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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**



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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

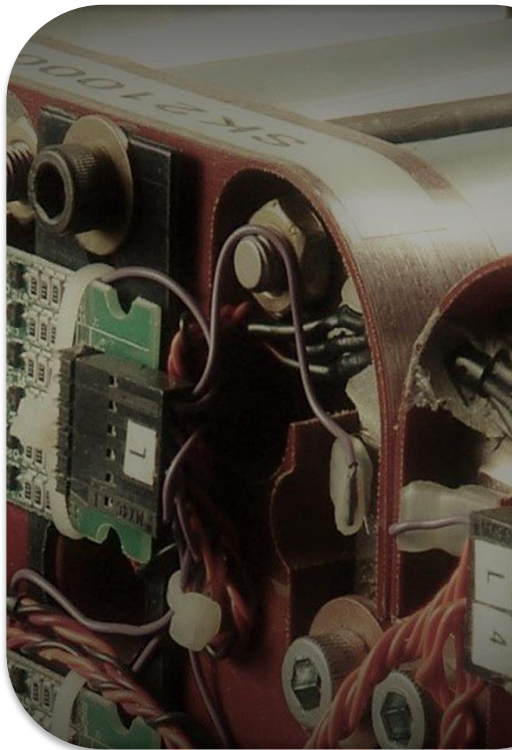
- Shipping weight limits
- Construction season
- Interconnection voltage

Technology Pathways

Bidirectional Electrical Storage

Flexible Generation and Controllable Loads

Chemical and Thermal Storage





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.



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2. Serving Remote Communities

Scope

- Island, coastal, and remote communities

Major Drivers

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

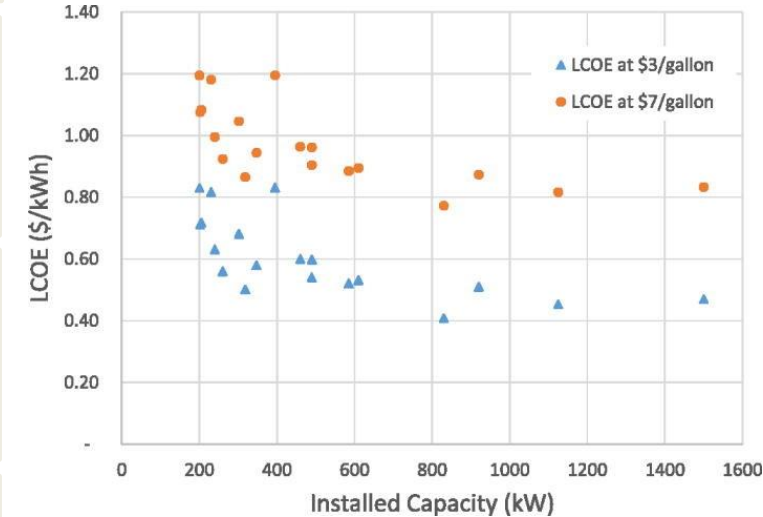
Success Statement

- 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



“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>



3. Electrified Mobility

Scope

- Charging infrastructure
- Energy storage systems for electric vehicles

Major Drivers

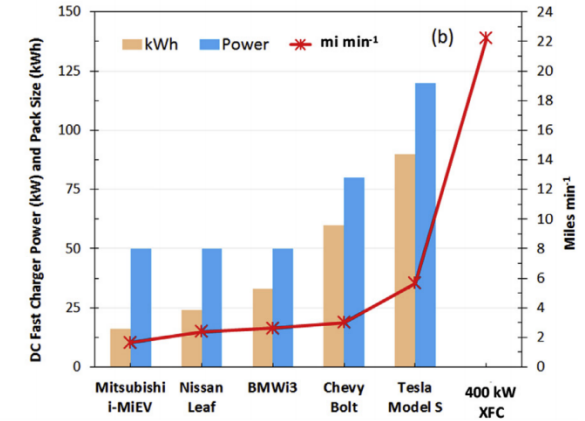
- Fast charging can stress the delivery capacity of the local distribution grid
- Opportunity for lower manufacturing costs and improved performance of electric vehicle batteries

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



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>



5. Critical Service Resilience

Scope

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

“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

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.

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

Beneficiaries

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



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



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U.S. Storage Industry 2030 Scenario

Use Case 1 Use Case 2 Use Case 6

2030: \$6-\$20 billion annual U.S. market for stationary storage

Firm 1 Firm 2 ... Firm 60

Demo 1 Demo 2 Demo 90

Bidirectional

Chemical & Thermal

Flex Gen and Load

Tech Pathway 1
Tech Pathway 2
...
Tech Pathway n

Tech Pathway 1
Tech Pathway 2
...
Tech Pathway n

Tech Pathway 1
Tech Pathway 2
...
Tech Pathway n

Tech Pathway X

- Wide Bankability
- High-Value Deployments
- Market Access
- Commercial Validation
- Large Scale Testing
- Controls Interop.
- Scalable Manufacture
- Component Validation
- Device Prototyping
- Materials scaling
- Materials R&D
- Foundational Science