SAND2018-3193C

Safety Considerations During ESS Commissioning

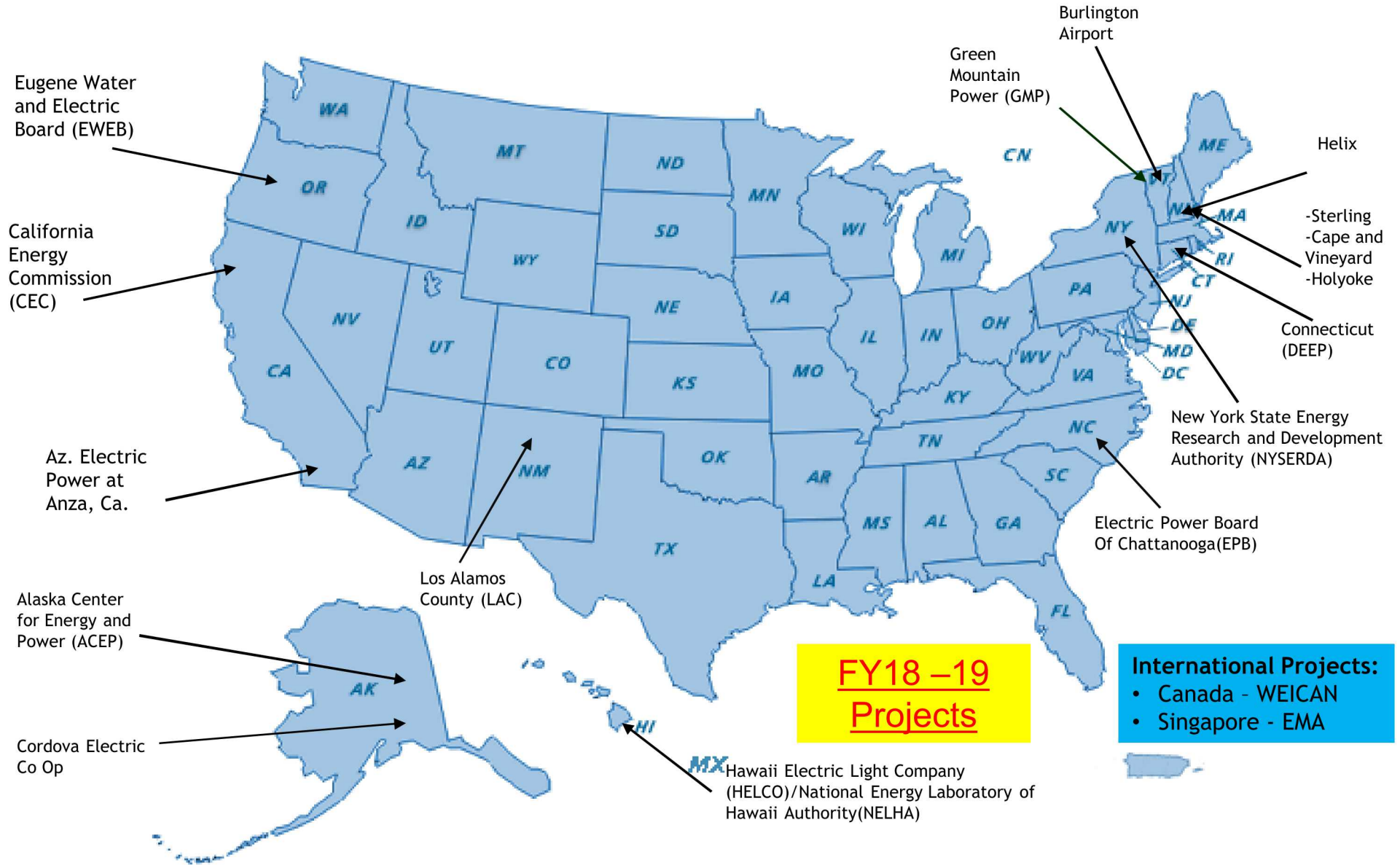
Dan Borneo

DOE OE ENERGY STORAGE PROJECTS AND ANALYSIS TEAM

What We Do and Why

- Work with Utility, Industrial, State and International entities to:
  - Provide **third party independent analysis** for cells and systems
  - Support the development and implementation of **grid-tied ES** projects
    - **RFI/RFPs**
    - **Design and Procurement Support**
    - **Application/Economic analysis**
    - **Commissioning Plan Development**
  - Monitor and analyze operational ES Projects
    - Differing applications
    - Optimization
    - Operational performance
  - Develop public information programs
- Goal
  - Inform the Public and encourage investment.

SANDIA/DOE ES PROJECTS

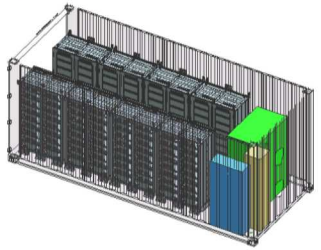


FY18 –19 Projects

International Projects:
- Canada - WEICAN
- Singapore - EMA

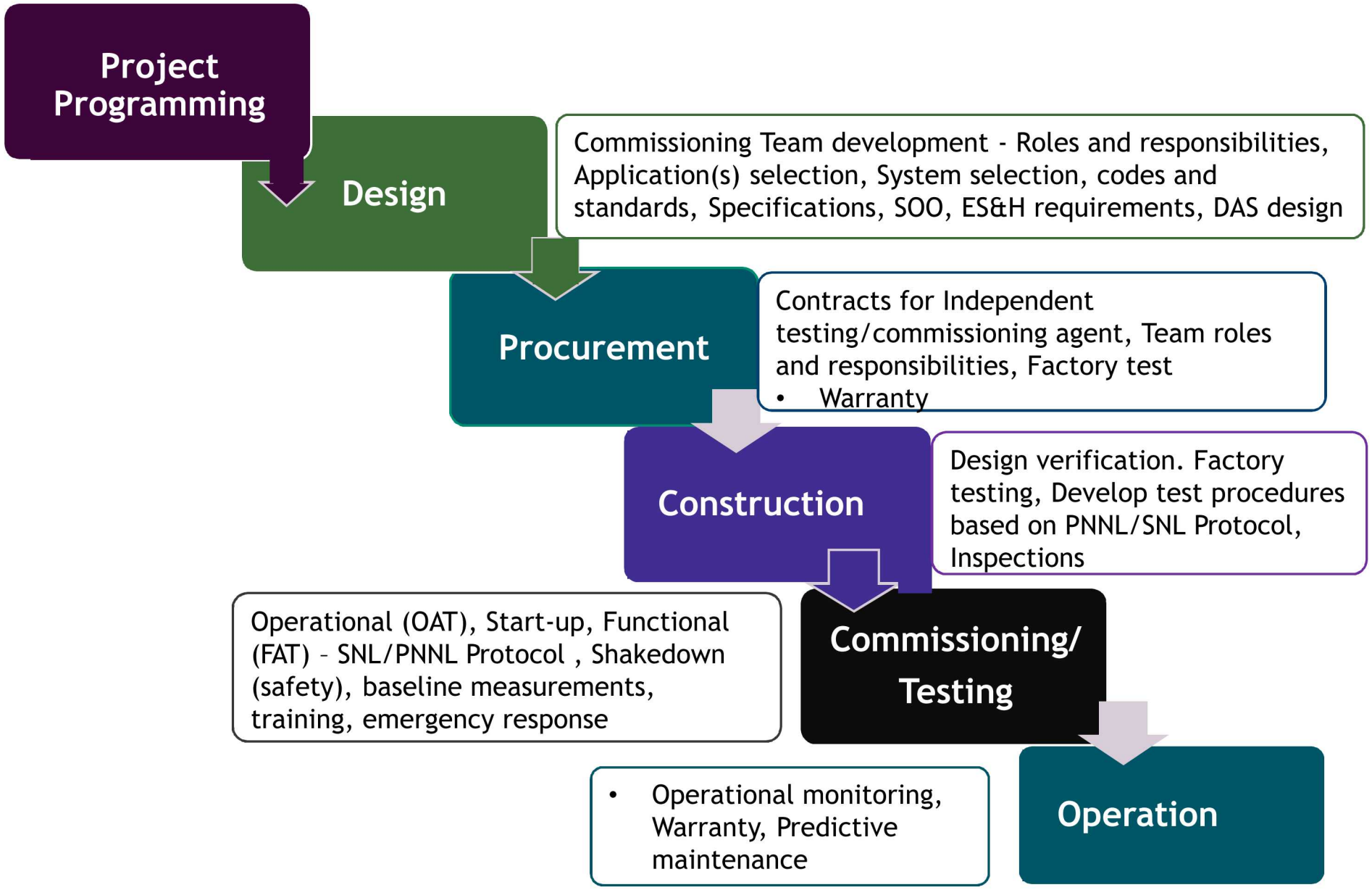
Elements of an Energy Storage System

Storage	Power Control System (PCS)	Energy management System (EMS	Balance of Plant
• Storage device • Battery Management & Protection (BMS) • Racking	• Bi-directional Inverter • Switchgear • Transformer • Data Acquisition System (DAS)	• Charge / Discharge • Load Management • Ramp rate control • Grid Stability	• Container / Housing • Wiring • Climate control • Fire protection



NOTE: Important to have single entity responsible for the ESS integration.

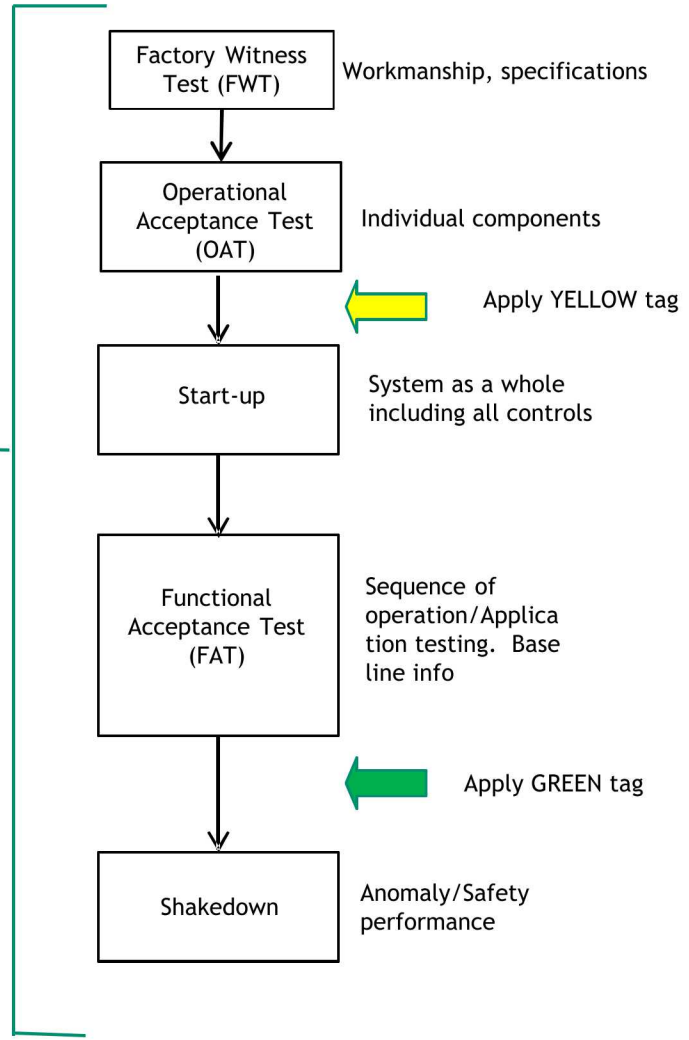
Commissioning Activities during Project Phase



Commissioning/Testing Process

COMMISSIONING

Safety and Reliability



Commissioning Activities During Construction

- Factory Acceptance Tests
  - Vendor conducts factory Acceptance testing using SOO
- Develop start-up procedures
  - Based on equipment list, system manuals, SOO and operating specifications
    - Operating Specifications – Parameters that the system should operate within.
- Develop testing procedures
  - Based on SOO and applications
  - PNNL/Sandia Testing Protocol
    - http://www.sandia.gov/ess/publications/SAND2016-3078R.pdf
- Develop installation review checklists and perform inspections
  - Design Verification – Installed as designed & specified; labeling and signage in place, clearances,
  - Code adherence
  - Punchlist items noted
- Develop Training and emergency response procedures
  - MSDS
- Implement Lock-out/Tag-out process

Introduction to PNNL/SNL Protocol

A set of "best practices for characterizing ESS and measuring and reporting their performances

Available at http://www.sandia.gov/ess/publication/

7 Applications

- Peak Shaving - Using an ESS to discharge during on-peak periods for electric power while charging the ESS during off-peak periods
- Frequency Regulation - Regulate the electric power frequency by providing up regulation by discharging an ESS and providing down regulation by charging
- Islanded Microgrids - Using an ESS as an electrical island separated from the utility grid
- Renewables Firming (PV, Wind) - Using an ESS to supplement renewable energy generation to provide steady power output
- Power Quality - Mitigating voltages sags by injecting real power from ESS for a few seconds
- Frequency Control-Using a discharge/charge from an ESS to make up for a sudden loss of generation or load

Codes and Standards

Application	Standard Org	Standard	Standard Title
ESS Commissioning	ANSI	Z535	Safety Alerting Standards
ESS Commissioning	IEEE	450	Recommended Practice for Maintenance, Testing and Replacement of VRLA Batteries for Stationary Applications
ESS Commissioning	IEEE	1106	Recommended Practice for Installation, Maintenance, Testing and Replacement of Vented NiCd Batteries for Stationary Applications
ESS Commissioning	IEEE	1188	Recommended Practice for Maintenance, Testing and Replacement of VRLA Batteries for Stationary Applications
ESS Commissioning	IEEE	1578-2007	Recommended Practice for Stationary Battery Electrolyte Spill Containment and Management
ESS Commissioning	IEEE	1657	Recommended Practice for Personnel Qualifications for Installation and Maintenance of Stationary Batteries
ESS Installation	AS	2676-1983	Installation and Maintenance of Batteries in Buildings
ESS Installation	AS	4777-1-2005	Grid Connection of Energy Systems via Inverters
ESS Installation	IEC	62935	Planning and Installation of Electrical Energy Storage Systems
ESS Installation	IEEE	519-1992	Recommended Practice and Requirements for Harmonic Control in Electrical Power Systems
ESS Installation	IEEE	1145-1999	Recommended Practice for Installation and Maintenance of Nickel-Cadmium Batteries for Photovoltaic Systems
ESS Installation	IEEE	1187-2013	Recommended Practice for Installation Design and Installation of VRLA Batteries for Stationary Applications
ESS Installation	ICC		International Building Code
ESS Installation	ICC		International Fire Code
ESS Installation	ICC		International Wildland Urban-Interface Code
ESS Installation	IEEE	937	Recommended Practice for Installation and Maintenance of Lead-Acid Batteries for PV Systems
ESS Installation	IEEE	1184	Guide for Batteries for UPS Systems
ESS Installation	IEEE/ASHRAE	1635-2012	Guide for the Ventilation and Thermal Management of Batteries for Stationary Applications
ESS Installation	IEEE	1547	Standard for Interconnecting Distributed Resources with Electric Power Systems
ESS Installation	IEEE	C2-2012-2012	National Electrical Safety Code (NESC)
ESS Installation	NFPA	70-2017	National Electrical Code (NEC) (Updated section on Energy Storage)
ESS Installation	NFPA	70E-2012	Standard for Electrical Safety in the Workplace
ESS Installation	NFPA	400-2013	Hazardous Material Code
ESS Installation	IEC	62485-2	Safety Requirements for Stationary Batteries
ESS Installation	UL	96A	Installation Requirements for Lightning Protection Systems
ESS System	ANSI	C84-1	Electric Power Systems and Equipment
ESS System	IEC	62040-1 Ed.1	UPS General and Safety Requirements in operator access areas
ESS System	IEC	62040-1 Ed.2	UPS General and Safety Requirements installed in restricted access locations
ESS System	IEC	62257-9-5	Small renewable energy and hybrid systems for rural electrification - protection against electrical hazards
ESS System	IEC	62257-9-1	Small renewable energy and hybrid systems for rural electrification - Micropower systems
ESS System	IEC	62932-2-1	Flow Battery Systems for Stationary Applications - performance requirements and methods of tests
ESS System	IEEE	485	Lead-Acid Batteries for Stationary Applications
ESS System	IEEE	1375?	Guide for the Protection of Stationary Battery Systems
ESS System	IEEE	1491	Guide for Selection and Use of BMS in Stationary Applications
ESS System	NFPA	111-2013	Standard on Stored Electrical Energy Emergency and Standby Power Systems
ESS System	NFPA	791-2014	Recommended Practice and Procedures for Unlabeled Electrical Equipment Evaluation
ESS System	UL	1741	Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy
ESS System	UL	1778	Uninterruptible Power Sources
ESS System	UL	9540	Outline for Investigation for Safety for Energy Storage Systems and Equipment

Courtesy of PNNL/Sandia edited by Schenkman/Borneo. for exhaustive list see **http://www.sandia.gov/ess/publications/SAND2016-5977R.pdf**

Additional C&S' List (Laurie Florence, UL)

Overview of Current Standards

Document No.	Title
ANSI UL 1973	Batteries for Use in Light Electric Rail (LER) and Stationary Applications
UL Subject 9540	Safety for Energy Storage Systems and Equipment (under development)
IEEE 3575	Guide for the Protection of Stationary Battery Systems
IEEE 1679	Recommended Practice for the Characterization and Evaluation of Emerging Energy Storage Technologies in Stationary Applications
IEC 62485-2	Safety requirements for secondary batteries and battery installations – Part 2: Stationary batteries
IEC CD 62619	Secondary cells and batteries containing alkaline or other non-acid electrolytes. - Safety requirements for secondary lithium cells and batteries, for use in industrial applications (under development)
IEC NP 62897	Stationary Energy Storage Systems with Lithium Batteries – Safety Requirements (under development)
UL 3001	Distributed Energy Generation and Storage Systems

Summary

Start Project with Commissioning in mind

- Applications, Monitoring, Team, Testing, Operations
- Don't wait until system is installed to start the commissioning process

Challenges of Energy Storage Commissioning

- Need to settle on Safety requirements for ESS installation
- Need better understanding of optimization and how to use one ES System for multiple applications.
- Testing utilizing the correct load profile

Thank You!

Mention of our SNL Sponsor – DOE/OE - Grid Energy Storage Program, managed by
Dr. Imre Gyuk

blschen@sandia.gov
drborne@sandia.gov

Data Acquisition System(DAS)

- DAS to monitor battery performance
  - Operation
  - Capacity fade
  - Energy consumption Important aspects of a DAS
- Remote access & Time stamp of data
- Sampling rate
- 30+ day on-board memory

General Monitoring Parameters for ESS and Balance of Plant

AC Voltage(V)	Current(I)
Kwh in (efficiency)	Kwh out(efficiency)
Balance of plant monitoring	State of Charge(SOC)
System Temperature	Ambient Temperature
Frequency	DC Voltage
Cell Temperature	System KW
Ramp Rate	System KVA
Response Time	

Overview of DAS Connections