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ARRA ES Projects Lessons Learned

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Project Goal

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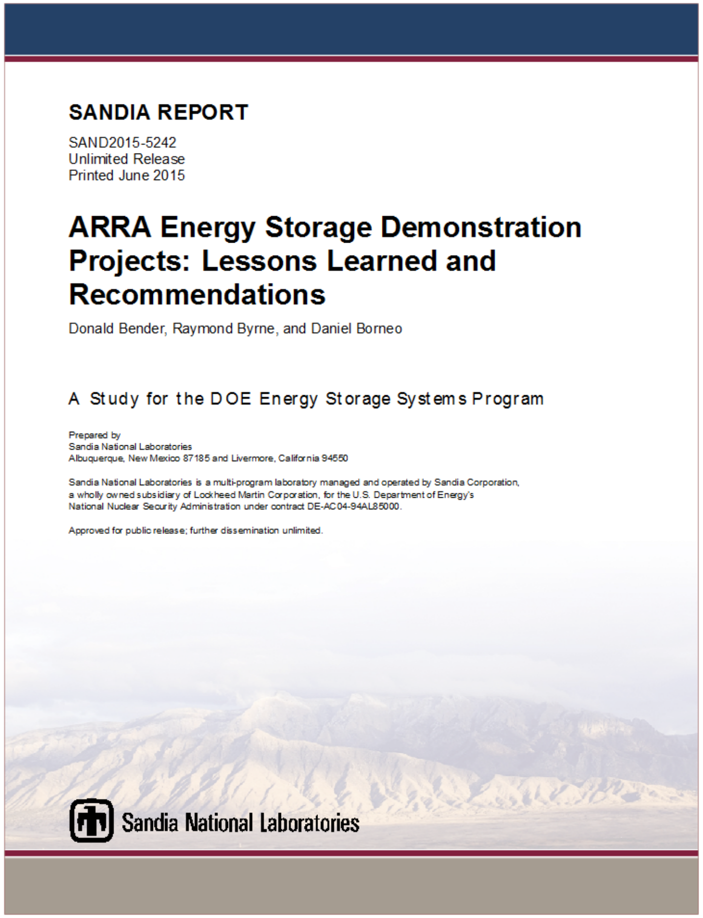
- Summarize lessons learned across the ARRA energy storage demonstration projects
- Information was derived from:
  - Questionnaire and interview with project teams
  - DOE peer review presentations
  - ARRA required reporting (e.g. interim and final technical reports)
- Published as SAND 2015-5242
  - Available on-line http://www.sandia.gov/ess/publications/SAND2015-5242.pdf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ARRA Energy Storage Demonstration Projects: Lessons Learned and Recommendations

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A Study for the DOE Energy Storage Systems Program

Prepared by
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ARRA Projects

Diverse technologies, scale, and levels of maturity

Participants

Company	Contributor
Amber Kinetics	Ed Chiao, Seth Sanders
Aquion Energy	Ted Wiley
Beacon Power	Jim Arseneaux, Barry Brits
City of Painesville	Jeff McHugh
Detroit Edison	Haukur Asgeirsson
East Penn Manufacturing	Jeff Seasholtz, Jason Hoffman, Ralph Fegely
Enervault	Ron Mosso, Thomas Jahn, Craig Horne
Notrees Storage Project	Matthew Johnson, Stuart Gibson
Premium Power	Doug Alderton
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Pacific Gas & Electric	Michael Medeiros
PNM Prosperity	Jon Hawkins, Steve Willard
Seeo	Hany Eitouni, Ulrik Grape, Hal Zarem
SustainX	Ben Bollinger
SCE Tehachapi	Jay Rollo, Blake Chalson, Loic Gaillac

Lessons Learned

- The Smart Grid Demonstration Program advanced energy storage viability across the board
  - Technology readiness level improved for early stage companies
  - Commercial viability attained by several companies
  - Significant practical learning throughout the development process

- Lessons learned can be sorted into three groups
  - Market Readiness
  - Installation and Commissioning
  - Follow-on Programs

Market Readiness

- Maturity of monetization strategies vary
  - Frequency regulation was demonstrated in the market
  - No consistent view regarding economics of other applications
- ARRA funds were leveraged with investment
  - Several awardees secured investments multiplying ARRA funding
- ARRA demonstrations at facility scale facilitated disposition
  - Demonstrations at scale gave clearer insight into cost structure
- Regulatory barriers to optimal operation
  - FERC requirements preclude the marketing department from participating in reliability functions
- Technology 'pivots' are disastrous
  - Changing fundamental design or chemistry resets the schedule

Installation and Commissioning

- Permitting and code compliance challenges underestimated
  - Uncertainty as to how to treat different battery chemistries
  - Varies by location
  - Inspectors sometimes required fire hydrant, handicap parking & compliance with NEC codes that do not apply to a utility
- Applicable codes do not (yet) exist for battery energy storage
- No codes for flywheels either
- Large installations experienced transportation delays
  - DHS limits oversize/overweight travel to daytime

Follow-on Programs

- "Reference" demo seen as bridge to peaker or T/D deferral
  - Jump from < 1MW to 20 – 50 MW too large to do in one step
  - 2 – 5 MW reference plant validates scaling and tests market
- Desire for more accessible DOE loan guarantee program
  - Reducing loan size would help finance "reference" plant
- Utilities have unique challenges finding a place for storage
  - As a result of ARRA project learning, future installations will be more targeted and precise

Three example projects

Large (>1 MW), grid connected, continuous operation, generating revenue

- East Penn Manufacturing
  - 3 MW frequency regulation system
  - Uses Ecoult UltraBattery
  - Installed on-site☐ (behind meter)

- Beacon Power
  - 20 MW frequency regulation plant
  - 200 x 100 kW flywheels

- Duke Notrees Wind Energy Storage
  - Installed at Notrees, TX wind farm
  - Demonstrate firming, ancillary services

East Penn

- Installed behind the meter as
  Demand Response (DR) resource
  - Simpler, cheaper and faster than on the utility side
  - Cannot export power to the grid
  - Battery output cannot exceed load behind the meter
- Utility has never requested DR service
- Dynamic frequency regulation for PJM
- Original rack design based on UPS installation
  - Inadequate cooling for sustained use => thermal imbalance between strings was fixed
- Cell imbalance within strings – equalization should increase capacity
- Local code officer was not familiar with battery technologies
- Initial smoke detectors unsuitable – a lot of false alarms
- UL codes for stationary energy storage would be helpful
- Assert that they are ready to develop and sell product for the FR ancillary service market without additional government funding

Beacon

- Follow-on to Stephentown plant
  - Faster commissioning
  - About 30% lower cost to build out
- Challenges related to site
  - Storm water runoff
    (National Pollutant Discharge System)
  - Blasting
- Largely trouble-free operation
  - Turbo pump bearing was unreliable
  - A new design pump seems to have solved the problem (last 10 flywheels)
  - Negligible impact on performance because of redundancy
  - Availability > 98%
  - Performance score of 97% vs. 80% for other regulation resources
- PJM is best market for FR service
  - Stephentown plant works harder but makes less money

Duke - Notrees

- Storage demonstration project at 153 MW Notrees Wind Farm
- Nominal installed storage: 26 MW, 24 MWh
- Operating concept evolved over time to providing FR ancillary service
- Cell technology mismatch with current application
  - System operated at 22 MW to improve battery life
  - Improved longevity at 100% SOC
  - Regulation up only to minimize time at partial state of charge
  - Plan to incorporate lithium ion cells over time

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Questions?

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