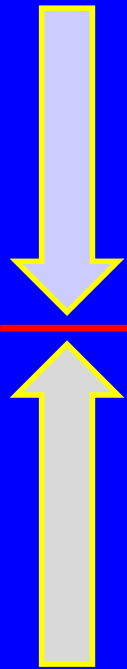
Industry  
Developers  
Researchers



Materials                      Prototype                      Device                      Deployment

**Storage System**

# 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

# Materials Research for Cost Competitive Energy Storage

Sandia, Pacific Northwest, OakRidge

225 Articles, 109 Patents, 9 R&D 100 Awards!

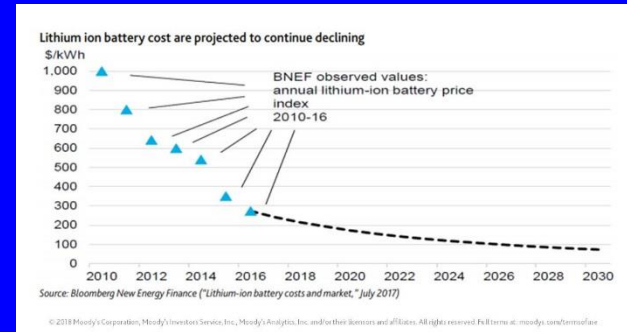
# Li-ion Batteries?

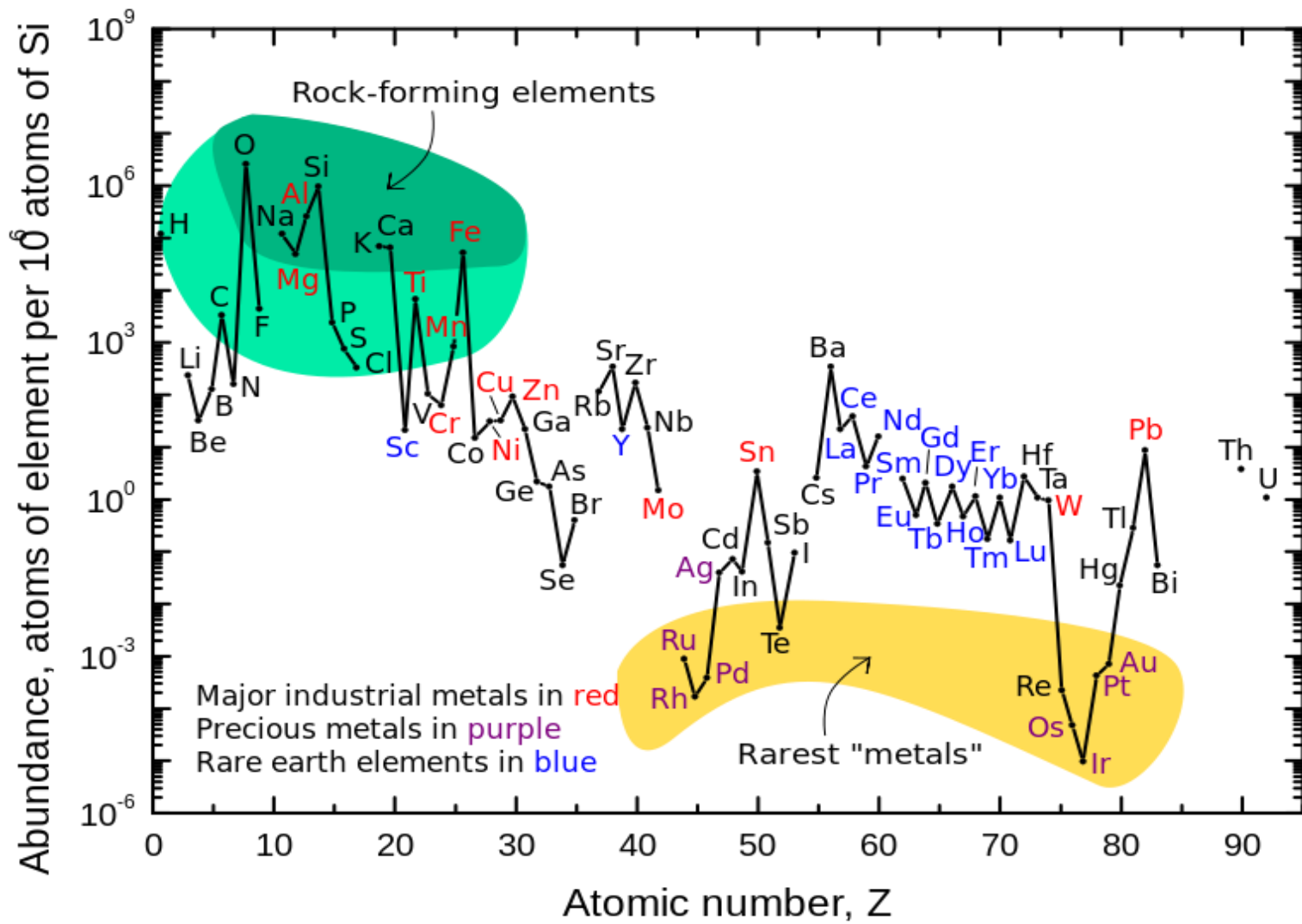
Low cost, market ready  
Tie-in with EV development



*27 +MW Lithium Fires in 2017!*

Cycle life <<20years  
No Recycling!  
No U.S. Manufacture





We want low Cost !

# Cost Goals for Focus Technologies

Manufactured at scale

Aqueous Soluble Organic (ASO)  
Redox Flow Batteries (Stack+PE)      \$125/kWh

Zinc Manganese Oxide (Zn-MnO<sub>2</sub>)  
2 Electron System      \$ 50/kWh

Low Temperature Na-NaI  
based Batteries      \$ 60/kWh



Transition from Benchtop  
and Prototype  
to Commercial Gridscale is  
a difficult Technical Challenge!

Testing at Scale followed by  
extensive Field Experience  
is essential for  
Commercial Success!

Building  
Business Cases  
for Value

# Metlakatla, AK: Island System with Hydro

Hydro: 4.9 MW *Due to frequent brownouts:*  
Load following Diesel: 3.3 MW

*Increasing fuel costs (\$400K/yr) prompted GNB/GE/DOE-Sandia study*

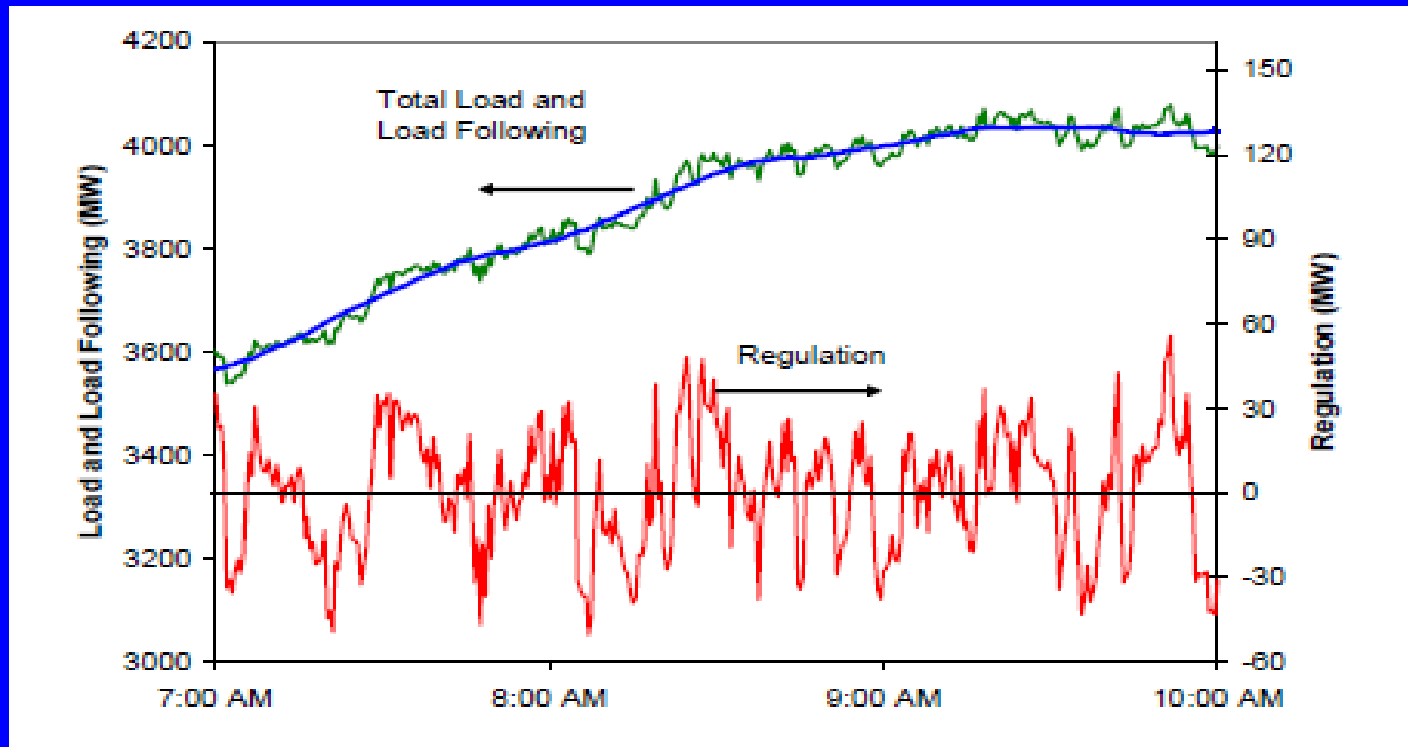
Retrofit L/A Storage: 1.0 MW (GNB, Exide)

Operating Costs \$K	w/o BESS	with BESS
Fuel Oil	4,864	184
Island Delivery	2,039	78
Diesel Maintenance	1,100	400
Replacement	N/A	682
Diesel Operation during Maintenance	N/A	21
<b>Total 1997-2008</b>	<b>8,003</b>	<b>1,364</b>



1MW / 1.4MWh Feb. 1997

# Frequency Regulation



**Old solution:** Fossil fuel generator keeps 5-10% reserve – gets paid for capacity. Response time > duration of fluctuation.



**ARRA Project – Beacon**  
Hazleton, PA.  
20MW Frequency Regulation for PJM.  
Commissioned Aug. 2014

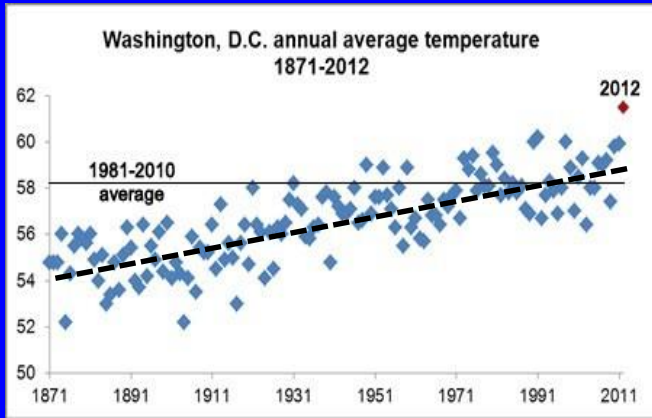
\$K 5,936/year potential revenue  
R. Byrne, SAND 2016-1080C

► 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

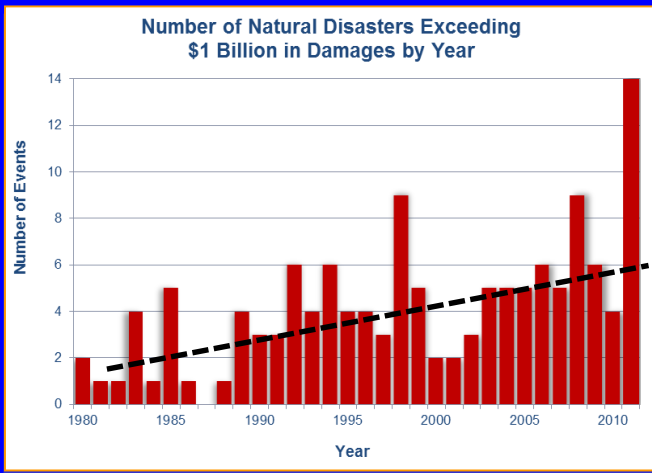
# Designing for Resilience



Florida, Harvey, 2017



Mexico Earthquake 2017



Puerto Rico, Maria 2017



Hawaii 2018

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:

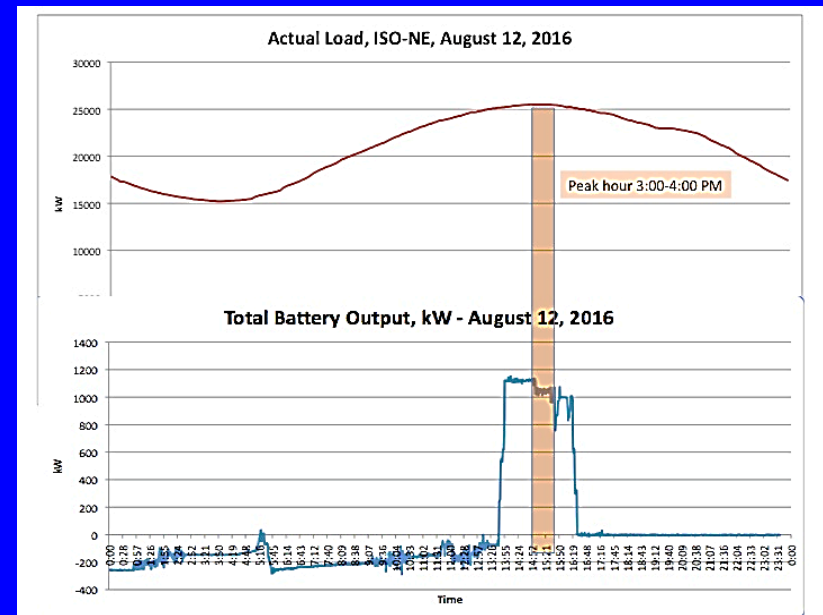
## Regional Network Service (RNS):

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!

# The Vermont Storage Ecosystem :

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.  
\$600,000 saved during August 6 peak!!

- **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

## New at GMP:

Milton, Ferrisburgh, Essex  
Each: 5MW PV + 2MW/8MWh

**Vermont Electric Co-op**  
1.9MW / 5.3MWh,



# 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!

Capital cost: \$2.7M\$@2MW,  
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

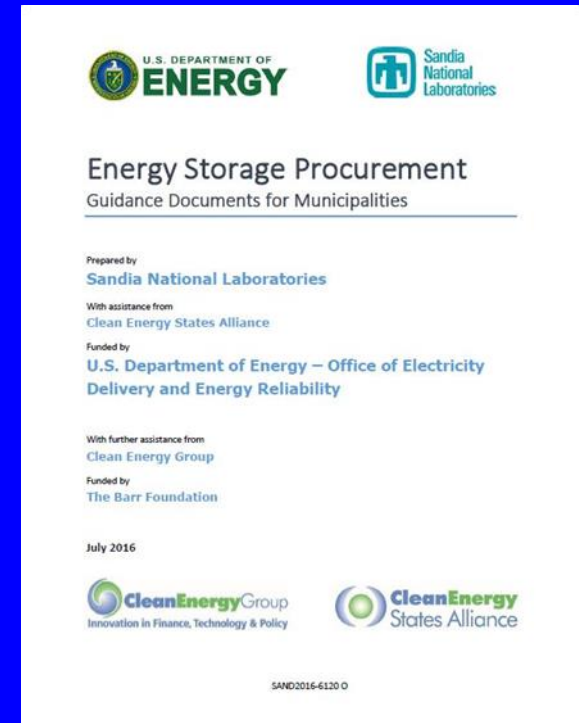
S. Hamilton, Sterling



After 23 Months:  
Saving / month = 32K  
Monthly Maintenance: \$400!!  
Payback: 7 years

# 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](http://www.sandia.gov/ess)  
SAND 2016-8544

*2017 GTM Grid Edge Award!*

**Visitors:** Germany, Switzerland, Denmark, Sweden, England, Ireland, Australia, Japan, Malaysia, Taiwan, Brazil, Chile

# The Massachusetts Storage Ecosystem:

- Sterling Community Project: solar + storage  
2 MWh energy storage with 1 MW community solar
- MMWEC, which serves 42 municipal utilities in MA,  
providing centralized operation and dispatch services
- 7 more MA municipal utilities have resiliency grants with  
storage
- Nantucket, MA with National Grid and Tesla  
Transmission Line Deferral.
- Worcester, MA with National Grid  
With wind power – 500kW/ 3MWh. V/V flow battery. Oct. 4, 2017
- **MA adopts 200 MWh utility energy storage procurement target**

## **Storage Ecosystems in Development:**

Northwest: Washington, (Decatur Island), Oregon (EWEB)

Alaska: Cordoba (Run of River Hydro), Village systems,  
Railbelt

Hawaii: NELHA ...



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!!