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# ARRA ES Projects Lessons Learned

September 23, 2015

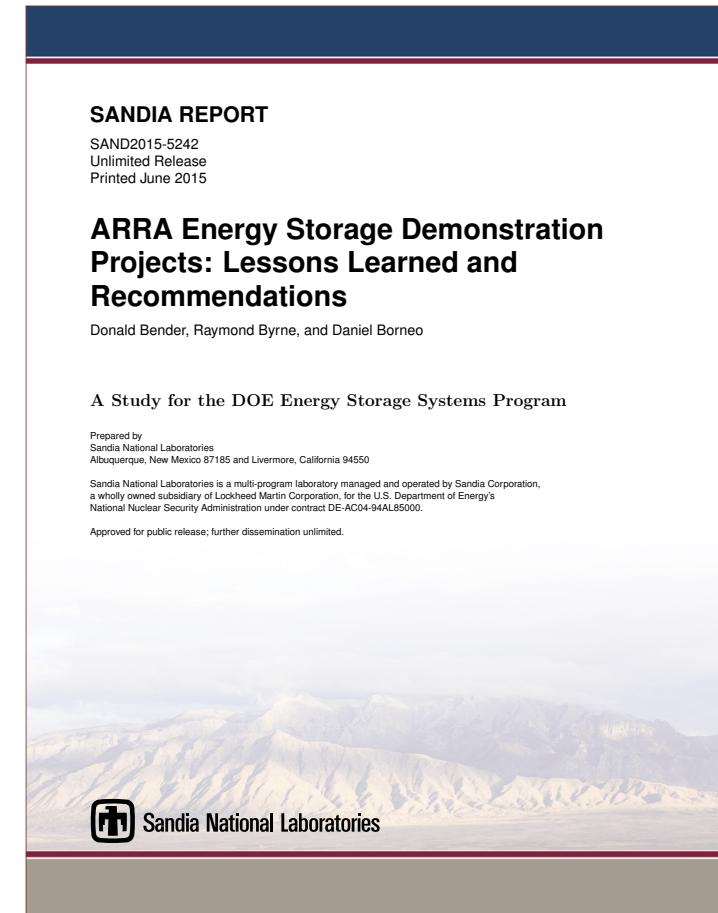
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# Project Goal

- 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](http://www.sandia.gov/ess/publications/SAND2015-5242.pdf)



# ARRA Projects



Diverse technologies, scale, and levels of maturity

# Participants

## Company

Amber Kinetics  
Aquion Energy  
Beacon Power  
City of Painesville  
Detroit Edison  
East Penn Manufacturing  
Enervault  
Notrees Storage Project  
Premium Power  
Primus Power  
Pacific Gas & Electric  
PNM Prosperity  
Seeo  
SustainX  
SCE Tehachapi

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# 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 Ecoul 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
- 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



The authors gratefully acknowledge the support of Dr. Imre Gyuk  
and the Department of Energy's Office of Electricity Delivery &  
Energy Reliability.

## Questions?

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