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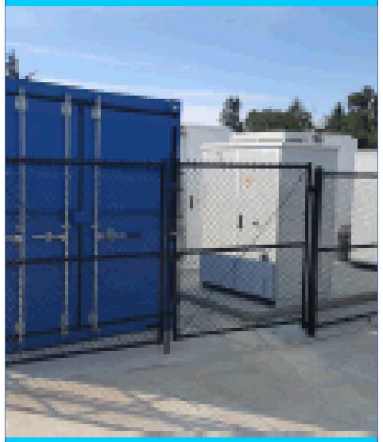
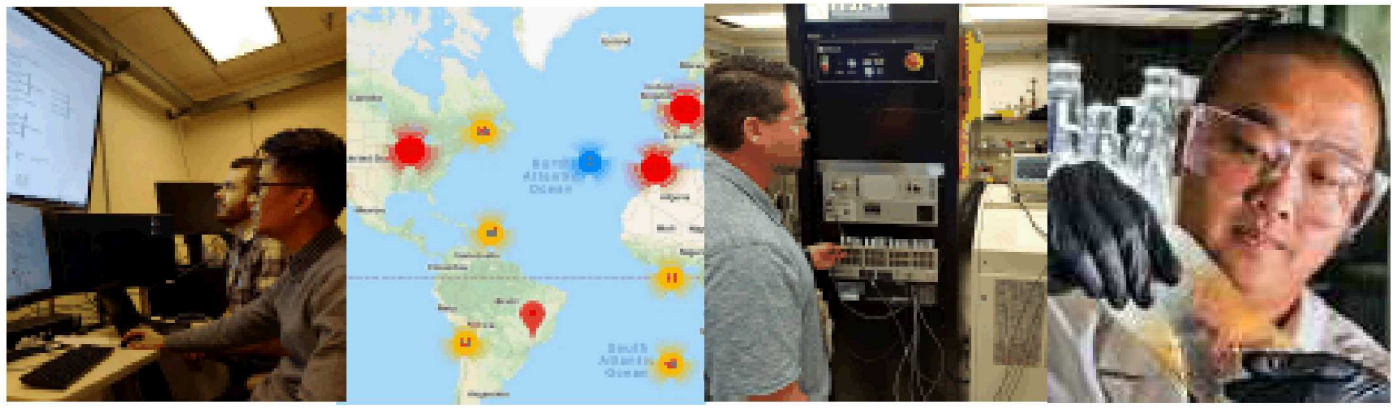


Sandia Safety Forum
March 6, 2019



Commissioning Overview

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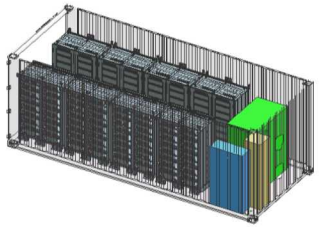
SAND2019

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

Elements of Battery Energy Storage System (ESS)

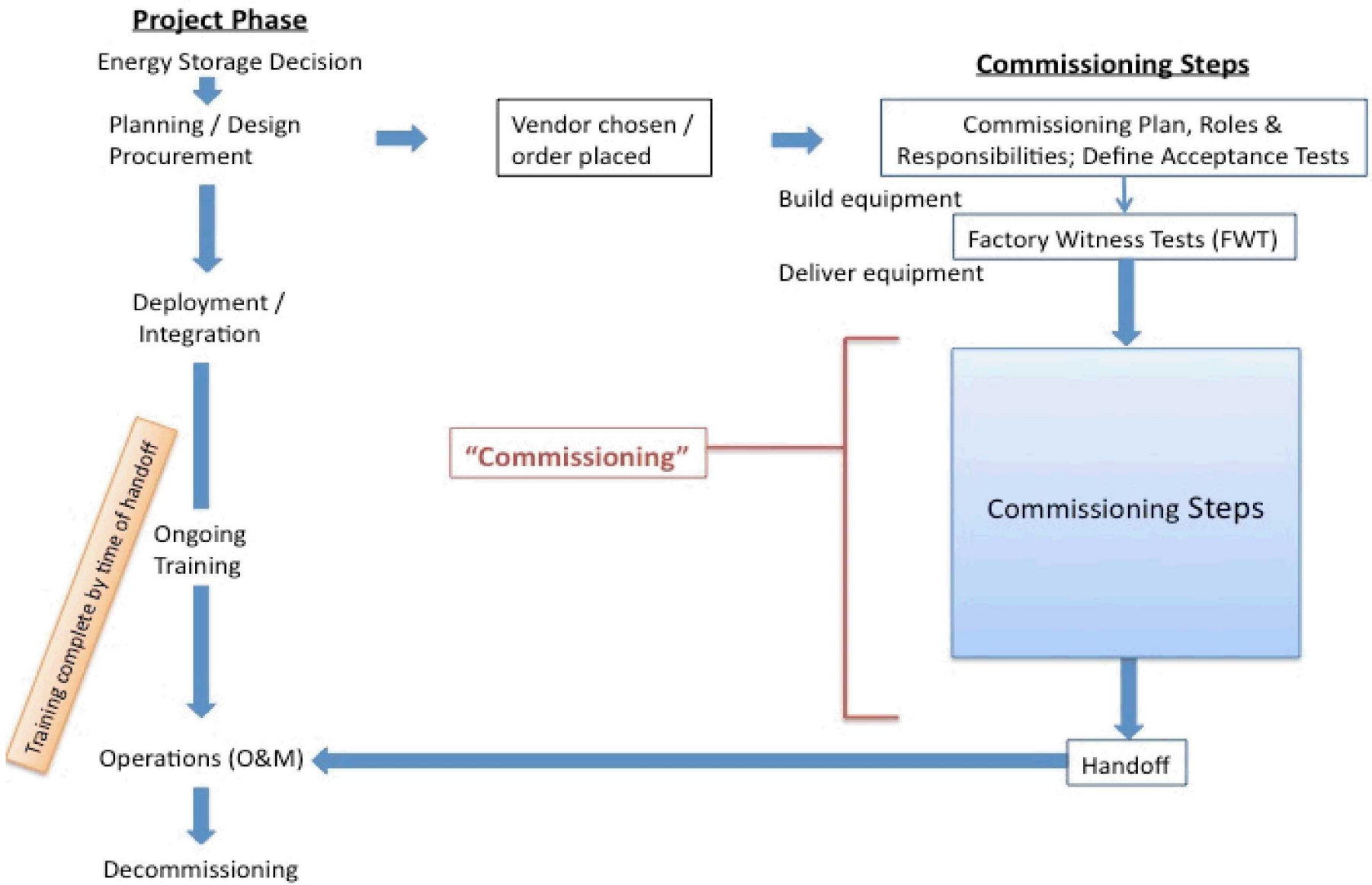
Storage and BMS	Power Control System (PCS)	Energy management System (EMS)	Site Management System (SMS)	Balance of Plant
• Storage device • Battery Management & Protection (BMS) • Racking • $/KWh	• Bi-directional Inverter • Interconnection / Switchgear • Transformer • $/KW	• Charge / Discharge • Load Management • Ramp rate control • Grid Stability • Monitoring • $ / ESS	• Distributed Energy Resources (DER) control • Synchronization • Islanding and Microgrid control • $ / microgrid	• Housing • Wiring • Climate control • Fire protection • Construction and Permitting • $ / project (function of scale)





NOTE: All–in can increase cost by 2-4x.

Commissioning Process starts at RFP

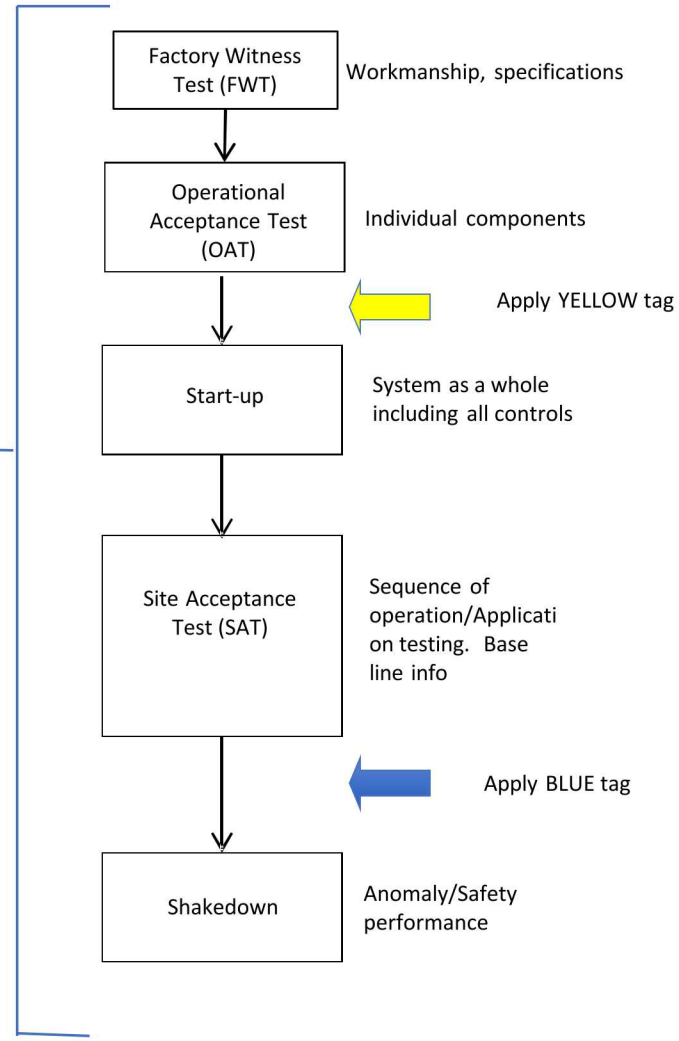


Commissioning / Testing Process details

COMMISSIONING

Safety and Reliability

Base line measurements
- Voltage
- Capacity
- Charge time
- Discharge time
- IR scan connections and batteries



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

Commissioning/Testing Process

COMMISSIONING PHASES

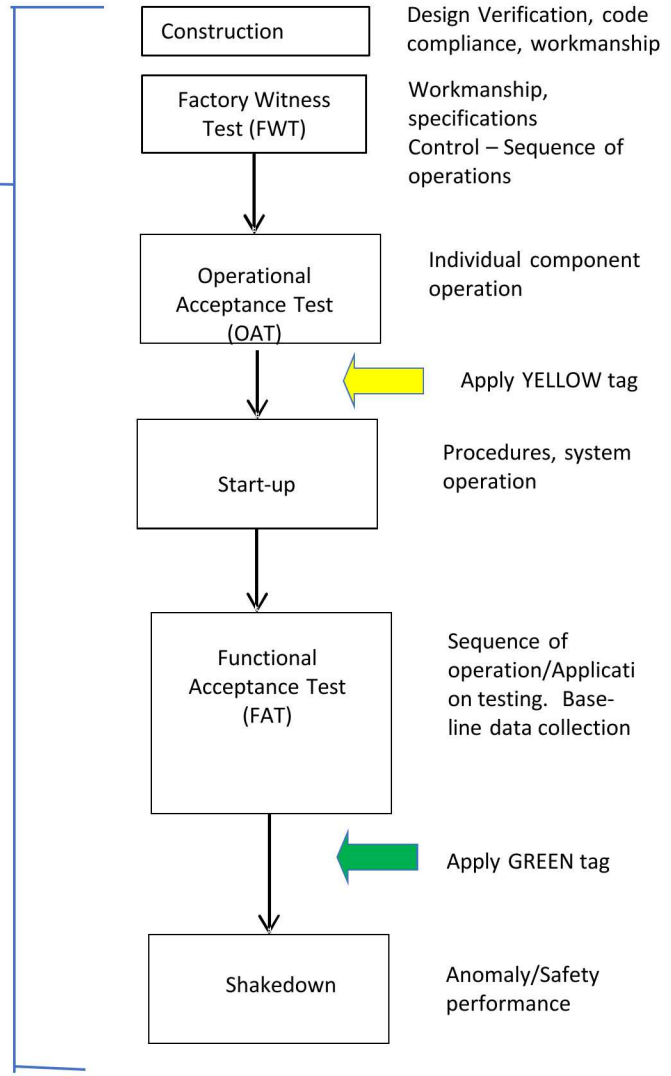
GOAL: To Ensure a **Safe and Reliable** System is installed as designed, operates, and performs the services intended.

NOTES on Tags (for larger systems with many componets)

Tags act as gates to advance pivotal events for the owner in the following manner:

(**Pick** a **Color**)
YELLOW Tag: Contractor owned, Owner-Operated, Not Transitioned
GREEN Tag: Transition (Hand-Off) to operations completed

The yellow tag is removed once a green tag is applied.
The green tag may be removed at the owner's discretion AFTER the project is completed and signed off.



Commissioning Process- Operational Acceptance Testing (OAT)

Do the Individual components of the system operate?

- Verify and test that the individual electrical, mechanical components of the system are ready for start-up
  - Meggering, torqueing, rotation/phasing, covers and barriers
- Verify that the controls are in place and test operation
    - Point to point check
- Verify electrical protection and relays are coordinated and are operational
- Verify and test that all safety systems are installed and operating.
  - Temperature, leak, security, fire alarm, flow, pressure
- Verify and test that all communication systems are operating
- Emergency procedures are in place and Lock/out tag out process implemented
- **Tag and sign off – System is ready to operate**

Note: Is 3rd party testing required?

Commissioning Process– Start-up

Do the components operate as a system?

- Using start-up procedures, operate all components as a system
  - Record base-line data
    - Voltage, currents, temperatures, flows, pressures
    - Perform initial IR scan
  - Record and repair punch list items

✓ Does Automatic and remote control operate as required

✓ Is Data Acquisition system operating, recording data and transmitting/Saving as required

Commissioning Process- Functional Acceptance Test (FAT)

- Using Testing plans and procedures test to insure systems performs the functions/applications for which it was designed.
  - Are all components and sub-systems operating in unison
  - Do controls operate as intended
  - Is communication system sending and receiving data as intended- type and frequency. Are anomalies being annunciated
  - Is data collected adequate to determine system performance
  - Record and repair punchlist items
  - Is training complete for operators, maintenance and first responders
  - Is operation and maintenance plan in place
  - Is warranty in place
  - Is emergency response procedures in place- 1-800 number in the event of an emergency
  - Log additional baseline data

✓ **Tag and sign off that system is now owned and operated by customer/owner**

Commissioning Process-Shakedown

When any site utility is interrupted, and then restored (e.g., electricity, gas, water, data, communication, etc.), does the system operate in such a manner as to protect the people, the environment, the equipment, and the facilities?

- *Turn off major utilities serving project.*
  - Determine if safety systems work as designed or needed.
  - Evaluate if systems fail in a safe mode.
  - Assess if back-up systems operate as needed.
  - Do alarms serve the purpose
- *Turn on major utilities*

  Determine if the systems come up in a safe manner.

  Assess if backup systems turn off in a safe/ready mode.

Operation

- Monitor capacity fade
- Predictive maintenance adventure
- Warranty
- Data Collection, Monitoring
  - Remote Access
  - On-board Storage

Protocol for Evaluation of ES Systems

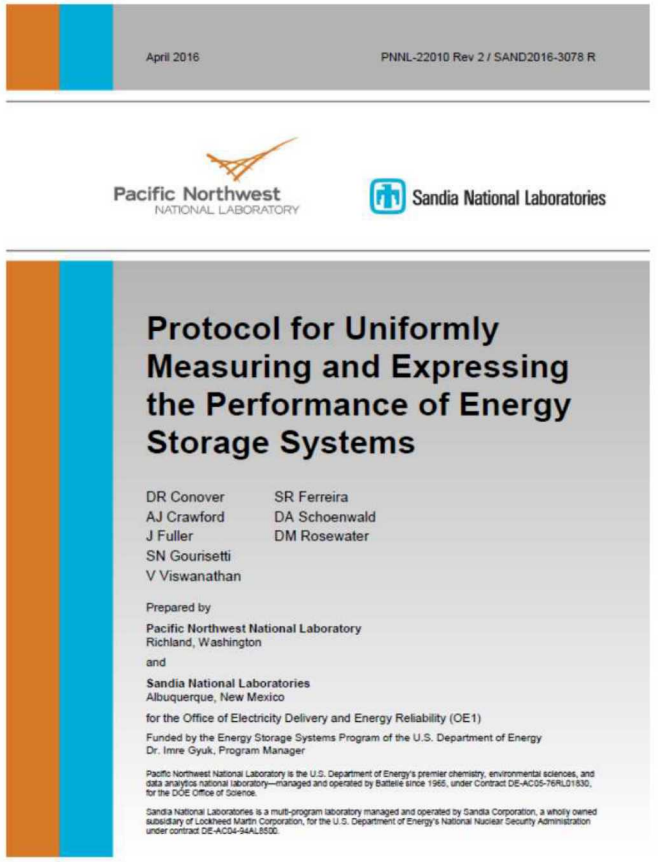
Companies looking for an accurate method to gauge how well large batteries and other grid-scale energy storage systems work use these evaluation guidelines, called the Energy Storage Performance Protocol.

The guidelines currently evaluate three energy storage performance uses:

- Peak Shaving
- Frequency Regulation
- Islanded Microgrids

Additional Lab Protocols:

- Duty Cycle for ESS Firming
- Duty Cycle for PV Smoothing



Code and Standards Support for Safety Design of ES Systems