Resilience: Building Microgrids with Storage and Renewables that Pay for Themselves!

IMRE GYUK, DIRECTOR, 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!

- WIND
- FOSSIL
- SOLAR PV
- STORAGE
- EV
- LOAD
- ROOFTOP PV
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!
Frequency Regulation
This project provided the basis for FERC to establish “PAY FOR PERFORMANCE”!

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

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

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!

1999 - 2011, PJM utilities spent 48.8 cents per MW of load on frequency regulation

2012 - 2016, PJM utilities spent 24.4 cents per MW of load on frequency regulation

(SE Energy News 2016/11/28)
ARRA - Southern California Edison / LG Chem – Li-Ion:

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

Commissioned: Sept. 2014
Integrator: ABB

Tehachapi: 4,500MW Wind by 2015!

8MW / 32MWh Storage Plant
Energy Storage Systems for Peakshaving, Loadshifting, Ramping

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

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

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

Referenced as model in VT Energy Strategic Plan! New projects planned.  
Testimony to VT Senate. Bill on Storage Initiative passed.
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!
Sterling, MA: Microgrid/Storage Project

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: $1.7M/MW
-simple payback: 6.7 years

<table>
<thead>
<tr>
<th>Description (1MW/1hr)</th>
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<tbody>
<tr>
<td>Arbitrage (buy low, sell high)</td>
<td>13,321</td>
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<tr>
<td>Reduced Monthly Peak</td>
<td>98,707</td>
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<tr>
<td>Reduced Yearly Peak</td>
<td>115,572</td>
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<td>Frequency Regulation</td>
<td>60,476</td>
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<tr>
<td>Total</td>
<td>288,076</td>
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</tbody>
</table>

- **2016** December
- **2017** Feb, March
- **2017** Apr, May
- **2017** June (annual) !!!
- **2017** July

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R. Byrne, Sandia

S. Hamilton, Sterling
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.
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
Electric Power Board of Chattanooga, TN, and DOE Office of Electricity

Delivery

Installation

100kW / 400kWh UET Vanadium Redox Flow Battery
Electrified September 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

Birmingham, AL with Southern Research
Utility Test site - 100kW/500kWh. Conference Sept 28

Eugene, OR, Water & Energy Board
Resiliency Microgrid, 500kW Storage + 125kW PV + Diesel gen sets at 2 aggregated sites

Cordova, AK, Study with ACEP
Hydropower Smoothing, eliminating diesel back-up
Northampton, MA with MA Dept. of Natural Resources and National Grid
Design for microgrid to back up critical infrastructure with storage.

Kona, HI, with NELHA and HELCO
Enabling more solar PV
100kW/500kWh of V/V Batteries

Orcas Island with OPALCO
WA Clean Energy Fund
500kW/4 hour V/V system for resilience

Portland, OR with Portland General
Resilience for Utility supported Data centers
Korean Funding, 2MW/4MWh Li-Ion, Analysis
The Bigger Picture
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.

- Provided information to WA, OR, CA, and MA commissions on valuation of energy storage assets.
- Supporting plenary dockets on energy storage initiated by the Washington UTC and the Oregon PUC.
- Supported CA-ISO in review of storage market rules.
- Testified to VT Senate on potential Storage Mandate.
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 1550 energy storage projects from 60+ countries.
50 energy storage technologies are represented

Partnerships with Australian Energy Storage Alliance

Partnership with EIA on Storage Reporting
<table>
<thead>
<tr>
<th>Category</th>
<th>Employment</th>
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<td>T&amp;D</td>
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<tr>
<td>Pumped Hydro</td>
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<tr>
<td>Other Grid Modernization</td>
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</table>
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!!