Commissioning Energy Storage

May 20, 2014
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State & Federal Energy Storage Technology Advancement Partnership (ESTAP)

Todd Olinsky-Paul
Project Director
Clean Energy States Alliance
Thank You:

Dr. Imre Gyuk
U.S. Department of Energy,
Office of Electricity Delivery and
Energy Reliability

Dan Borneo
Sandia National Laboratories
ESTAP is a project of CESA

Clean Energy States Alliance (CESA) is a non-profit organization providing a forum for states to work together to implement effective clean energy policies & programs.

ESTAP is conducted under contract with Sandia National Laboratories, with funding from US DOE.

ESTAP Key Activities:

1. Disseminate information to stakeholders
   - ESTAP listserv >500 members
   - Webinars, conferences, information updates, surveys

2. Facilitate public/private partnerships at state level to support energy storage demonstration project development
Project Director: Todd Olinsky-Paul

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SIGN UP FOR THE LISTSERV

The Energy Storage Technology Advancement Partnership (ESTAP) is a federal-state funding and information sharing project, managed by CESA, that aims to accelerate the deployment of electrical energy storage technologies in the U.S.

Project Objective

The project’s objective is to accelerate the pace of deployment of energy storage technologies in the United States through the creation of technical assistance and co-funding partnerships between states and the U.S. Department of Energy.

ESTAP conducts two key activities:

1) Disseminate information to stakeholders through:

NEW RESOURCES

- May 1, 2014
  - The Economics of Grid Defection
    By Rocky Mountain Institute

- April 4, 2014
  - ESTAP Webinar Slides: Microgrid Technologies
    By ESTAP

- April 4, 2014
  - ESTAP Webinar Recording: Microgrid

UPCOMING EVENTS

- May 20, 2014
  - ESTAP Webinar: Commissioning Energy Storage,

LATEST NEWS

- April 30, 2014
  - NYSERDA Announces Opening of Battery and
Today’s Guest Speakers


**Dan Borneo**, Engineering Project Manager, Distributed Energy/Electrical Energy Storage, Sandia National Laboratories

**Matt Galland**, Principal, Renewable Energy Project Solutions, Grant Manager for Sunpower Corp.

**Laurie B. Florence**, Principal Engineer for Large Batteries & Fuel Cells, UL
Energy Storage Commissioning:
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Making sure it works!

IMRE GYUK, PROGRAM MANAGER
ENERGY STORAGE RESEARCH, DOE
Commissioning is essential!

Increasing Number of Installations
Increasing number of Technologies
Need to build Confidence in Customers
Failed or Faulty Systems hurt the entire Industry!
In the Factory and in the Field
Commissioning Experience cuts Cost!

Need for a Standardized Approach / Manual
Electrical Energy Storage
Start-up & Commissioning Overview

Daniel Borneo, P.E.

Presentation for
Clean Energy States Alliance (CESA)

May 2014
Acknowledgments:

DOE and our Sponsor – Dr. Imre Gyuk, Program Manager for the Office of Electricity’s Stationary Energy Storage Program
Presentation Outline

- Introduction to Energy Storage (ES) commissioning
- Overview of Project implementation and Commissioning Process
- Commissioning Activities During Design and Construction
  - Team and Commissioning Program Development
  - Factory testing/Procedures/Inspections/Training
- Electrical Energy Storage System Commissioning Process
  - Operational Acceptance testing (OAT)
  - Start-up
  - Function Acceptance testing (FAT)
  - Shakedown
- Case Study
- Recap
Note:

This presentation will cover only the commissioning process, NOT the actual tests. The focus is on Stationary Electrical Energy Storage.

Since the actual tests and checklists are project specific please contact Dan Borneo drborne@sandia.gov for more information or assistance.
Commissioning is one step in the project implementation plan that verifies installation and tests that the device, facility, or system's performance meets defined objectives and criteria.

**Significance**
Commissioning helps insure that a system was correctly designed, installed and tested. The value of commissioning is to insure proper operation of the energy storage system, safety systems, and ancillary systems. **ALSO, Commissioning is an excellent means to help familiarize the Operation & Maintenance (O&M) staff with the system, how it operates, and how to respond in an emergency.**

**Process**
Commissioning is an orderly series of events to **demonstrate, measure** and record component and system performance. It is a process that develops and implements a set of **tests** tailored to a specific design. The commissioning process uses checklists, specifications, codes, standards, engineered drawings, and procedures to validate performance and to discover and correct problems before the system goes “online”.

Project Implementation Process

GOAL: To ensure a Safe and Reliable System is specified, designed and installed.

- Project Development
- Design
- Construction
- Commissioning
- Closeout
GOAL: To Ensure a Safe and Reliable System is Installed as designed and is verified operational.

NOTES on Tags

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

(Pick a Color)
YELLOW Tag: 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.
Daydreaming
Commissioning Activities During Design

- Identify commissioning team and **roles and responsibilities** and **integrate** with project team
  - Construction team
  - Energy Storage (ES) System integrator – (**Important position**) Energy Storage (ES) System integrator
  - Engineering designer – (**ES installation and balance of plant**) Engineering designer
  - Inspectors /EHS representatives/First Responders
  - Operations and Maintenance
  - Utility Representative – (**Point Of Connection**) Utility Representative
  - ES Equipment Vendor
  - Construction contractor?
- Review equipment specifications and applicable codes & standards
  - what is the KW/KWh rating, why?
  - Parameters that system needs to meet
- Develop and/or review the system **Sequence Of Operations (SOO)**
  - What **application(s)** will system be used for and Develop **equipment list** of items that will be commissioned
- Review and/or establish ESH requirements
  - What safety systems need to be installed
  - Develop Site Incident Prevention Plan-Authorization POC, LOTO, Hot-work
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
- Develop installation review checklists and perform inspections
  - Design Verification – Installed as designed & specified; labeling and signage in place, clearances,
  - Codes
  - Punchlist items noted
- Develop Training and emergency response procedures
- Implement Lock-out/Tag-out process
Commissioning Process - Operational Acceptance Testing (OAT)

Do the Individual components of the system operate?

- Verify and test that the 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 initiate system and operate all components.
  - Record base-line data
    - Voltage, currents, temperatures, flows, pressures
  - Perform initial IR scan
  - Record and repair and punchlist items
Commissioning Process - Functional Acceptance Test (FAT)

Does the system perform its intended service?

- Using Testing plans and procedures test the system to see if it 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 announced?
  - 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 the site.**
  - 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.
Case Study – Matt Galland
Recap:

1. Commissioning process needs to be started early in the project
2. Commissioning team needs representations from all the stakeholders, have clear R&R, and be partnered with project team (one and the same?)
3. The commissioning process may take 5 hours, 5 days or 5 weeks, but it must be done
4. Plan your work and work your plan

Questions?

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PV & Advanced Energy Storage for Demand Reduction

Demonstration Program Case Study & Lessons Learned

May 20, 2014
Agenda

- Case Study Overview
- Program Lessons Learned
- Project Overviews & Lessons Learned
  - ZBB at UCSD
  - Ice Energy at Kohl’s
- Project Team
PV+ES Program Overview

- In 2010 SunPower won a CSI grant to demonstrate PV integrated ZBB and Ice Energy storage systems
  - Site, design, install, operate and monitor systems for 2-years
  - Utilize existing installed PV systems
  - Assess operations and maintenance performance of ES systems
  - Measure impact on demand reduction and value proposition
  - Compare alternatives of deploying PV or ES separately

- In 2012-13, refined program objective to focus on energy storage technology demonstration; extended timeline
  - Mid-course change of demonstration partner (from Target to Kohl’s and UCSD) forced siting delays, design changes and plan revisions
  - CPUC granted additional 2-year no-cost time extension to Q1-2015
  - Introduced integrated SunPower grid controller to ZBB system
  - M&V to be modeled from ES performance vis-à-vis PV production, site load data and rates that are provided by demonstration partners.
Vendor & Partner Scope

- **ZBB at UCSD:**
  - Manufacture and install 6x 50kW ZBB EnerStore flow-batteries, a ZBB 125kW inverter and an ZBB EnerSection control system
  - ZBB scheduled for commissioning in December 2013
  - Provide O&M services and performance data for term of program

- **Ice Energy at Kohl’s:**
  - Manufacture, design and install 6x Ice Bear units integrated with existing HVAC systems
  - Manage all siting, construction, permitting and contracting logistics
  - Provide O&M services and performance data for term of program

- **DNV-GL & Sandia, both sites:**
  - Provide design, engineering and 3rd-party verification services
  - Perform site visits and ES system performance assessments at beginning, 6-month and 1-year intervals from commissioning
  - Provide reporting, public outreach and education programs
Program: Lessons Learned

- Proposing is easy; contracting is not
  - Can add substantial time to project between award and actual start
  - Must balance public interest with intellectual property protections
  - May require last-minute or after-the-fact partner substitutions

- Ensure senior-level endorsements are in place, up front
  - Must have authority to sign contracts on behalf of partner agency
  - Keep informed and engaged through regular meetings and updates

- Refine and assign scope, roles and responsibilities early
  - Proposal team <> delivery team

- Be flexible
  - Resources and project constraints change with extenuated delays
If project planned for two years, double it

- **Project Administration** (80% Complete)
- **Site Selection** (100% Complete)
- **Design & Build** (100% Complete)
- **Install, Commission** (95% Complete)
- **O&M, M&V** (30% Complete)
- **Decommission**
ZBB at UCSD: Plan & Design

- DNV/KEMA design and engineering plans
ZBB at UCSD: Install & Commission(ing)
ZBB at UCSD: Lessons Learned

- Identify collaborative host partner interested in research
  - Strictly commercial propositions (i.e. based on economic merit alone) impose logistical and operational limitations on pre-commercial demonstration projects

- Clarify siting capabilities and constraints early
  - Ensure adequate coverage for design, engineering, permitting, procurement, installation AND systems integration work

- Ensure essential permitting, certifications and education are explained and understood by the right stakeholders
  - ETL <> UL; CEO <> EHS; Construction Manager <> Operations
  - Vendor, installer, customer, inspector and fire marshal on same page

- Engage EHS through commissioning process, including:
  - Testing, acceptance/verification, communications and emergency response procedures.
Ice at Kohl’s: Plan & Design

- Working through Redding Electric Utility, Ice Energy secured a site license with and developed plans for Kohl’s, leveraging an existing 304kWp Sun Edison PV installation.
Ice at Kohl’s: Install & Commission

- Six Ice Bear units installed (Dec. 2012) and initial monitored data being received late 2013. REU installing additional meters for whole-site load data.

Ground mounted to mitigate rooftop weight loading

Rooftop and adjacent to HVAC load

Rooftop with onsite PV generation
Ice at Kohl’s: Lessons Learned

- Best if energy storage vendor can assume all responsibility for design, engineering, permitting and installation
- Helpful when proposed solution already has an installed – and proven – base of commercial customers.
- Enlist vendor to identify candidate host partners
- Ensure metering, data acquisition and reporting are in place
  - You can’t improve what you don’t measure!
For additional information...

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Stationary Battery Energy Storage Systems – A Standards and Codes Overview

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Agenda

Terminology & Standards
Terminology
Key Standards & Other Documents (examples)
What dictates standards needed?
Application
Chemistry
Application + Chemistry
Regulations
Effect of regulations on standard choices
Codes (examples)
Adoption of Codes & Reference to Standards
Example
Terminology & Standards
Terminology

**Code** – A document that is a systematic collection of laws or regulations

**Standard** – A document established by consensus and approved by a recognized body, that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context

**Recommended Practice** – A document that provides technical guidance, philosophy or preferred procedures regarding a given topic. A recommended practice may be similar in format to a standard but does not contain mandatory language.

**Guide** - document giving general advice or recommendations
Key standards and other documents (examples)

**ATIS-0600330**  
Valve-regulated lead-acid batteries used in the telecommunications environment

**Telcordia GR-3020-CORE**  
Nickel cadmium batteries in the outside plant

**Telcordia GR-3150-CORE**  
Generic requirements for secondary non-aqueous lithium batteries

**Telcordia GR-4228-CORE**  
VRLA battery string certification levels based on requirements for safety and performance

**UL 1973**  
Batteries for use in Light Electric Rail (LER) and Stationary Applications

**UL Subject 9540**  
Safety of Energy Storage Systems

**PNNL 22010**  
Protocol for Uniformly Measuring and Expressing the Performance of Energy Storage Systems

**IEEE 484**  
Recommended Practice for Installation Design and Installation of Vented Lead Acid Batteries for Stationary Applications

**IEEE 1184**  
Guide for Batteries for Uninterruptible Power Supply Systems

**IEEE 1361**  
Guide for selection, charging, test and evaluation of lead-acid batteries used in stand-alone photovoltaic (PV) systems

**IEEE 1375**  
Guide for the Protection of Stationary Battery Systems

**IEEE 1661**  
Guide for Test and Evaluation of Lead-Acid Batteries Used in Photovoltaic (PV) Hybrid Power Systems

**IEEE 1679**  
Recommended Practice for the Characterization and Evaluation of Emerging Energy Storage Technologies in Stationary Applications

**IEC 60896-11**  
Stationary lead-acid batteries - Part 11: Vented types - General requirements and methods of tests

**IEC 60896-21**  
Stationary lead-acid batteries – Part 21: Valve regulated types – Methods of test

**IEC 61427-1**  
Secondary cells and batteries for renewable energy storage - General requirements and methods of test - Part 1: Photovoltaic off-grid application

**IEC CD2 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 (not published)

**IEC CDV 62620**  
Secondary cells and batteries containing alkaline or other non-acid electrolytes – Secondary lithium cells and batteries for use in industrial applications (not published)

**IEC 62485-2**  
Safety requirements for secondary batteries and battery installations – Part 2: Stationary batteries
What dictates standards needed?
Application

- Grid applications: peak power shaving, frequency regulation, load following, time shift service
- ESS for renewable energy (i.e. wind farms, etc.)

Utility

- Data storage rooms
- UPS
- ESS for renewables (i.e. wind & PV)
- EV charging
- Community Energy Storage (CES)

Commercial & Residential
Chemistry

Lead Acid  Nickel  Lithium ion  Sodium Beta  Flow Batteries  Electro-chemical capacitors
Application + Chemistry

Applications

- Telecom
- PV
- Grid/Utility
- UPS
- General

Chemistry

- Lead Acid
- Nickel
- Lithium Ion
- Electrochemical Capacitors
- Other Chemistries

Standards and Guidelines:

- ATIS-0600330
- Telcordia GR-3020-CORE
- Telcordia GR-3150-CORE
- UL 810A
- UL 1973
- PNNL 22010
- IEEE 484
- IEEE 1184
- IEEE 1361
- IEEE 1375
- IEEE 1661
- IEEE 1679
- IEC 60896-11
- IEC 60896-21
- IEC 61427-1
- IEC 62619
- IEC 62620
- IEC 62485-2
- UL Subject 9540
- Lithium Ion
- Nickel
- Lead Acid
- Electrochemical Capacitors
- Other Chemistries
Regulations

Local and regional regulations will dictate standards to be applied.
Effect of regulations on standard choices
Codes (Examples)

NFPA 1, Fire Code
NFPA 2, Hydrogen Code
NFPA 70, National Electrical Code
NFPA 30, Flammable and Combustible Liquids Code
NFPA 54, National Fuel Gas Code
NFPA 5000, Building Construction and Safety Code
ICC IFC, International Fire Code
ICC IBC, International Building Code
ICC IFGC, International Fuel Gas Code
ICC IMC, International Mechanical Code
ICC IPC, International Plumbing Code
ASME B & PVC (Section VIII), Boiler & Pressure Vessel Code
ASME B31 (series) Piping Code
Adoption of Codes & Reference to Standards

Local municipalities and regional governments → use the codes as the basis for their regulations → Codes require compliance to standards by:

- Referencing standards directly in codes or
- Requiring that certain equipment be “Listed”
  - Listing infers, by definition, 3rd party certification to an appropriate standard

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Example
Example
A 5 kW lithium ion energy storage system for use in a data storage center and installation location is city of Chicago, IL:

Regulations: Chicago Building Code Electrical Requirements

• Dated February 8, 2000
• Based upon NFPA 70 (1999 edition) and references NFPA 75, Standard for the Fire Protection of Information Technology Equipment

18-27-90.7 Examination of equipment for safety

• “All equipment, devices, and appliances covered by the provisions of this chapter shall be tested by and bear the label of a recognized testing laboratory. Manufacturers or distributors of specialized, limited production, or custom built equipment for which there is no commercially available, test laboratory labeled substitute may apply for evaluation and recognition by the building commissioner. Self-certification of equipment or installations shall not be acceptable.”

18-27-645.2 Special requirements for information technology equipment room.

• 18-27-645.2 (b) Requires listed information technology equipment be installed.
• Certified to UL 60950-1 for example

Other Applicable Provisions of the CBC

• i.e. 18-27-480 applicable criteria in the storage battery section, etc.
Example

ANSI UL 60950-1 Scope -

1.1.1 Equipment covered by this standard:

“This standard is applicable to mains-powered or battery-powered information technology equipment, including electrical business equipment and associated equipment, with a rated voltage not exceeding 600 V.”

1.1.3 Exclusions:

“This standard does not apply to:

- Power supply systems which are not an integral part of the equipment, such as motor-generator sets, battery backup systems and transformers;
- building installation wiring;
- devices requiring no electric power.”

ANSI UL 1973 Scope –

1 Scope

1.1 “These requirements cover electric energy storage systems as defined by this standard for use as energy storage for stationary applications such as for PV, wind turbine storage or for UPS, etc. applications.”
THANK YOU.

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Today’s Guest Speakers

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Webinar Archive: www.cesa.org/webinars

ESTAP Website: http://www.cesa.org/projects/energy-storage-technology-advancement-partnership/

ESTAP Listserv: http://www.cesa.org/projects/energy-storage-technology-advancement-partnership/energy-storage-listserv-signup/