



Energy Storage & Electromobility

Opportunities, challenges and requirements of energy storage in distributed power systems

Santiago, Chile

August 13th, 2018

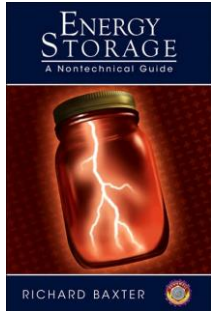
Richard Baxter

President, Mustang Prairie Energy



Richard Baxter, Mustang Prairie Energy

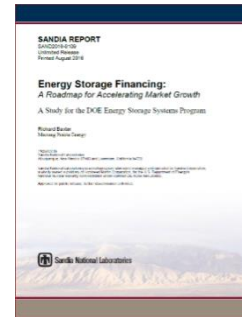
Advisory



**Energy Storage:
A Nontechnical Guide**

- Support Investors, Project Developers, & OEMs
- 18 Years in the industry
- Former Board of Director, Energy Storage Association
- Energy Storage: A Nontechnical Guide (PennWell)

Project Financing



**Energy Storage Financing:
SAND2016-8109**

ACES: Advancing Contracting in Energy Storage

- Best Practice Guides
- Program of California Clean Energy Fund (CalCEF)

System Costs

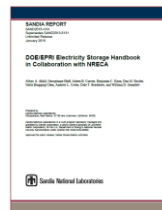
Lazard Levelized Cost of Storage (LCOS)

- Enovation Partners
- LCOS 1.0, 2.0, 3.0



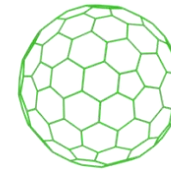
U.S. DOE Energy Storage Handbook - Pricing Survey

- All major technologies
- Capital & Operating costs



Battery Materials

Member, Board of Directors



NOVOCARBON

TSX-V: GLK

Energy Storage & Electromobility

Opportunities

Market
Growth

Renewable /
Storage

Customers

Challenges

Technical:
Safety &
Integration

Economic:
Operate
Profitably

Contract:
Performance
Metrics

Requirements

Revenue
Certainty

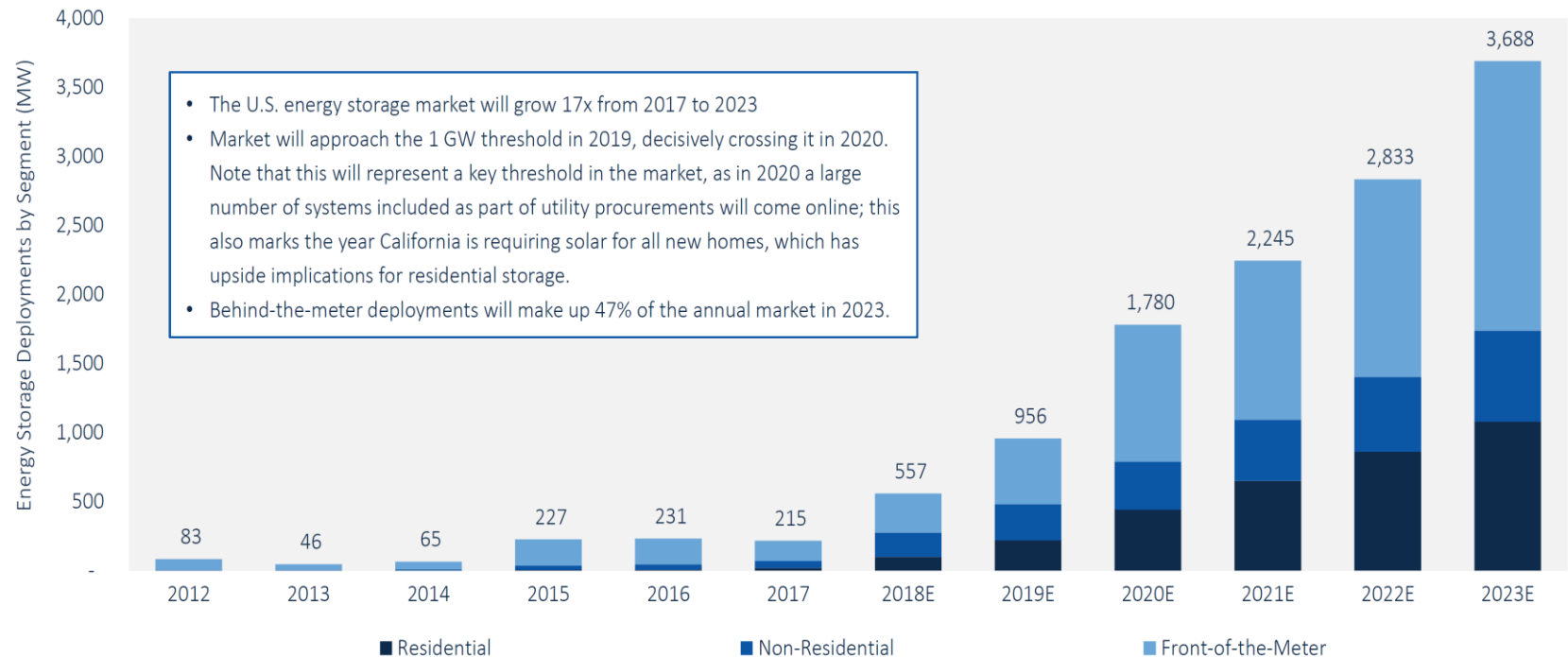
Clear Market
Rules

Technology
Options

Market Growth: Broad Expansion

U.S. Front of the Meter Market Expands Rapidly

U.S. Annual Energy Storage Deployment Forecast, 2012-2023E (MW)

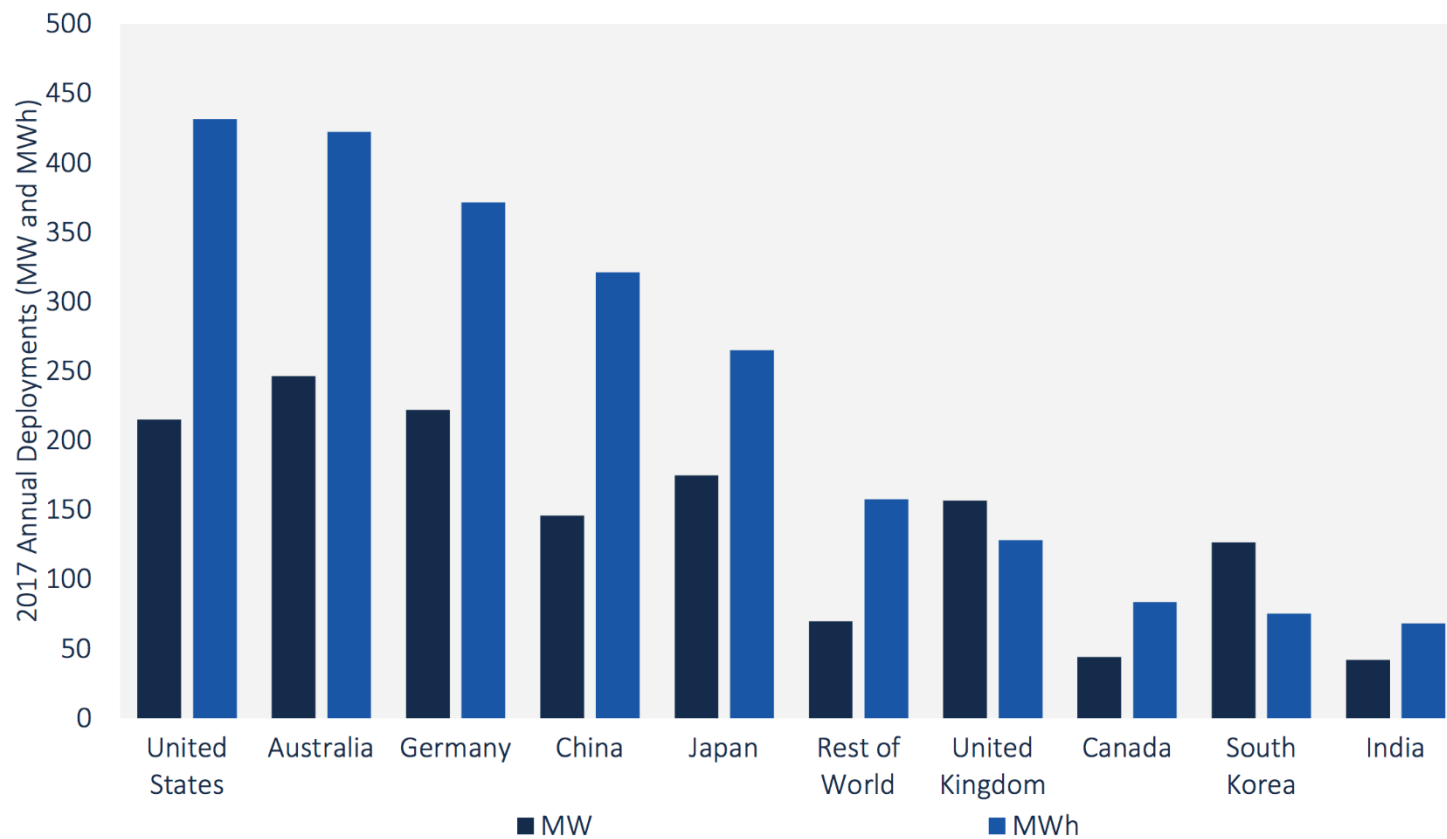


Source: GTM Research

Source: GTM, Energy Storage Monitor, Q2 2018

Market Growth: Global Expansion

Annual Energy Storage Deployments by Market, 2017 (MW and MWh)



Storage/Renewable: Growing Bids For Utility Capacity

Xcel Energy RFP Response: Expanding Bids, Declining Costs Declining

RFP Responses by Technology

Generation Technology	# of		# of	Project	Median Bid	
	Bids	Bid MW			Projects	MW
Combustion Turbine/IC Engines	30	7,141	13	2,466	\$ 4.80	\$/kW-mo
Combustion Turbine with Battery Storage	7	804	3	476	6.20	\$/kW-mo
Gas-Fired Combined Cycles	2	451	2	451		\$/kW-mo
Stand-alone Battery Storage	28	2,143	21	1,614	11.30	\$/kW-mo
Compressed Air Energy Storage	1	317	1	317		\$/kW-mo
Wind	96	42,278	42	17,380	\$ 18.10	\$/MWh
Wind and Solar	5	2,612	4	2,162	19.90	\$/MWh
Wind with Battery Storage	11	5,700	8	5,097	21.00	\$/MWh
Solar (PV)	152	29,710	75	13,435	29.50	\$/MWh
Wind and Solar and Battery Storage	7	4,048	7	4,048	30.60	\$/MWh
Solar (PV) with Battery Storage	87	16,725	59	10,813	36.00	\$/MWh
IC Engine with Solar	1	5	1	5		\$/MWh
Waste Heat	2	21	1	11		\$/MWh
Biomass	1	9	1	9		\$/MWh
Total	430	111,963	238	58,283		

Solar / Storage

- 87 Bids
- 16,725 MW
- \$36/MWh

Wind / Storage

- 11 Bids
- 5,700 MW
- \$21/MWh

Xcel Energy: Public Service Company of Colorado

2016 Electric Resource Plan 2017 All Source Solicitation 30-Day Report

<https://assets.documentcloud.org/documents/4340162/Xcel-Solicitation-Report.pdf>

Customer Opportunities

Variable Demand



- Large Power Swings
- Poor System Inertia
- Power Quality
- Microgrid

Weak Distribution



- Remote Location
- Limited Power
- Curtailment
- Limit Large Scale RE

Peak Shaving



- Demand Charges
- TOU Rates
- PV Power
- Fast Charging EV

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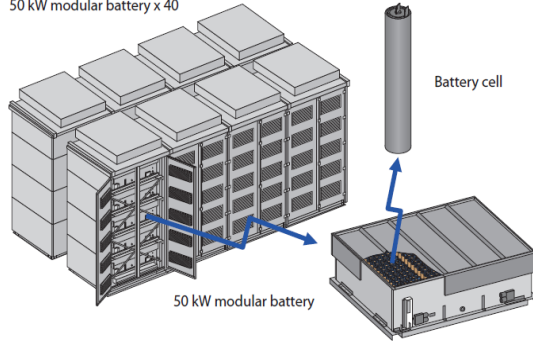
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Lessons Learned: Safety Improvements

NGK Insulators

NAS Battery System (2,000 kW)
50 kW modular battery x 40



Joso City, Ibaraki Prefecture Mitsubishi Materials

2011

- 4 MW Facility
- NAS Sodium Sulfur
- Module Short Circuit

Company Covers Replacement

Beacon Power



Beacon Power Facility Stephentown, NY

2011

- 20 MW Facility – 100kW unit
- Flywheel
- Composite Rotor Failure

Facility Remains in Operation

Xtreme Power



Oahu, HI Kahuka Wind Farm

2012

- 11 MW Facility
- Advanced Lead Acid
- Transformer / Battery Stacks

Business Interruption

System Design, Integration, & Deployment

Design

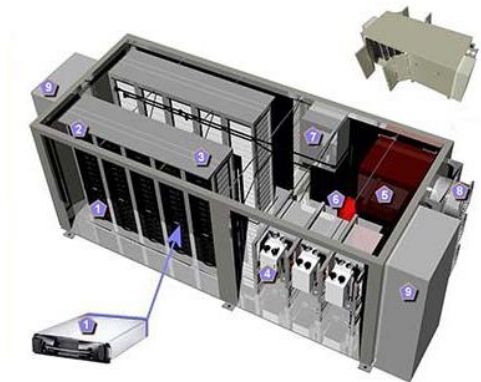
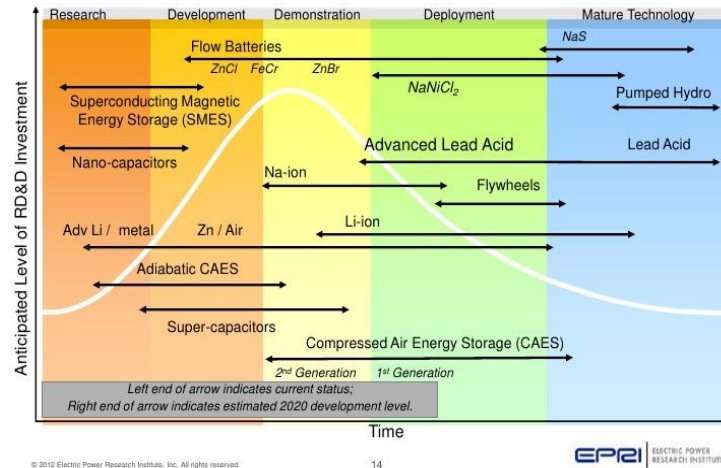
- Technology Characteristics
- Equipment Capability
- Independent Engineering Report

System Integration

- Standards (IEC TC120)
- System Capability Optimization
- Manufacturing

Deployment

- EPC
- Commissioning



Profitable Operations

Costs

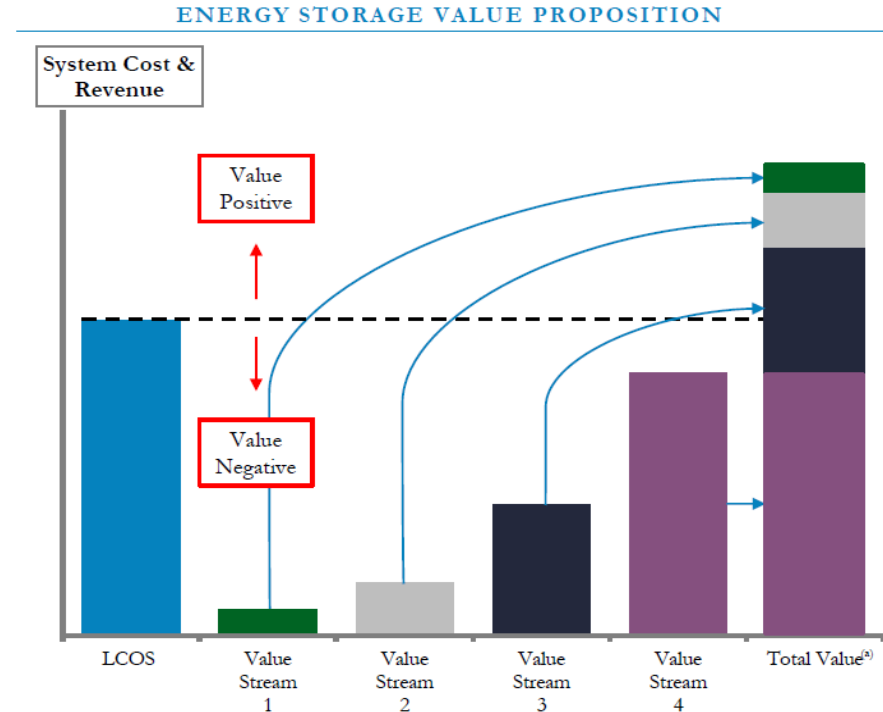
- Equipment
- Augmentation
- Operating
- Project Development

Revenue

- Existing Value Streams
- Emerging Value Streams
- Variability
- Design Implications

Value

- Value Stacking
- Falling Costs
- New Revenue Streams



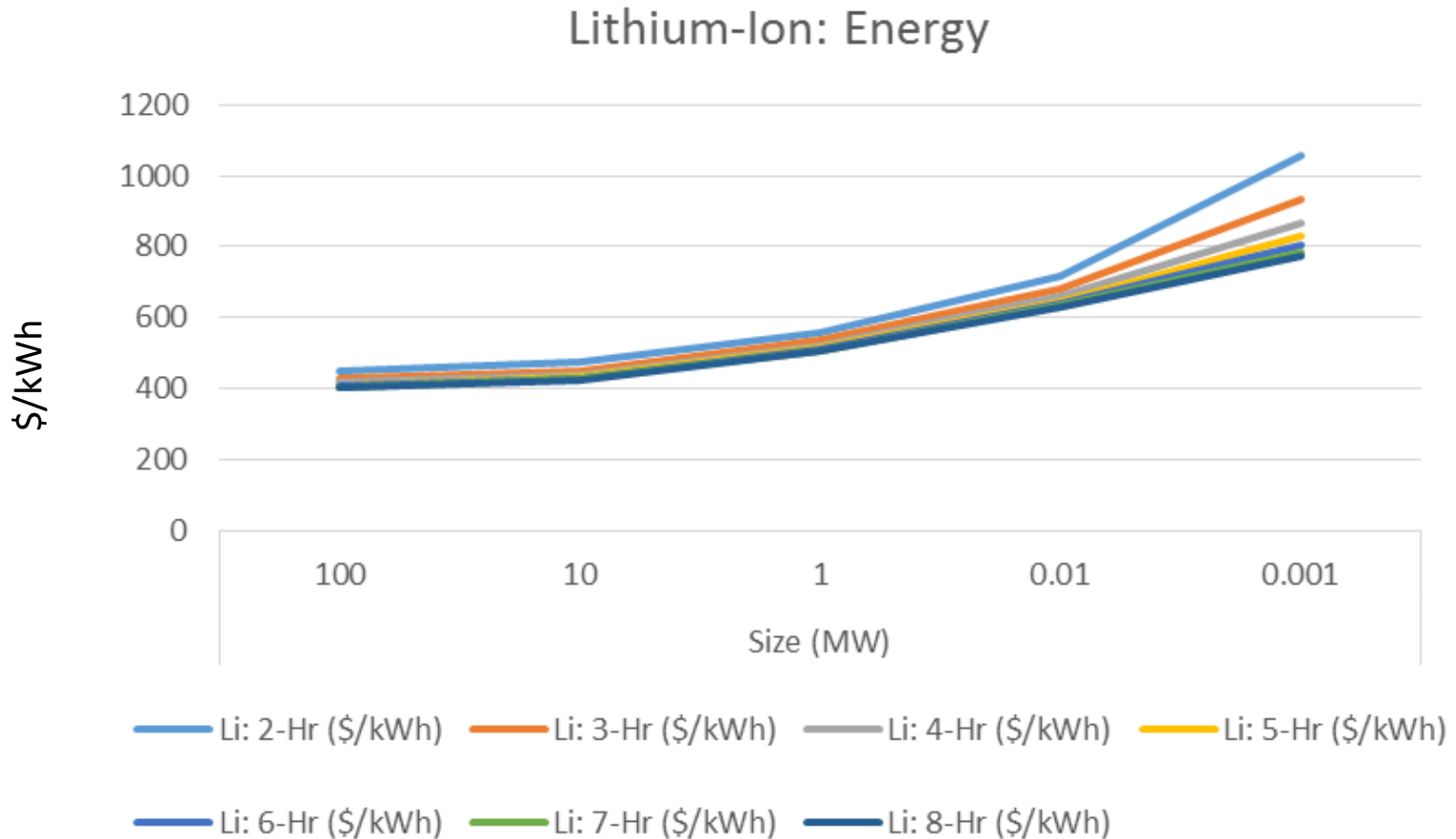
Lazard LCOS 2.0

Risk Management

- Low Probability / High Impact Events

Complete Energy Storage System (ESS) Costs

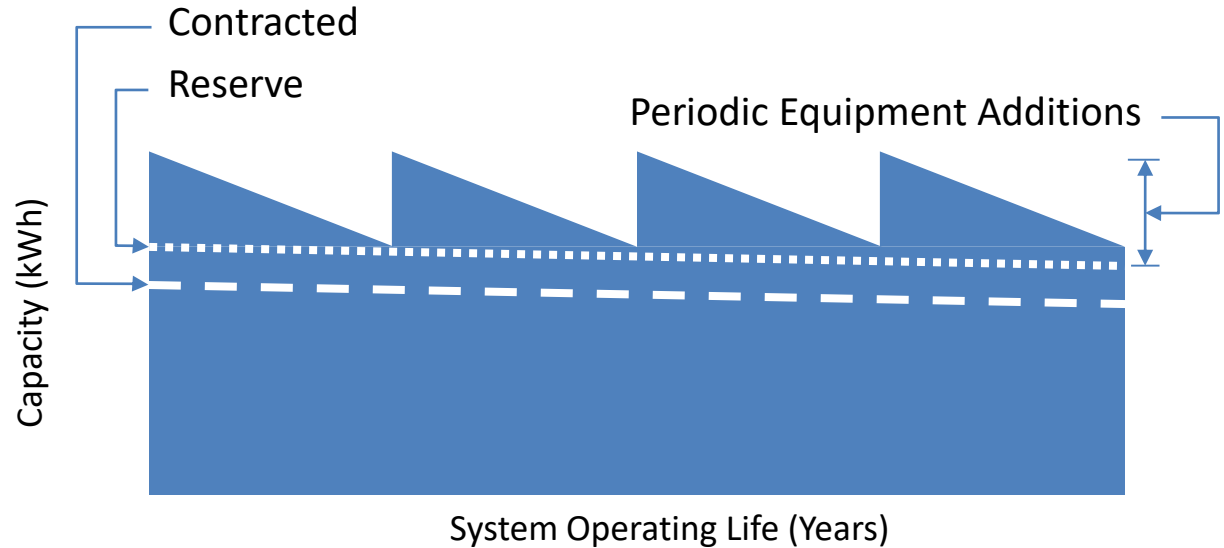
Installed System Costs, 2018 Prices



Economics: Augmentation Cost

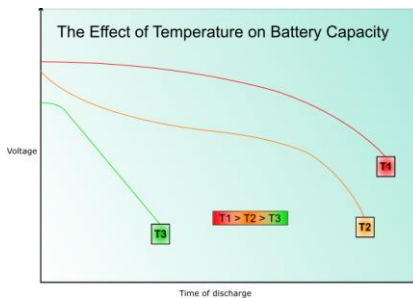
Augmentation

- Oversizing system to sustain rated energy capability
- Periodic additions
- Driven by environmental and usage factors
- Timing of additions impacted by declining equipment costs

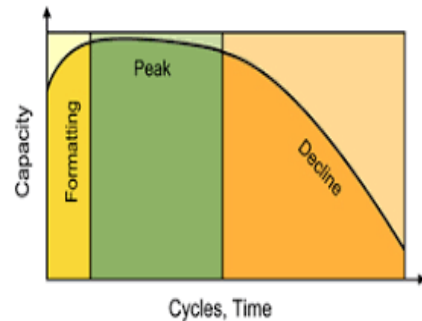


System Degradation Drivers

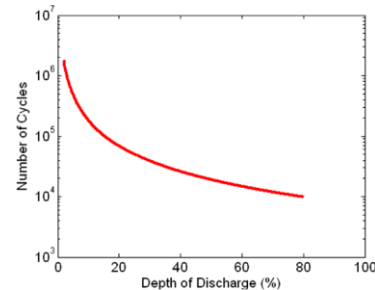
Environment



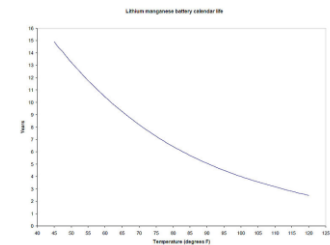
Cycle Life



Depth of Discharge



Calendar Life



Economics: Revenue

Value
Streams

Discrete

Definable

Not Easily
Priced

ISO/RTO Services

- Arbitrage
- Frequency Regulation
- Spin/Non Spin Reserves
- Voltage Support
- Blackstart

Utility Services

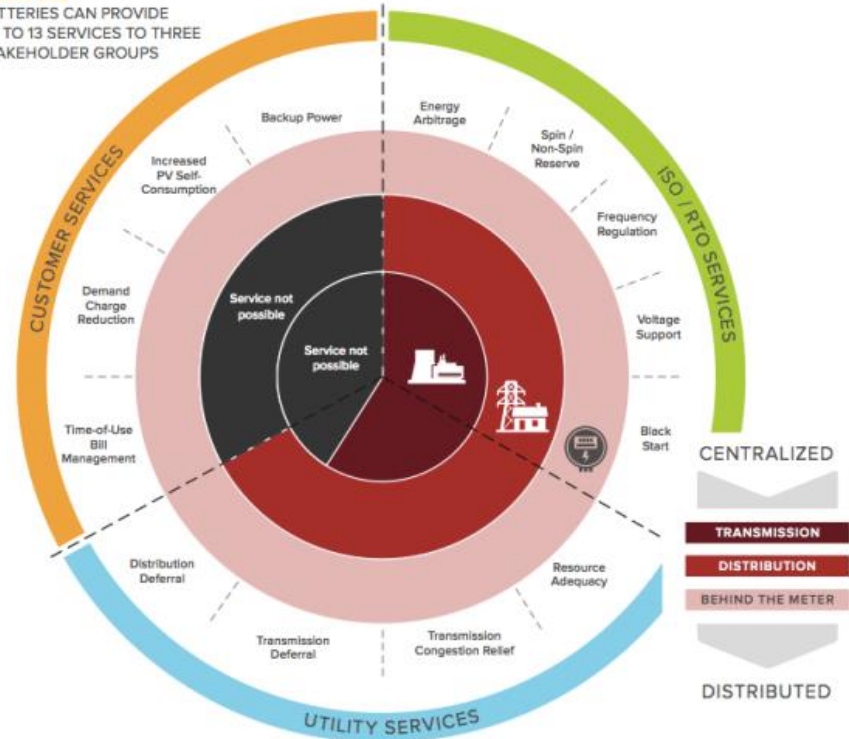
- Resource Adequacy
- Distribution Deferral
- Transmission Congestion Relief
- Transmission Deferral

Customer Services

- TOU Bill Management
- PV Self Consumption
- Demand Charge Reduction
- Back-up Power

FIGURE ES2

BATTERIES CAN PROVIDE UP TO 13 SERVICES TO THREE STAKEHOLDER GROUPS



THE ECONOMICS OF BATTERY ENERGY STORAGE | 6

Contracts: Performance Metrics

- PJM – Frequently Regulation, RegD Market
- Performance Score (Accuracy, Delay, & Precision)
- 2015 - RES Americas, “Jake” & “Elwood” FR plants
- Performance Score & Hedge → Revenue Guarantee
- Financing through Prudential & Lincoln National Life Ins. Co.

PJM – Average Performance Score



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Thank You



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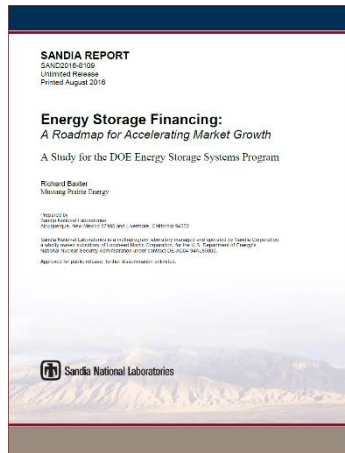
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@MustangPrairie

Report Series: Energy Storage Financing

Energy Storage Financing: A Roadmap for Accelerating Market Growth

SAND2016-8109

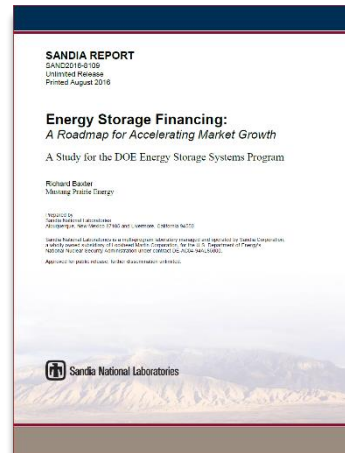


Reduce Barriers of Entry

- New Lenders
- Managing Risk
- Mapping Storage Financing to Traditional Financing

Energy Storage Financing: Performance Impacts on Project Financing

SAND2017-xxxx

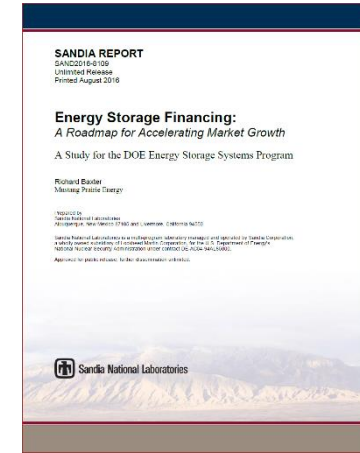


Promote Access to Capital

- De-Risk Project Development
- Financeable Performance Metrics
- Performance Insurance

Energy Storage Financing: Advancing Contracts in Energy Storage

SAND2018-xxxx



Improve Documentation

- Project Documents
- Enabling Efforts
- Contract Language

Additional Resources

U.S. Department of Energy, Energy Storage Systems: Publications

- <http://www.sandia.gov/ess/publication/>

Protocol for Uniformly Measuring and Expressing the Performance of Energy Storage Systems

- <http://energymaterials.pnnl.gov/pdf/PNNL-22010Rev2.pdf>

Energy Storage Safety

- <http://www.sandia.gov/ess/resources/energy-storage-safety/>

DOE/EPRI Electricity Storage Handbook with NRECA

- <http://www.sandia.gov/ess/publications/SAND2015-1002.pdf>

Global U.S. DOE Energy Storage Database

- <https://www.energystorageexchange.org/>

Energy Storage Financing

- Energy Storage Financing: *A Roadmap for Accelerating Market Growth* ([SAND2016-8109.pdf](#))
- Energy Storage Financing: *Performance Impacts on Project Financing* – 2017:Q4 [SAND2017-xxxx]

Additional Resources (Cont.)

Energy Storage Technology Advancement Partnership

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

Energy Storage Procurement Guidance Documents for Municipalities

- <http://www.cesa.org/assets/2016-Files/Energy-Storage-Procurement-Guidance-Document.pdf>

Commissioning Energy Storage

- <http://www.cesa.org/assets/Uploads/ESTAP-Webinar-Slides-5.20.14.pdf>

Lazard Levelized Cost of Storage (LCOS) Survey

- LCOS 1.0: <https://www.lazard.com/perspective/levelized-cost-of-storage-analysis-10/>
- LCOS 2.0: <https://www.lazard.com/perspective/levelized-cost-of-storage-analysis-20/>
- LCOS 3.0: <https://www.lazard.com/perspective/levelized-cost-of-storage-analysis-30/> (Nov 2017)

DNV GL: Safety, operation and performance of grid-connected energy storage systems

- <https://rules.dnvgl.com/docs/pdf/DNVGL/RP/2015-12/DNVGL-RP-0043.pdf>

NECA 416 – 2016, Recommended Practice for Installing Energy Storage Systems

- <https://www.necanet.org/store/product/neca-416-2016-recommended-practice-for-installing-energy-storage-systems-416-16>

Additional Resources (Cont.)

International Electrotechnical Commission TC120 – Electrical Energy Storage Systems

- http://www.iec.ch/dyn/www/f?p=103:7:0::::FSP_ORG_ID:9463

NEC 2017 – Article 706: Energy Storage Systems

- <https://www.necanet.org/docs/default-source/default-document-library/2015-academy-working-group---slides.pdf?sfvrsn=0>

NECA – Energy Storage Systems & Microgrids

- http://www.neca-now.com/wp-content/uploads/Energy-Leadership-Storage-Systems_Johnston_0830-1000_032917.pdf