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Energy Storage Grand Challenge

Use Case Overview

April 23, 2020

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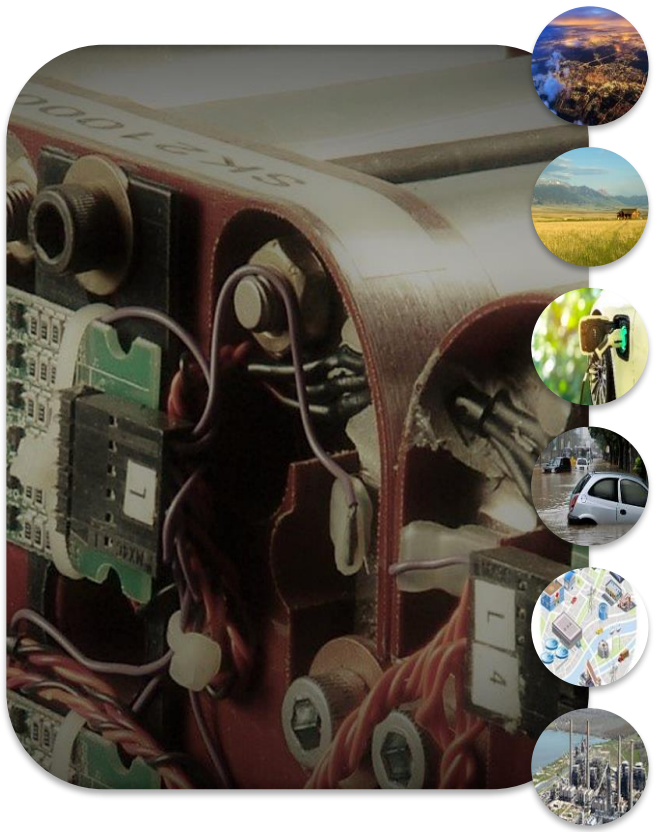
Presentation Outline

- **Use Case Framework and Details**
  - Facilitating An Evolving Grid
  - Serving Remote Communities
  - Electrified Mobility
  - Interdependent Network Infrastructure
  - Disaster Resilience and Recovery
  - Facility Flexibility, Efficiency and Value Enhancement
- **Technology Portfolio: A 2030 Scenario**
- **Accelerated Pathways**

Use Case Mapping to Technology Pathways

"Guidepost" Use Cases



- Facilitating An Evolving Grid
- Serving Remote Communities
- Electrified Mobility
- Critical Service Resilience
- Interdependent Network Infrastructure
- Facility Flexibility, Efficiency and Value Enhancement

Tech Neutral Requirements

Performance	• Duration • Cycles per Year • Ramp Rate • Response Time • Lifetime
Operations	• Temperature • Moisture • Saline Resistance • Emissions Runtime • Noise Limits • Flammability Risk
Delivery, Installation, Connection	• Shipping weight limits • Construction season • Interconnection voltage

Technology Pathways

- Bidirectional Electrical Storage
- Flexible Generation and Controllable Loads
- Chemical and Thermal Storage

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1. Facilitating an Evolving Grid

Scope
- The U.S. electric power system

Major Drivers
- Increasing adoption of variable renewable energy
- Dynamic changes in customer demand
- Weather, physical, and cyber threats

Success Statement
- Cost-effective storage, flexibility, and enabling technology solutions to maintain and enhance the provision of electricity services to end users as the grid increases in complexity and diversity.

Beneficiaries
- Utilities, balancing authorities
- Localities, states, regions
  - With high carbon-free electricity mandates
  - Facing increasing external threats

Brattle estimated the benefit of distribution investment deferral at $14/kW-year [in Texas]; Edgette et al. estimated $104/kW-year [in Minnesota]; Maitra et al. estimated $9/kW-year [in the LADWP area]

Balducci, Patrick J., et al. "Assigning value to energy storage systems at multiple points in an electrical grid." Energy & Environmental Science 11.8 (2018): 1926-1944.

"…energy storage capacity costs below a roughly $20/kWh target would allow a wind-solar mix to provide cost-competitive baseload electricity in resource-abundant locations…"

Ziegler, Micah S., et al. "Storage requirements and costs of shaping renewable energy Toward grid decarbonization." Joule 3.9 (2019): 2134-2153.

2. Serving Remote Communities

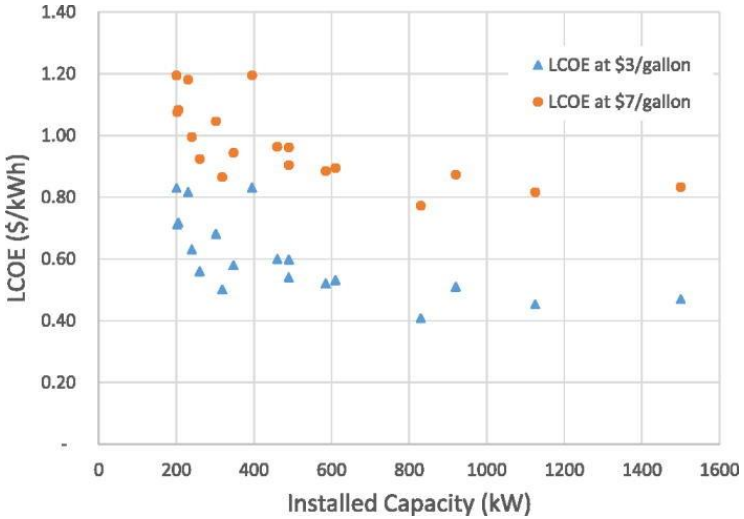
Scope
- Island, coastal, and remote communities

Major Drivers
- Electricity premium due to fuel logistics and maintenance
- Fuel supply disruptions

Success Statement
- Clean, resilient, and cost-effective storage and flexibility solutions to provide electricity for critical and beneficial public services.

Beneficiaries
- Communities
  - without current electrical infrastructure
  - power provided by delivered fuel
  - bulk power connections are not practical or economically unfeasible
- Remote Department of Defense locations
- Grid connected regions to improve local resiliency and flexibility

Levelized cost of electricity for Alaskan Communities under different fuel costs



Nathan Green; Marc Mueller-Stoffels; Erin Whitney; Journal of Renewable and Sustainable Energy 9, 061701 (2017) DOI: 10.1063/1.4986585

2 WEEKS READY
Follow us on Facebook
https://www.facebook.com/2WeeksReady

"Oregon's Office of Emergency Management encourages people to be prepared to be on their own for a minimum of two weeks."

https://www.oregon.gov/OEM/hazardsprep/Pages/2-Weeks-Ready.aspx

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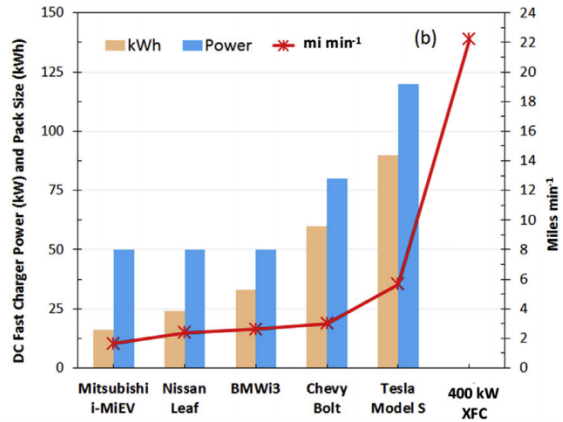
3. Electrified Mobility

Scope
- Charging infrastructure
- Energy storage systems for electric vehicles

Major Drivers
- Fast charging can stress the delivery capacity of the local distribution grid
- Opportunity for lower manufacturing costs and improved performance of electric vehicle batteries

Success Statement
- Clean and cost-effective storage solutions that facilitate a large-scale adoption of electric vehicles while maximizing beneficial coordination with the power grid.

Beneficiaries
- Fleet owners, including
  - Department of Defense
  - Delivery companies, logistics operators
  - Emergency and first responders
- Electric utilities
- End consumers
- New business models, such as charging station operators



"During high use times, multiple XFC events may occur either simultaneously at a single location or back-to-back at the same location. An effective energy storage solution would need to be able to buffer both the power and energy demands of such a station."

USDOE, "Enabling Fast Charging: A Technology Gap Assessment" October 2017

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4. Interdependent Network Infrastructure

Scope

- Other infrastructure sectors critical to the electric grid, including
  - Natural gas and water
  - Communications, information technology, financial services

Major Drivers

- Interdependencies mean loss of function and service within these infrastructure can have far-reaching costs and impacts

Success Statement

- Cost-effective storage solutions that sustain and enhance normal operations amidst short term disruptions of energy inputs.

Beneficiaries

- Owner-operators of critical infrastructure equipment and systems

"Most telecommunications facilities have at least eight-hour backup— often required by regulation—but locations prone to lengthy power outages, such as hurricane-prone areas, require backup capability between 24 and 72 hours."

https://www.hydrogen.energy.gov/pdfs/44520.pdf

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5. Critical Service Resilience

Scope

- Critical sectors, including:
  - Defense
  - Emergency Services
  - Government Facilities
  - Healthcare and Public Health
- Companies, manufacturers, who need to maintain operations

Major Drivers

- Disaster-related and other power outages

Success Statement

- Cost-effective storage solutions that maintain critical services for a sufficient duration following extended power outages.

Beneficiaries

- Owners, operators, and users of critical sector facilities
- Residents and businesses relying on critical services

"At a minimum MDLARA will require that sufficient on-site fuel storage be available to provide… demand for at least 24 hours."

Michigan Department of Licensing & Regulatory Affairs
Requirements For Emergency Fuel In Hospitals
https://www.michigan.gov/documents/mdch/Emergency_Fuel_and_Water_Supply_for_Hospitals_199271_7.pdf

Requirements regarding onsite fuel source during emergency [for FL Assisted Living Facilities]:

- 16 beds or less = 48 hours
- 17 or more beds = 72 hours

http://jchc.virginia.gov/5.%20Assisted%20Living%20Facilities%20-%20Generator%20Requirement%20FINAL.pdf

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6. Facility Flexibility, Efficiency and Value Enhancement

Scope	• Commercial and Residential Buildings
Major Drivers	• Enhance the overall facility value to the owner, operator and the end consumer
Success Statement	• Storage and flexibility solutions that deliver net benefits including energy expenditures, comfort, and functionality.
Beneficiaries	• Commercial and residential building owners, operators, and occupants

"In an effort to save taxpayers money…GSA has enrolled approximately 25 MW of load in demand response programs and receives about $1 million in annual benefits." [$40/kw-yr equiv.]

https://www.ferc.gov/legal/staff-reports/2019/DR-AM-Report2019.pdf

Scope	• Energy-Intensive Facilities, including
	  • Electric Power Generation
	  • Industrial Process Applications

Major Drivers	• Opportunities for improvement in economics, flexibility, and market diversity
Success Statement	• Storage and flexibility solutions that maximize the total value obtained from the process of interest.
Beneficiaries	• Utility plant owners, operators and shareholders • Industry plant owners, operators, and shareholders

"Upgrades to increase the maximum output, decrease the minimum output, increase the ramp limit, and combinations of all features would lead to a greater increase in net revenues under…a recent proposal by PJM to reform its reserve market."

https://www.eme.psu.edu/sites/www.eme.psu.edu/files/rewarding_flexibility_pjm_final_1.pdf

U.S. Storage Industry 2030 Scenario