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Project Process: Developing & Deploying Battery Energy Storage Systems

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BESS Project Process

Objective – From a System Owner Perspective

- Gain an understanding of a Battery Energy Storage System (BESS) project process
- Be able to apply specific lessons learned on various project phases
- Construct a safe, reliable, cost-effective BESS

Recent DOE OE Sponsored Projects

State or Territory	Partner
Alaska	Cordova Electrical Cooperative (CEC)
Alaska	Alaska Village Electrical Cooperative (AVEC)
Arizona (x3)	Navajo Tribal Utility Authority (NTUA)
Colorado	Poudre Valley Rural Electrical Association (PVREA)
Florida (x4)	Seminole Tribe
Hawaii	Natural Energy Laboratory of HI Authority (NELHA)
Iowa	Alliant Energy
New Mexico	Santa Fe Community College
New Mexico	Albuquerque Public Schools

State or Territory	Partner
New Mexico	Picuris Tribe
North Carolina	NC Electric Membership Corporation (NCEMC)
North Carolina	Ft. Bragg Sandhills Utility Services (SUS)
Puerto Rico	Villalba Municipality
South Dakota	Ellsworth AFB West River Electric Association (WREA)
Tennessee	Electric Power Board of Chattanooga (EPB)
Vermont	Green Mountain Power (GMP)

Starting a BESS Project

BESS Project Phases & Key Topics

★ = Lessons Learned

Project Initiation	Identify the business need that a BESS will meet
Project Development & Design	Project analysis, both technical and economic
Procurement	Request for Proposal (RFP) development & Ownership model
Construction	Monitor, Monitor, Monitor…
Acceptance Testing	What should be tested and how • Don’t call this phase ‘Commissioning’
Operations & Maintenance	Project close-out, warranty, and maintenance decisions

EXECUTION (Procurement – Acceptance Testing)

CLOSE-OUT (Acceptance Testing – Operations & Maintenance)

BESS Project Phases

Project Initiation

- Identify a business need, opportunity or problem
  - High penetration of PV on a section of distribution line (PV shifting)
  - Need for resiliency in natural disaster prone areas (fire, flood, hurricane, etc.)
  - Value stacking – adding other functions, i.e. demand reduction, peak shaving, etc.
- How can a BESS solve one of these issues?
  - Feasibility study – *There are some free analytical tools available*
- Broadly scope the project
  - What combination of technology is the right fit (solar + storage, wind + storage)
  - BESS siting ★
  - Interconnection request & approval ★
  - Communications/Data Acquisition ★
  - Ownership Model/Contracting Methods

BESS Project Phases

Project Initiation

Ownership Models

System Ownership	Pros	Cons
Owner/Operator • Owner pays for developer to build ES system, or to provide a turnkey system • Owner will operate system	• Control of system installation and operation • Ability to adjust operations and applications as markets warrant	• Owner assumes risk • Warranty or O&M agreements to solve operational issues and maintenance requirements
Lease (w/Option to buy) • Customer leases ESS from owner for specified time • Customer will operate system within parameters of lease	• Control of system within lease parameters • Some ability to adjust operations. • Maintenance burden usually born by ESS owner	• Lack of ownership • Storage customer bears some operational risk, and is responsible for maximizing benefits
Power Purchase Agreement (PPA) • Project developer/operator builds and operates ESS • Customer pays for kWh and/or services delivered	• Performance risk and maintenance burden is borne by ESS owner/operator • Customer only pays for energy and/or services	• Lack of ownership • Customer may be locked into operating load profiles and/or applications that become inconsistent with markets or project needs

BESS Project Phases

Project Initiation

Contract Methods

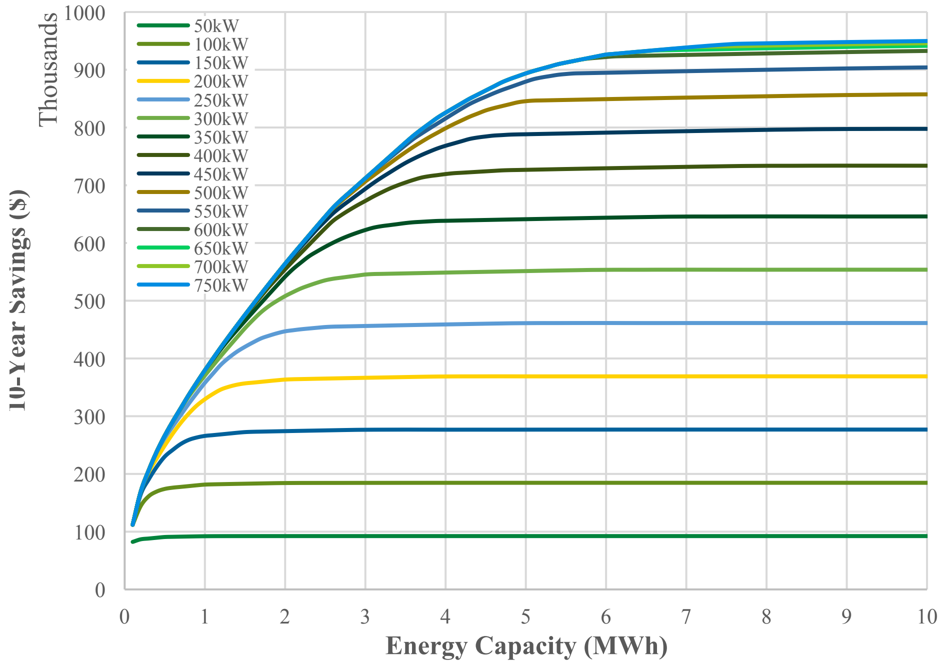
Contracting Strategy	Description	Comments
Design / Bid / Build (DBB) or Engineer/Procure/Construct (EPC)	Using this strategy, the owner will place a contract with a design firm or developer, and then once the design is complete, the design is put out to bid for procurement and installation.	When the owner has adequate staff, this strategy allows the owner more control, as the owner can act as the gate between design and construction.
Design / Build (D/B)	In this strategy, a ES system provider or developer is hired by the owner to design and build the ESS project. Sometimes called a turnkey system	This is a convenient strategy when the owner has limited engineering and/or construction management resources.
Hybrid	Owner separates the infrastructure design and installation from the ESS design and installation	More oversite by owner to coordinate the interface between infrastructure and ESS, i.e., conduits, cabling, electrical distribution. But integration may be a hassle

BESS Project Phases

Project Development & Design

- Project Analysis – Technical & Economic
  - An extension or refinement of the feasibility study
- Technical Analysis (Power System Simulation)
  - What size of BESS in power and energy solves the business need
  - Where on the distribution system does the BESS provide the greatest benefit
- Economic Analysis (Techno-economic)
  - Does the 'right size' BESS make sense economically
    - Based on rate structure, project funding availability, etc.

Analysis output example



BESS Project Phases

Project Development & Design

Available Analysis Tools

Valuation Tools		
QuESt	DOE - SNL	Free
ESET	DOE - PNNL	Free

Design Tools		
MDT	DOE - SNL	Free
DER-CAM	DOE - LBNL	Free
REopt	DOE - NREL	Free

Valuation Tools		
Storage-VET™	EPRI	Free
energystoolbase	Energy Toolbase	Commercial
BatSIMM	Ascend Analytics	Commercial

Design Tools		
DER-VET	EPRI	Free
Homer	Homer Energy	Commercial

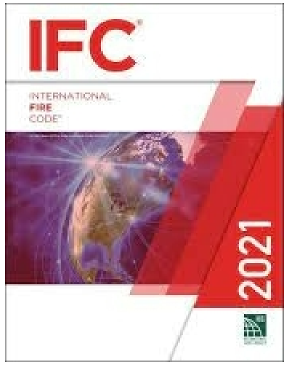
https://link.springer.com/article/10.1007/s40518-021-00186-4

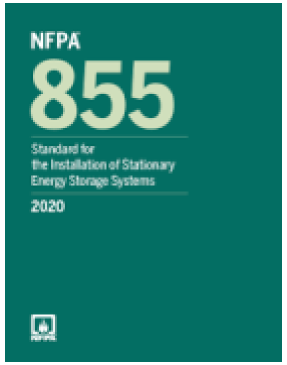
BESS Project Phases

Procurement

- Developing a Request for Proposal (RFP)★
  - The ES system RFP requirements determine much of the ‘Who’ and ‘How’ of the Construction and Acceptance Testing tasks
  - This has shown to be especially true when specifying Codes/Standards that the ES system is to be designed to meet
  - It is recommend that ‘best practice’ Codes/Standards are used in the RFP (specifically UL9540 2020 & NFPA 855 2020/IFC 2018 or 2021) no matter what Code year the State has adopted
  - Who supplies training on what component and when?
  - An RFP template can be used (i.e. EPRI ESIC Energy Storage Technical Specification Template)
    - https://www.epri.com/research/products/000000003002013531

- Determine Contracting Methods
  - Turn-key system or some involvement?





BESS Project Phases

Procurement

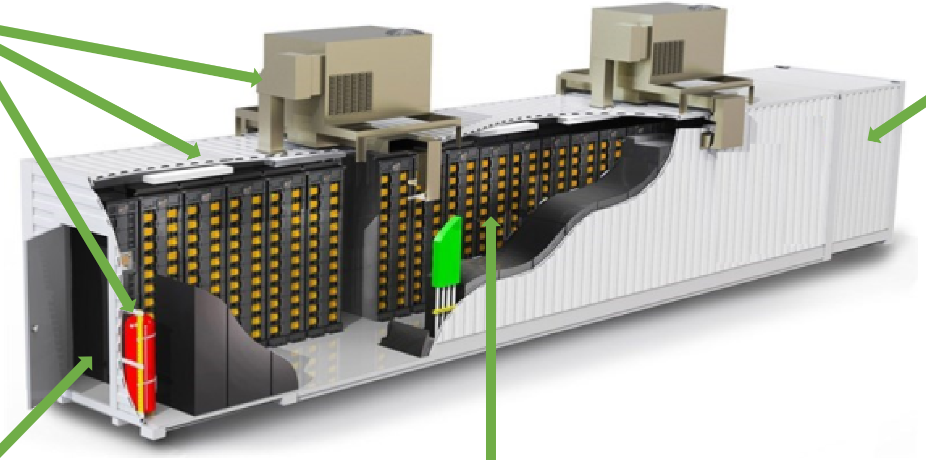
Continued

- Putting the proposal out for bid
  - Should have a way to reach a broad vendor base in addition to some preferred vendors
- Bidder down selection and bid analysis
  - Narrow down prospective bidders to three (if you have more than three good ones)
  - Set up discussion meetings to have a detailed review of offer
    - Need to ask appropriate questions to understand what is being supplied (required modifications?)★
    - Need to understand who is supplying what component of a BESS★
- Contract award

BESS Project Phases

Procurement

Components of a BESS



System Enclosure

- HVAC System
- Fire Protection
- Explosion Control

Energy Storage Management System (ESMS)

- Controls charge/discharge
- Load Management
- Monitoring & System History

Power Conversion System (PCS)

- Bi-directional Inverters
- Switchgear/Transformers

Storage (DC block)

- Batteries/Modules/Racks
- Battery Management System

Image credit: https://www.globalenergyworld.com/news/sustainable-energy/2018/04/09/battery-energy-storage-system-market-worth-854-bn-usd-2023

BESS Project Phases

Procurement

BESS Supplier Model

Battery Supplier (DC Block)
- Partners w/an integrator or…
- Supplies batteries and/or enclosure as a one-off bid/supply process

System Supplier/Integrator
- Integrator has a relationship with a battery vendor or bids out for batteries
- Integrates batteries/enclosure into the rest of the system

Developer/Bidder
- Company that is a manufacturers rep for the system integrator
- Can deliver system X for $Y

System Owner
- Potential system owner puts an RFP ‘out on the street’
- Awards contract for a turn-key battery energy storage system

BESS Project Phases

Construction

- Monitor site safety status
- Monitor scope, schedule, and budget
- Review & Approve Submittals
  - For owner supplied equipment (xfmr's)
- Respond to Requests for Information (RFI's)
- Make sure that everything is in place for Acceptance Testing
  - Additional specialty contractors such as:
    - Battery systems
    - ESMS
    - Fire Protection
- Develop Emergency Response Plan (side by side with local First Responders)

BESS Project Phases

Acceptance Testing

Accepting Testing

- System component testing
- Start-up/Functional performance testing
- Site acceptance testing

There are some great resources for this!

- Baseline measurements
- Communication & Controls/Data Acquisition System (DAS)
- O&M training
  - RFP/bid analysis should have determined ‘who’ delivers this and for what system component – battery vendor, integrator, etc.
- Emergency response
  - Plan should already be developed, this part of the process is site walk-thru and plan iteration with First Responders

BESS Project Phases

Acceptance Testing (Commissioning)

Accepting Testing

Document	Purpose
Protocol for Uniformly Measuring and Expressing the Performance of Energy Storage Systems	- A set of "best practices for characterizing ESS and measuring and reporting their performances" - Contains 7 Application Duty Cycles – see additional slides https://www.sandia.gov/ess/publications/sandia-national-labs/sandia-national-laboratories-snl-publications/
Energy Storage Integration Council (ESIC) Energy Storage Commissioning Guide 2018 • *EPRI/SNL/Others working on a new revision*	A non-project-specific practical guide for utility users, suppliers, and other stakeholders who are planning energy storage system projects that include a system commissioning stage of project execution https://www.epri.com/research/products/000000003002013972
Energy Storage Integration Council (ESIC) Energy Storage Test Manual	Test manual provides guidance on the definitions of performance and functional parameters that a utility or other owner may consider when evaluating energy storage systems. https://www.epri.com/research/products/000000003002013530

BESS Project Phases

Operations & Maintenance

- Resolve outstanding issues
  - These aren’t show-stopper items but must be taken care of prior to final contract payment
  - Refer to punch-list items
- Warranty
  - Check on start and duration of warranty (typically 1 year)
- Maintenance
  - Can be built into the RFP for the vendor to provide as part of overall cost of system
    - Vendor maintenance contracts can be expensive
  - Can require the vendor to provide staff training for up to X personnel as part of RFP
  - Can require a period of maintenance support + training for a period of time (1 year)
    - This will allow time to determine if self-performing maintenance is desired or third-party solutions are best

Lessons Learned

Lessons Learned

Project Initiation

- Interconnection Request & Approval

It can be a long process – start early, make contact with the Utility, follow through

- BESS Siting (Location)

Installation Standards/Codes consideration

  - *The BESS can be classified as Remote or a Location near exposures (NFPA 855)*
  - *This classification triggers requirements (Table 4.4.3) that will result in required documentation from the system vendor*

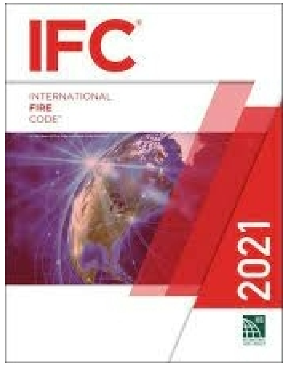
Lessons Learned

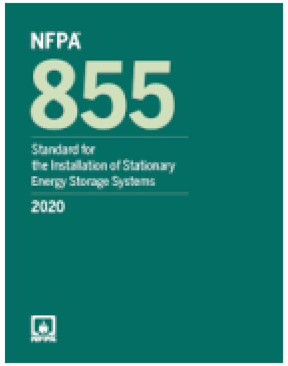
Procurement

Request for Proposal (RFP)

- Developing a RFP
  - It is recommend that ‘best practice’ Codes/Standards are used in the RFP (specifically UL9540 2020 & NFPA 855 2020/IFC 2018 or 2021) no matter what Code year the State has adopted

Know and understand both Product Listing Standards (UL9540) AND Installation Codes/Standards (IFC/NFPA 855) and how they apply (or you want them to apply) to your particular location and system





Lessons Learned

Procurement

Bid Analysis

- Need to ask appropriate questions to understand what is being supplied (required modifications?)

If 'best practice' Codes/Standards were specified in your RFP there are several things to know:

There exists a knowledge gap between Product Listing Standards (UL9540) and the Installation Standards (IFC/NFPA855) that can affect the system deliverable

What documents you should be expecting and from whom, especially:

- *Hazard Mitigation Analysis (HMA) & Large-Scale Fire Testing (UL9540a) data– these will be required by the Authority Having Jurisdiction (AHJ) to approve exemptions to the Size and Separation & Maximum Stored Energy limitations*
- *UL9540a test data also forms the basis for design of the battery enclosure fire protection systems and explosion control*
- *Explosion Control (NFPA 855 4.12 & IFC 1207.6.3)*
  - *In the Installation Codes/Standards, not Product Listing Standard(UL9540)*

Lessons Learned

Procurement

Bid Analysis

- Need to understand who is supplying what component of the BESS
  - In most cases there will be multiple vendors suppling different portions of the energy storage system which can lead to confusion about who is responsible for acceptance testing of individual components

Battery Supplier (DC Block)
- Partners w/an integrator or…
- Supplies batteries and/or enclosure as a one-off bid/supply process

System Supplier/Integrator
- Integrator has a relationship with a battery vendor or bids out for batteries
- Integrates batteries/enclosure into the rest of the system

Developer/Bidder
- Company that is a manufacturers rep for the system integrator
- Can deliver system X for $Y

System Owner
- Potential system owner puts an RFP 'out on the street'
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- *Know who is supplying what part of the ES system*
- *Understand the relationship between the different suppliers (have they done other projects together?)*
- *Check references on past projects – were there delays?*
- *Does the battery supplier have a strong/deep North American office?*
- *Who is specifying and who is performing acceptance testing tasks on what component?*
- *Understand what additional resources will be needed to commission fire protection system(s) – this can range from the fire control panel to the dry-chem systems to the smoke, heat, and gas detectors*

Lessons Learned

Acceptance Testing

Comms/Data Acquisition

Battery/DC Block:
- Rack, module, cell level data
  - DC voltages, currents
  - Temperatures
- Calculated values
  - Aggregations, SOC, SOH

Power Conversion:
- Inverter data (individual & aggregate)
  - DC voltage, current
  - AC voltage, current, frequency, power factor
- Aggregated/calculated values

Balance of Plant (Environment, Safety Systems):
- Enclosure data:
  - Temperature, humidity
- Local data
  - Outside temperature, humidity
- Fire Protection
  - Water and/or dry chem system status
  - Smoke/heat sensors
- Alarms
  - Faults, e-stops, door open, etc.
- Grid (Point of Interconnection – POI)
  - Voltage, current

Category	Tier 1	Tier 2	Tier 3	Tier 4
Battery	N/A	~60	~70(+)	All available
Power Conversion	~25	~65	~90(+)	All available
BOP	~20	~20	~20(+)	Most – installation dependent
Total Data Points	~50	~150	~200+	All available (~1000’s)

Installed System Example where Tier 2 is the system owner (Utility) and Tier 3 is SNL

- Collecting ES data for monitoring can be complex and only scales in complexity with the size of the system, data points you have/want, frequency, etc. Get an IT person on-board the project team
- Cybersecurity of remote monitoring/data collection is a growing concern

Lessons Learned

Acceptance Testing

If the contractual mechanism is available to withhold 5-10% of progress payments (retainage/retention) pending successful start-up and operations – USE IT!

Summary – *Key Takeaways*

- Start some processes early
- Knowledge is key to a successful BESS installation:
  - Relevant Codes/Standards
  - Suppliers and their relationships to/with each other
    - Be prepared to reference check previous projects
  - Supplier deliverables
    - Not just ES components but analysis and safety documentation, etc.
  - ES data collection can be difficult
    - Get an IT/industrial automation person onboard as part of project team

Thank You!

Questions? Contact Our Team

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This work was Directed by Dr. Imre Gyuk through the Department of Energy Office of Electricity (DOE-OE) Stationary Energy Storage Program.

Additional Information

Available Analysis Tools

Descriptions

Description	Features
Quest (by SNL)	
Open-source software application suite for energy storage analyses developed in Python	• QuESt Valuation for evaluating the potential revenue of an ESS participating in electricity markets • QuESt BTM for estimating cost savings for TOU and net metering customers using BTM energy storage • QuESt Tech Select for choosing the proper ES technologies for a given project. • QuESt Data Manager for acquiring relevant data.
Storage-VET™ (by EPRI)	
Open-source software to inform ESS deployment with recommended technology, location, and optimal sizes.	• Cost-benefit valuation of energy storage projects across different grid and customer services. • Selection of storage technologies. • Sensitivity analysis for optimal siting and sizing.
ESET (by PNNL)	
A web-based suite of modules and applications that to model, optimize, and evaluate various energy storage systems.	• BSET for evaluating and sizing BESS for grid applications. • HSET for valuating hydrogen energy storage systems for grid applications. • MASCORE for optimal sizing DER for microgrids. • PSHET for valuating pumped storage hydroelectric systems.

MDT (by SNL)	
A decision support software tool for microgrid design using genetic algorithms to find and evaluate different microgrid designs that meet user-defined objectives.	• Topology and asset selection to find the optimal microgrid topology and components' sizes. • Multi-objective optimization for search space exploration. • Energy and asset reliability to evaluate reliability of different microgrid designs. • Performance assessment of microgrid designs.
DER-CAM (by LBNL)	
A decision support tool to find the optimal investments on new DERs for buildings or microgrids.	• DER investment optimization for optimizing the DER investments that minimizes the total annual energy supply cost of a building or a microgrid. • DER optimal dispatch to provide optimal dispatch of ESS participating in energy markets.
DER-VET™ (by ERPI)	
Open-source platform for valuating distributed energy resources (DER) based on their technical merits and constraints.	• Cost-performance analysis of DER to inform project-level decisions (e.g., investment, design)
REopt (by NREL)	
A web-based software tool, to optimize the integration and operation of energy systems for buildings, campuses, communities, and micro-grids.	• REopt Lite to find the optimal mix, sizes, and dispatch of different DERs and loads to minimize cost. • REopt Full (not publicly available) for customized analyses.

Introduction to the SNL/PNNL Protocol

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

Available at https://www.sandia.gov/ess/publications/sandia-national-labs/sandia-national-laboratories-snl-publications/

7 Application Duty Cycles

- ***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
- ***PV Smoothing*** – ES is dispatched mitigating ramp up and down from variable PV generation
- ***Renewable Firming*** - Renewables (solar) firming is the application of an ESS to provide energy to supplement renewable (solar) generation such that their combination produces steady power output Volt/Var Support - A volt/var application addresses fluctuations in grid voltage by providing volt-amperes reactive (var) support, injecting vars as grid voltage dips and absorbing vars as grid voltage increases.
- ***Power Quality*** - Mitigating voltages sags by injecting reactive 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