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# Energy Storage Grand Challenge

## Use Case Overview

February 24, 2020

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# Presentation Outline

- **Use Case Process**
- **Connections to Technology Pathways**
- **Use Case Details**
  - Facilitating An Evolving Grid
  - Serving Remote Communities
  - Electrified Mobility
  - Interdependent Network Infrastructure
  - Resilience and Recovery
  - Facility Flexibility, Efficiency and Value Enhancement

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# Technology Development: A Use Case-Informed R&D Strategy

## Vision

- What are your energy or infrastructure goals?
  - Home, business, community, regional
  - Potentially accelerated with next-generation storage

## Use Cases

- Who are the beneficiaries?
- What are the performance requirements?
- What are other technical or deployment constraints?

## Technologies

- What technologies could meet the use case need?
- Can substantial progress (cost, performance) be made by 2030?

## Pathways

- What is the R&D pathway to achieving commercial viability?
- What DOE resources (consortia, partnerships, test facilities, programs) would be utilized to accelerate each technology?

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# Use Case Families

Facilitating An Evolving Grid

Serving Remote Communities

Electrified Mobility

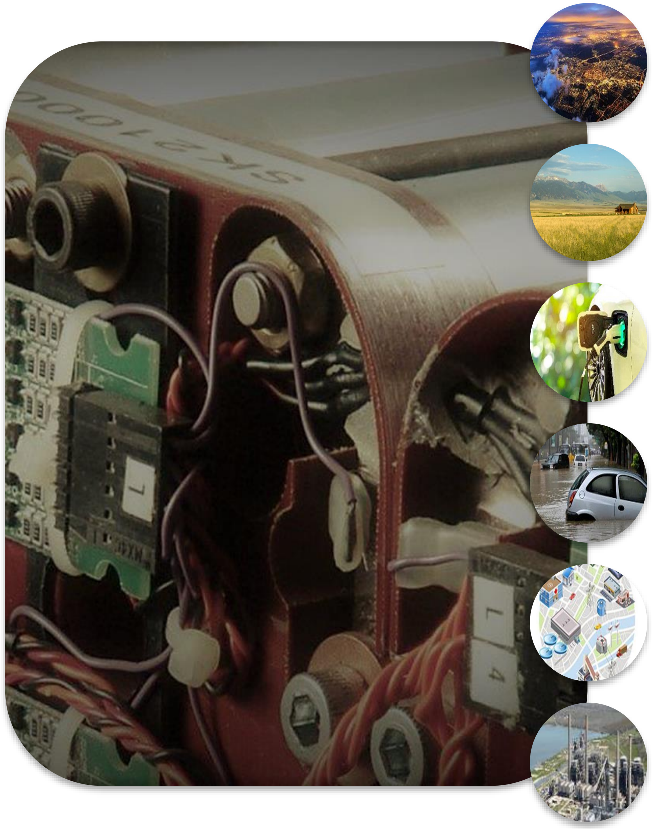
Interdependent Network Infrastructure

Resilience and Recovery

Facility Flexibility, Efficiency and Value Enhancement

# Use Case Mapping to Technology Pathways

## "Guidepost" Use Cases → Tech Neutral Requirements → Technology Pathways



### "Guidepost" Use Cases

- Facilitating An Evolving Grid
- Serving Remote Communities
- Electrified Mobility
- Disaster Resilience and Recovery
- 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
- Thermal and Chemical Storage
- Flexible Generation and Controllable Load
- Balance of Plant and Power Electronics

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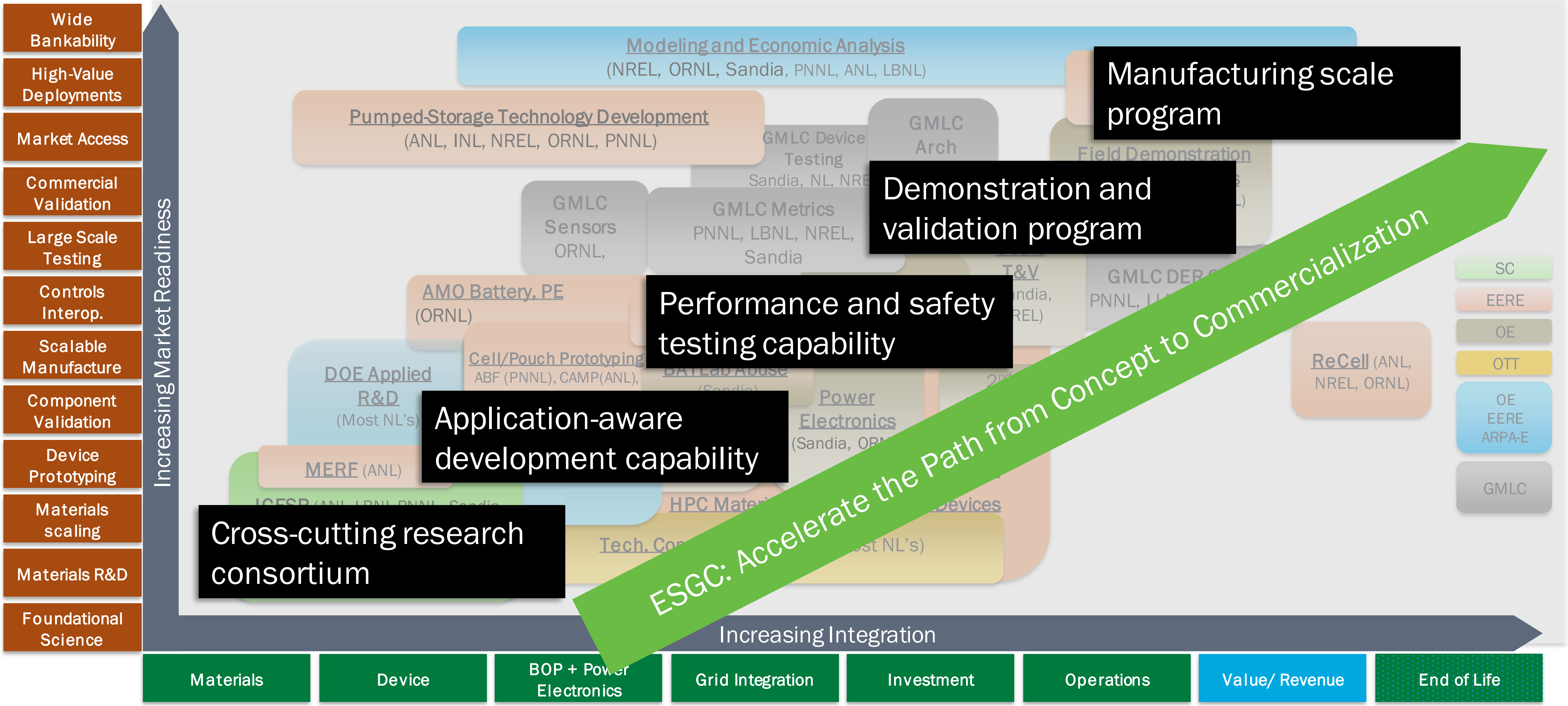
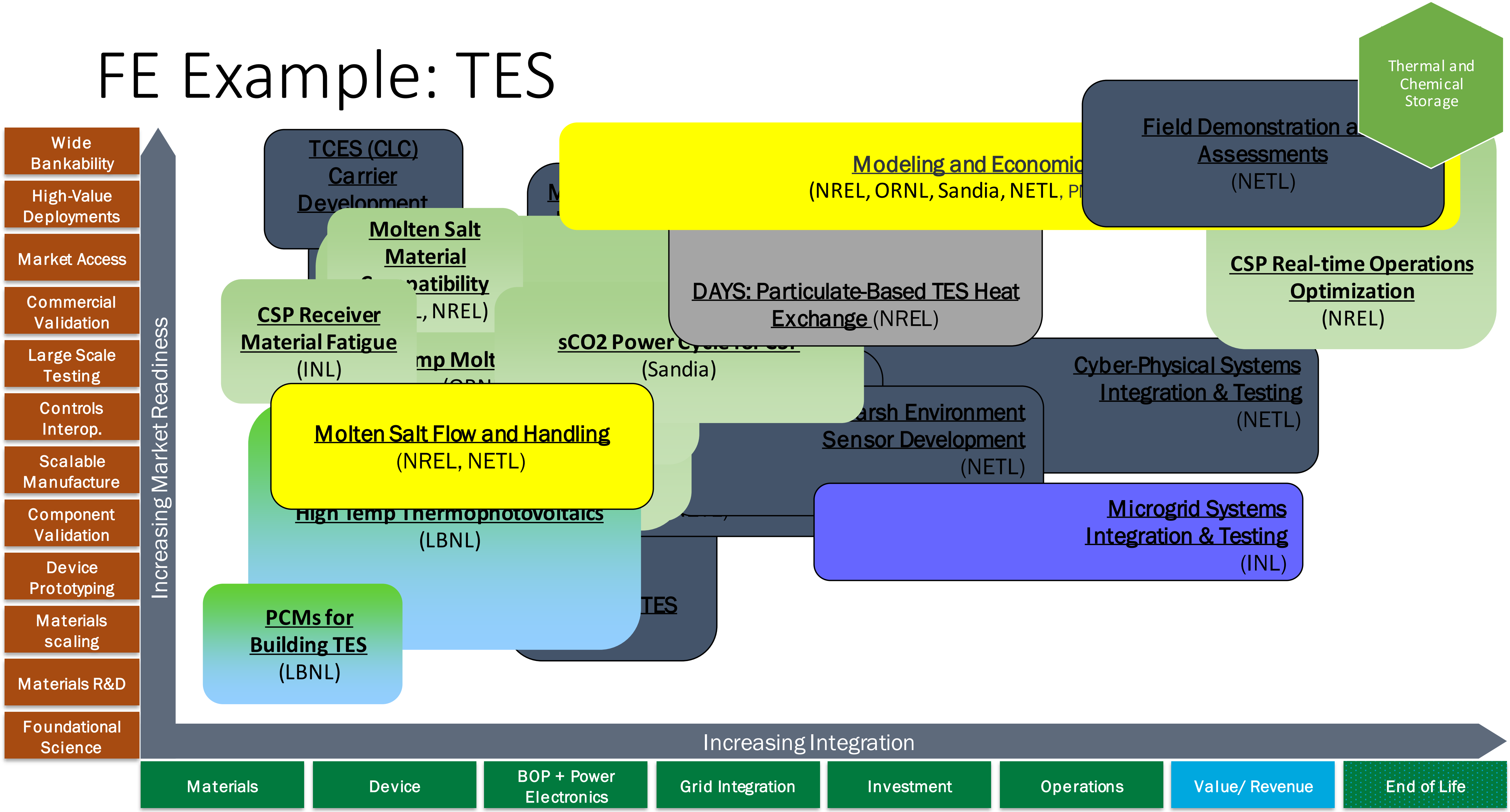
# Technology Pathways: Concept to Commercialization

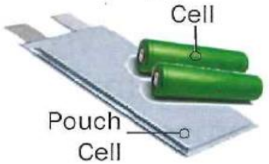
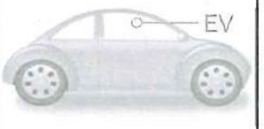


# FE Example: TES



Bidirectional Electrical Storage

# DOE's Ongoing Work Related to EV Battery Development

| Raw Materials Production | Materials R&D and Processing | Cell R&D and Manufacturing | Pack Manufacturing | EV Manufacturing | End of Life Recycling |
|---|---|---|---|---|---|
|  Lithium<br>Cobalt<br>Nickel<br>Graphite |  Cathode Powder<br>Anode Powder |  Cylindrical Cell<br>Pouch Cell | EV Battery Pack  |  EV | |
| CMI | Low-No Cobalt Cathode<br>SEISta Silicon Electrolyte Interface Stabilization<br>MERF @ Argonne National Laboratory<br>Battery 500 Consortium | USABC United States Advanced Battery Consortium LLC<br>XCEL eXtreme Fast Charge Cell Evaluation of Lithium-ion Batteries<br>CAMP @ Argonne National Laboratory<br>BMF @ Oak Ridge National Laboratory<br>Battery 500 Consortium | LPO Loan Programs Office | | ReCell Advanced Battery Recycling<br>American Made Battery Recycling Prize U.S. Department of Energy |

# OE Example: Electrochemical Storage

Bidirectional Electrical Storage

Balance of Plant and Power Electronics

**Energy Storage Research Center, Southern Research**
- Vendor and pre-deployment system validation
- Scale: turnkey systems

***Validated Integration***

**Grid Research Integration and Deployment Center, ORNL**
- System-level dynamic and efficient interactions
- Scale: batteries + power electronics to systems

***Devices to Systems***

**Battery Abuse, Testing Lab, SNL**
- Power electronics and energy storage system safety
- Scale: Packs and modules to systems

***Systems Integration***

**Grid Storage Launchpad, PNNL**
- Performance Validation of Storage Electrochemistries
- Scale: “Button-cell” to 100 KW

***Materials to Devices***

Increasing Market Readiness:

- 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

Increasing Integration:

| Materials | Device | BOP + Power Electronics | Grid Integration | Investment | Operations | Value/ Revenue | End of Life |
|---|---|---|---|---|---|---|---|

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# Potential Benefits of High-Power, High-Capacity Batteries

## APPENDIX B: DOE Battery Technology Activities

DOE is undertaking a range of R&D activities to increase the ability of batteries to provide higher power and longer duration capabilities. Not every storage or battery technology is represented in the following sections. Rather, this summary focuses on those technologies that are currently being deployed or are active research areas within the DOE program offices. DOE research in electrical energy storage is coordinated by Federal staff participation in cross-DOE program and proposal reviews, advisory committee meetings, responses to congressional requests, and regular meetings that include office leadership. In its fiscal year 2020 budget, DOE proposed the Advanced Energy Storage Initiative, which seeks to establish stronger cross-office activities and shared technology targets.

### Lithium-ion Batteries

#### *Ability to Provide Functional Requirements*

Lithium-ion batteries are one of the most widely used technologies for portable electronics due to their high energy density and cycling performance. These systems store electrical energy in electrodes that can accommodate lithium within their atomic structure, called intercalation or insertion compounds. Most commercial lithium-ion batteries are generally comprised of a

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# Facilitating an Evolving Grid

- **Introduction and Scope**
  - The ability of the United States (U.S.) electric power system (i.e., the electric grid) to reliably meet customer demand is crucial to our economy and national security. The increasing adoption of variable renewable energy (VRE) and dynamic changes in customer demand, as well as stresses from weather, physical, and cyber threats are creating the need for enhanced grid flexibility to ensure the continued reliability, resilience, and security of the electric power system. These evolving opportunities and risk factors require an expanded set of storage and flexibility solutions.
- **Success Statement**
  - If the Facilitating an Evolving Grid use case is successful, grid owners, operators, planners, and users will have access to 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.

**Use Case Example**

- California Public Utilities Commission (CPUC) predicts that 11-19 GW of additional storage will be needed in the state by 2030 to shift expected amount of solar generation for nighttime

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# Serving Remote Communities

- **Introduction and Scope**
  – Up to a billion people in the world do not have access to electricity. Island, coastal, and remote communities that are disconnected from the bulk power system pay a premium for electricity due to fuel logistics and maintenance associated with diesel generation. In remote communities' subject to extreme weather conditions, fuel supply disruptions are a major risk factor.
- **Success Statement**
  – If the Remote Environments use case is successful, remote communities will have access to clean, resilient, and cost-effective storage and flexibility solutions to provide electricity for critical and beneficial public services.

**Use Case Example**

- Alaska Energy Authority with grant from EPA is looking at replacing 8 antiquated diesel gensets with new Tier 2/3 gensets for an estimated reduction of 3.11 tons of nitrogen oxides, 1.74 tons of particulate matter, 0.68 tons of hydrocarbons, 4.68 tons of carbon monoxide, and 121.77 tons of carbon dioxide each year.

# Disaster Resilience and Recovery

- **Introduction and Scope**
  - Sectors that provide critical services include the Defense Industrial Base Sector; the Emergency Services Sector; Government Facilities Sector; and Healthcare and Public Health Sector. An extended loss of power to facilities in these sectors could lead to unacceptable public health and safety risks, especially following disaster-related power outages. Similarly, non-public companies or manufacturers have a need to resume and maintain operations in the event of an extended outage. The importance of these services reinforces the need to provide sufficient energy supplies to these facilities during an extended outage.
- **Success Statement**
  - If the Resilience and Recovery use case is successful, critical public service providers will have access to cost-effective storage solutions that maintain critical services for a sufficient duration following extended power outages.

**Use Case Example**

- For next 5 years, 2 Michigan utilities plan to spend $1.6 billion/year on infrastructure upgrades focused on resilience

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# Electrified Mobility

- **Introduction and Scope**
  - Transportation of people and goods is transitioning to increased electrification. To facilitate this transition, there is a need for wide scale, reliable, high power and cost effective charging infrastructure, enabling charging times equivalent to that of refueling at a traditional gas station. Because high power DC fast charging can stress the delivery capacity of the local distribution grid, this new charging infrastructure should minimize any negative grid impact and optimize operations with the grid and other end uses, including buildings. This infrastructure should be planned to account for population, transportation, and grid evolutions. This use case also considers the specific cases of electrified mobility under stress scenarios such as weather-related emergency evacuation needs, and the stationary adaptation of batteries originally developed for vehicles.
- **Success Statement**
  - If the Electrified Mobility use case is successful, transportation and electricity providers will have access to clean and cost-effective storage solutions that facilitate a large-scale adoption of electric vehicles while maximizing beneficial coordination with the power grid.

**Use Case Example**

- "After 2020, Dominion Energy will add **200 electric school buses** per year for the next 5 years, with the goal being to reach a 50% electric bus fleet — 1,000 electric school buses — by 2025. The aim is to reach 100% electric school buses by 2030."

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# Interdependent Network Infrastructure

- **Introduction and Scope**
  - The operation of the electric grid depends on other infrastructure sectors, including natural gas, communications, information technology, water, and financial services. Loss of function and service within these infrastructure due to energy delivery disruption can have far-reaching costs and impacts for end users. These interdependencies elevate the importance of sustaining the normal operations of critical infrastructure amidst short term disruption of energy inputs.
- **Success Statement**
  - If the Interdependent Network Infrastructure use case is succes interdependent infrastructure stakeholders will have access to cost effective storage solutions that sustain and enhance normal operations amidst short term disruptions of energy inputs.

**Use Case Example**

- El Dorado Irrigation District (EID) spent $800k last year on backup generators for water facilities after California public safety shutoffs

# Facility Flexibility, Efficiency and Value Enhancement (1/2)

- **Introduction and Scope**
  - This Use Case sub-family seeks to leverage opportunities to optimizing energy production and usage in facilities, including commercial and residential buildings. Optimized integrated processes can utilize high-performance, low cost energy storage technologies to enhance the overall facility value to the owner, operator and ultimately the end consumer.
- **Success Statement**
  - If the “Flexibility for Commercial and Residential Buildings” sub-family is successful, building owners, operators, and occupants will have access to storage and flexibility solutions that deliver net benefits including energy expenditures, comfort, and functionality.

**Use Case Example**

- Utilities, governments with net zero energy or carbon goals for buildings, and large scale energy consumers

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# Facility Flexibility, Efficiency and Value Enhancement (2/2)

- **Introduction and Scope - Flexibility for Energy-Intensive Facilities**
  - This Use Case sub-family seeks to leverage opportunities to integrate energy storage within a range of electric power generation and energy intensive industrial facilities. This sub-family is characterized by significantly higher energy flows and in forms not characteristic of the commercial/residential buildings sector. The nature of how energy is converted and transported in the processes associated with energy-intensive facilities optimization offers potential opportunities for improvement in economics, flexibility, and market diversity.
- **Success Statement**
  - If the "Flexibility for Energy-Intensive Facilities" sub use case is successful, industrial, generator, and other large-scale facilities will have access to storage and flexibility solutions that maximize the total value obtained from the process of interest.

**Use Case Example**

- Storage for commercial and industrial sectors predicted to achieve revenues $10.8 Billion a year, increase to 9.3 GW of total capacity by 2025

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# Input into Technology Development Strategy