SAND2015-2243C

# DOE/Sandia National Labs Energy Storage Program

**Daniel Borneo, P.E.**

**Sandia National Laboratories**

Oregon

March, 2015

Sandia National Laboratories

*Exceptional service in the national interest*

U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

SAND Document SAND #

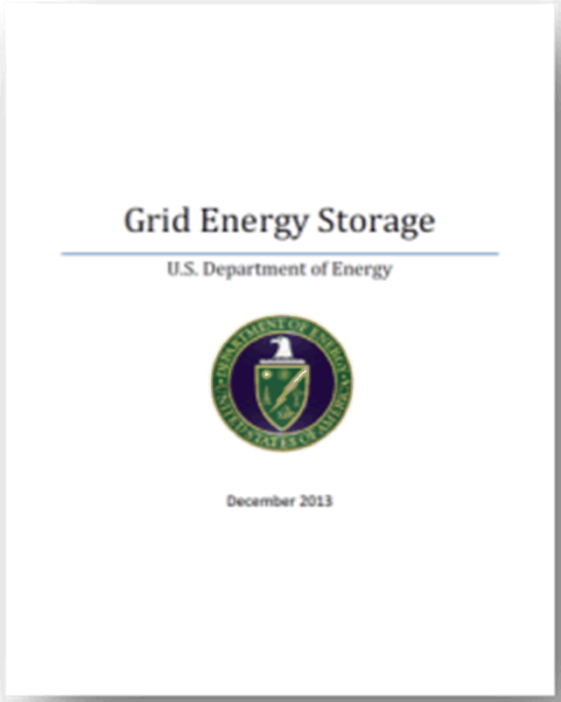
# Challenges for Grid Energy Storage

*During the commissioning hearings of Dr. Moniz to head US DOE, Senator Wyden requested a strategic plan for grid energy storage.*

DOE Published the report in December 2013

**Four Critical Challenges were identified**

1. Cost Competitive Energy Storage Technologies
2. Validated Reliability and Safety
3. Equitable Regulatory Environment
4. Industry Acceptance



# SNL ES Program Overview

U.S. DEPARTMENT OF ENERGY

Sandia National Laboratories

## Mission Statement:

Encourage investment in Energy Storage (ES) by:

- Develop new ES **Technologies**
- Develop new **Materials** for ES devices
- **Power Electronics** Research and Development
- Model, Evaluate, Analyze, and **Optimize** ESS
- Conduct Field **Demonstrations** of new and existing technologies in various applications
- **Commissioning** support and operational evaluation
- Develop **Codes, Standards and Regulations**
- Industry **Outreach**

# Industry and Acceptance Project Overview

## Approach

- Work with National and International entities
  - DOD, State Energy Offices, Utilities, ES Industry, Universities and Consumers to:
    - Provide **independent analysis and evaluation**
    - Support **grid-tied field demonstration** projects
    - Support State renewable/resiliency/ES initiatives
    - Develop public information programs

# Industry and Acceptance Project Overview

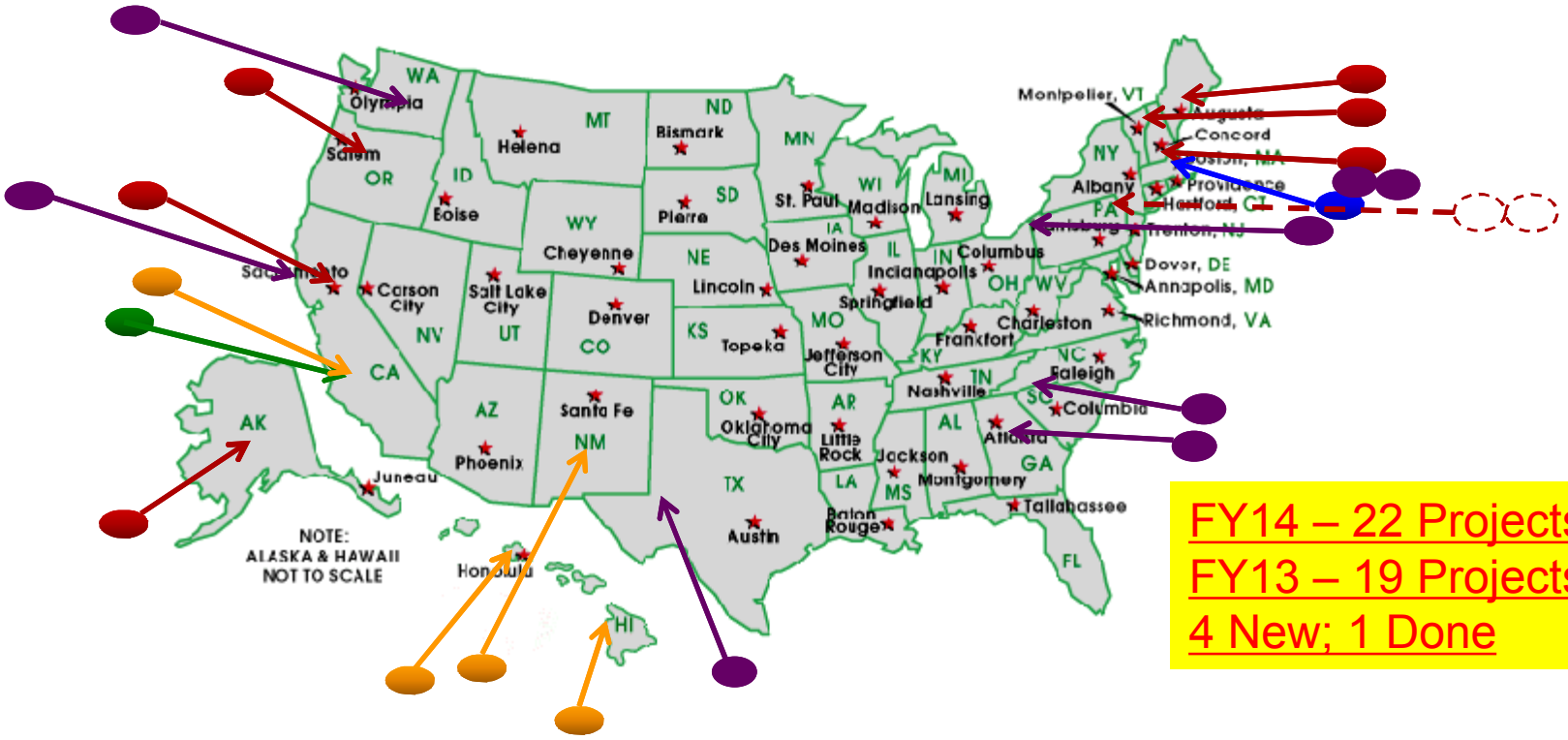
## Approach (continued)

- **State initiatives and Public education**

1. Through our Clean Energy States Alliance (CESA) partnership:
   - Provide Technical consulting to Various State Agencies
   - Develop projects and provide limited cost share

2. Partner with the ES industry, Academia, Consumers and others to provide education and act as ES information **clearinghouse**:
   - Energy Storage Guide
   - Various Sand Reports
   - Conduct ES related webinars

# Map of DOE-OE EES Projects 2015




FY14 – 22 Projects
FY13 – 19 Projects
4 New; 1 Done

Legend:

- State -6 (4)
- DOD-1 (2)
- Academia-1 (2)
- Commercial End User- 4 (2)
- Industry-8 (7)
- New or Proposed-2 (2)

*Stock Image source: http://www.devarticles.com/c/a/Web-Services/Cooking-With-Web-Services-PHP-and-GD/3/*

# State Collaborations

- California Energy Commission/California Public Utility Commission
- Connecticut Dept. of Energy and Environmental Protection
- Hawaii State Energy Office
- Natural Energy Laboratory of Hawaiian Authority
- Massachusetts Dept. of Energy Resources
- Massachusetts Clean Energy Center
- New Mexico Energy Conservation and Management Division
- New York State Energy Research Development Authority
- Oregon Department of Energy
- Vermont Public Service Department

# State Collaborations

| State | Project Description |
|---|---|
| California | Developing ES roadmap, and selection criteria for 1.3 GW initiative |
| Connecticut | Work with DEEP to develop RFP with ES component |
| Hawaii (Oahu) | Modeling and technical consulting for 160MW ES project |
| Hawaii (Kona) | Testing and analysis for new innovative ES installations |
| Massachusetts | RFP development and technical analysis of projects. $40M Grid resiliency program. |
| New Jersey | $10M ES for critical infrastructure  $200M NG Energy Resilient Bank |
| New Mexico | Analysis and optimization of an existing ES system |
| New York | Working with NYSERDA to develop microgrid projects including ES, and investigating technical performance and financial benefits.  $40 NY Prize |
| Oregon | Developing a RFP for ES project with ODOE with DOE cost share. |
| Vermont | Partner with GMP and Vt. DOE to install a 2MW PV; 4MW BESS with 1MWh Li-ion, and 2.4MWh LA |

# Thank You

Daniel Borneo, PE
Sandia National Laboratories
drborne@sandia.gov

- Back-up material

# Energy Storage Is Critical to the Stability and Resilience of the Electric Grid

U.S. DEPARTMENT OF ENERGY

Sandia National Laboratories

## Traditional Grid

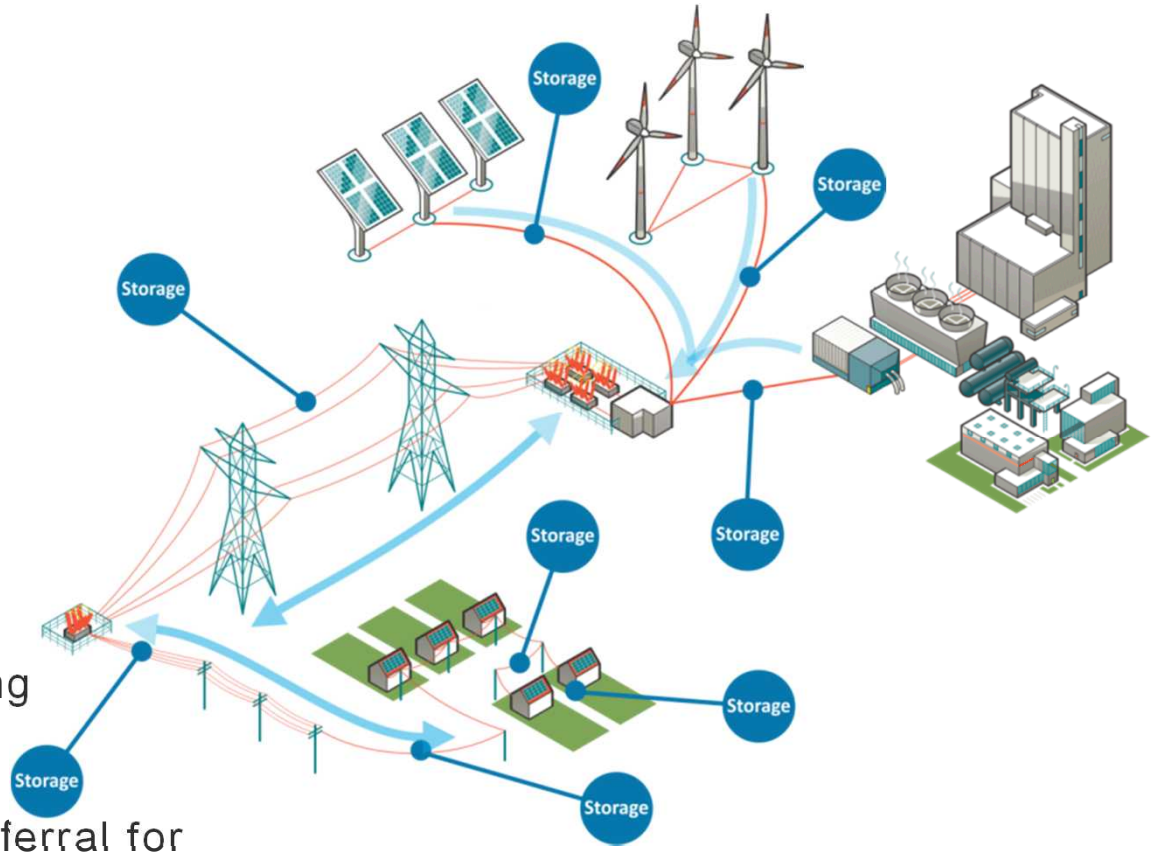
- One way flow
- Little/no renewable energy

## Today's Grid

- Integration of grid-scale and distributed renewable generation beginning, but with limited penetration

## Future Grid

- Storage provides buffering capability to enable high penetration of variable renewables and asset deferral for T&D systems (load management, ancillary services)
- Efficient two-way flow

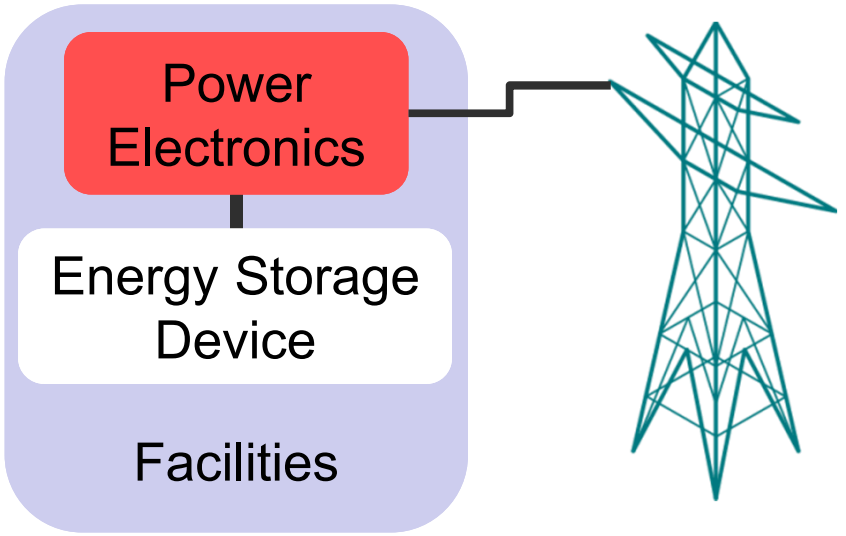


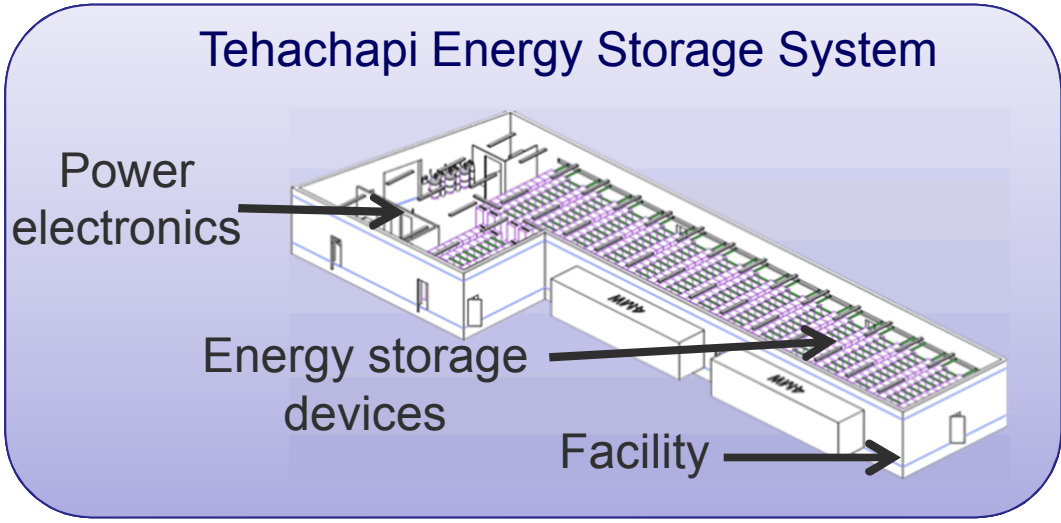
# Energy Storage System Configuration

Energy Storage Systems contain three major components:

- Energy storage device
  - Where energy is held until needed
  - Ex: chemical/electrolyte (used in battery), flywheel, etc.
  - ~25-40% of overall costs
- Power electronics
  - Ensures proper and safe charge and discharge of storage device and can provide grid support
  - ~20-25% of overall costs
- Facilities (balance of plant)
  - Houses all equipment, protects system from physical damage
  - Can include HVAC
  - ~20-25% of system costs

Other costs: consulting, financing, shipping, installation

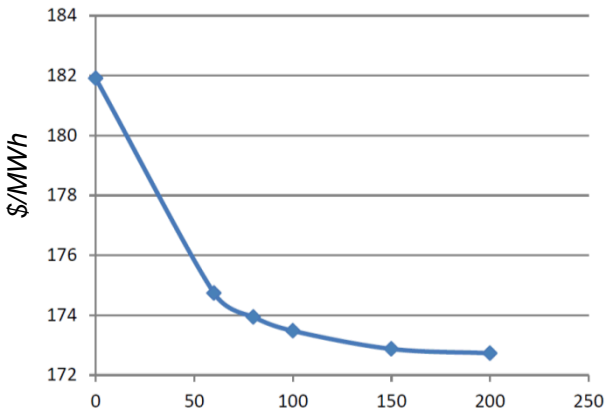


# Industry Acceptance
# Hawaii Electric Company

## Motivation:

- DOE/Sandia and Hawaii Electric Company (HECO) Collaboration.
- Working with HECO to assist in the selection and analysis of 160-200MW, 30 minutes of energy Storage for renewable integration and spinning reserve.




*Energy storage power (MW) for 30 minutes*

*HECO power plant at Kahe Point in West Oahu*

*Preliminary production cost modeling results, storage provides arbitrage and spinning reserve (includes frequency regulation)*

## FY14-15 Accomplishments:

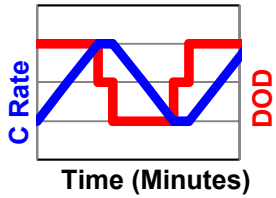
- Implemented MOU with HECO to provide ongoing support of ES projects
- Developed the RFP review criteria for HECO and reviewed 10+ energy storage project proposals.
- Presented overview of state-of-the-art ES technologies to HECO.
- Developed ES model to optimize system sizing.
- Provided technical analysis of selected battery technology, power and energy requirements, and costs for winning proposals

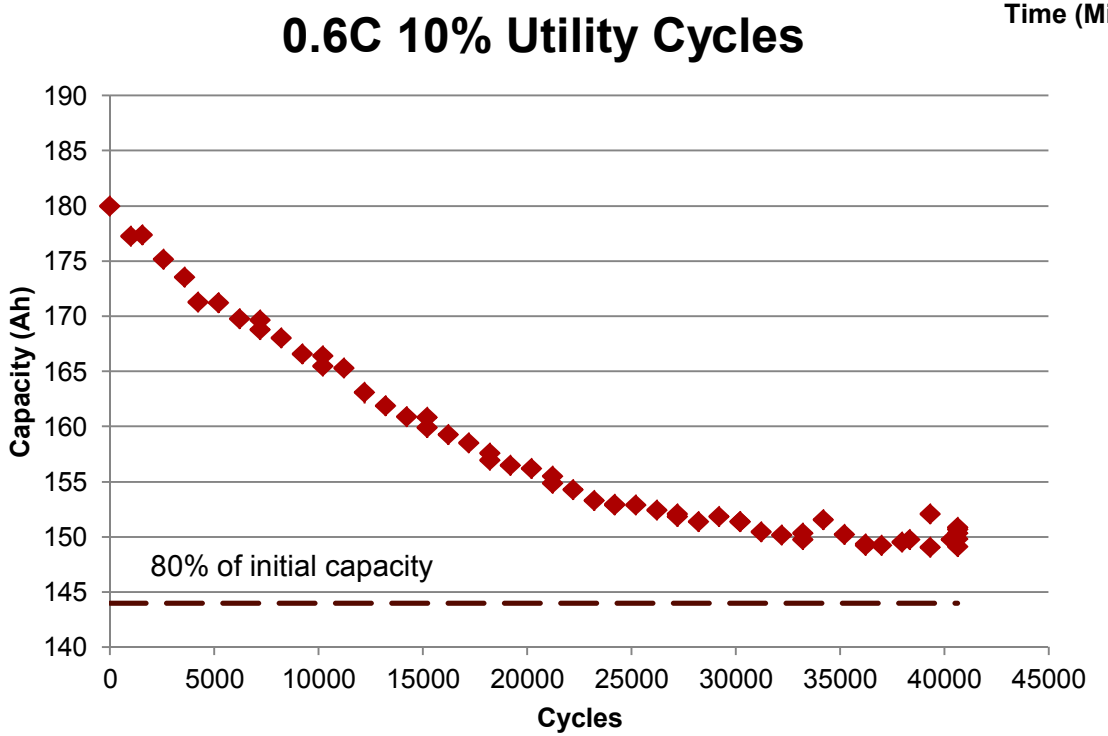
## FY15-16 Plans:

- Review ES project construction designs
- Review technical specifications and Installations
- Define commissioning requirements
- Develop Sequence of Operations (SOO)
- Develop and implement control optimization methodology
- Monitor and evaluate system operation

# International Battery Still Running after 40K cycles

International battery Li-ion $FePO_4$ large format prismatic 160 Ah cells




**Equivalent throughput energy of 4,000 full discharge cycles**

**~17% capacity loss after 40,000+ cycles**

# Industry Acceptance

## The Energy Storage Systems Analysis Laboratory (ESSAL)

***Providing reliable, independent, third party analysis and verification of advanced energy technologies for cell to MW systems***

## Cells and Modules

- 72V 1000A Bitrode (2 Channels)

Cell, Battery and Module Analysis

- 14 channels from 36 V, 25 A to 72 V, 1000 A for battery to module performance analysis
- Over 125 channels; 0 V to 10 V, 3 A to 100+ A for cell performance analysis
- Potentiostat/galvanostats for spectral impedance
- Multimeters, shunts and power supply for high precision testing
- Temperature chambers

## Fully Integrated Systems

### Lab Analysis

Energy Storage Test Pad (ESTP)

- Scalable from 5 KW to 1 MW, 480 VAC, 3 phase
- 1 MW/1 MVAR load bank for either parallel microgrid, or series UPS operations
- Subcycle metering in feeder breakers for system identification and transient analysis
- Thermal imaging
- System Safety Analysis (new)

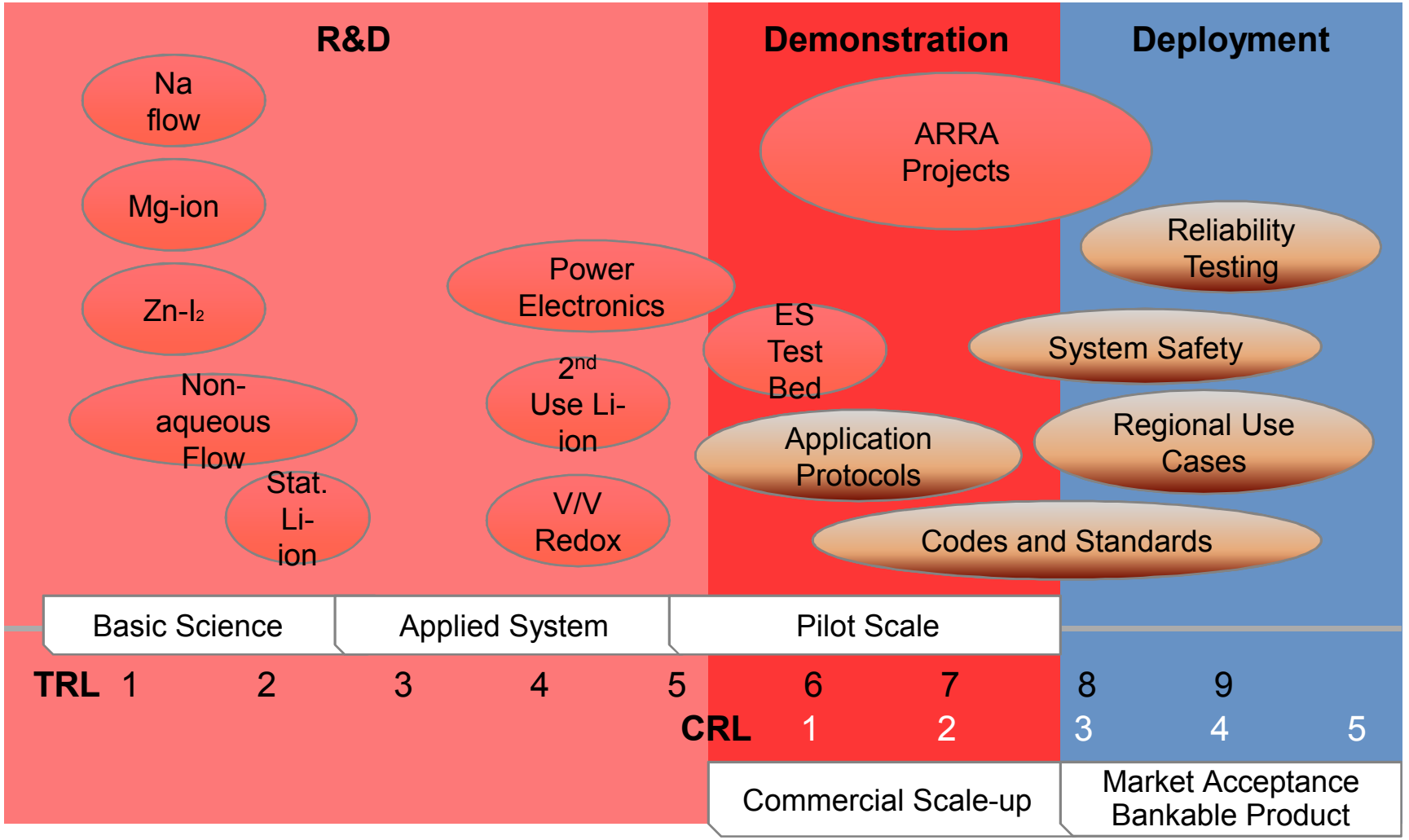
### Field Analysis (new)

Remote Data Acquisition System (RDAS)

- Portable, Modular, Remotely Reconfigurable, and outdoor-ready
- Subcycle metering
- Tractable calibration
- Command Signal Ready for Grid Operator Simulation
- No control over grid conditions

# OE Energy Storage Program Scope

*To accelerate the development and adoption of energy storage the OE-Energy Storage Program is working across the entire technology development cycle*




Technology Development Activities

Stakeholder Acceptance Efforts