ENERGY STORAGE PROJECT DEVELOPMENT

Sandia National Laboratories

Wisconsin Public Service Commission
June 9, 2021




PRESENTED BY
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U.S. DEPARTMENT OF ENERGY NNSA

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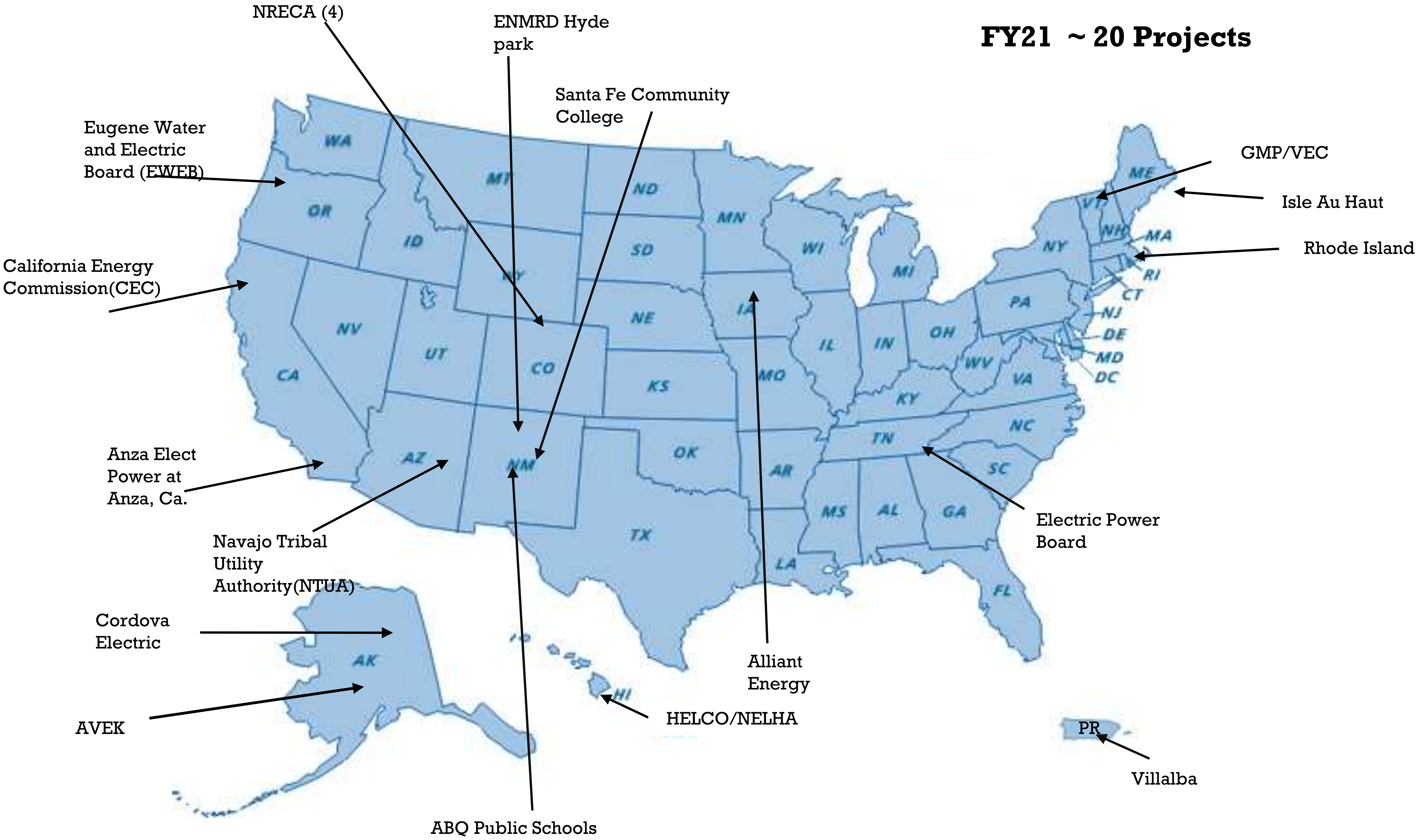
DOE/SNL ENERGY STORAGE PROJECTS



REPRESENTATIVE CURRENT PROJECTS

Project	Location	Power / Energy	Application
Cordova (Alaska)	Municipal Co-op	1MW / 1MWh	Hydro Power increase; Reduce diesel emissions
Sterling (Massachusetts)	Municipal Power	2MW / 3.9MWh	Reduce peak power fees
Alliant (Iowa)	Distribution / Residential feeder	2.5MW/2.9MWh	Increase rooftop solar capacity
ANZA (California)	Anza	2MW/4MWh	Transmission deferral
Albuquerque Public Schools (New Mexico)	High School site	500kW/2MWh	Reduce demand charges
Santa Fe Community College (New Mexico)	Community College site	100 kW/170kW	Renewable energy shift; fossil fuel reduction
Alaska Village Energy Cooperative (AVEK)	Saint Mary's and Mountain Village.	1MW/2MWh proposed	Tie between two villages to provide spinning reserve and make efficient use of wind power.
NRECA 1 Colorado	Poudre Valley RED Feather Lakes	140kW/446kWh	Community Resiliency utilizing micro grid
NRECA 2 North Carolina	NCEMC Rose Acre	2.5MW/5MWh	Resiliency in large manufacturing operation.
NRECA 3 North Carolina	Sandhills @ Fort Bragg	90kW/270kWh	Resiliency utilizing microgrid
NRECA 4 South Dakota	West River @ Ellsworth AFB	250kW/250-500kWh	Resiliency utilizing microgrid

SYSTEM ELEMENTS => DESIGN DECISIONS

Battery Storage	Battery Management System (BMS)	Power Control System (PCS)	Energy management System (EMS)	Site Management System (SMS)	Balance of Plant
• modules • Racks • $/KWh	• Battery Management & BESS Protection • $ included in storage cost	• Bi-directional Inverter • Inverter control • Interconnection / Switchgear • $/KW	• Charge / Discharge • Load Management • Ramp rate control • Grid Stability • Monitoring • $ / ESS system	• Distributed Energy Resources (DER) control • Synchronization • Islanding and microgrid control • $ / microgrid	• Transformer/ POC switchgear • BESS container • Climate control • **Fire protection** • Construction and Permitting • $ / project



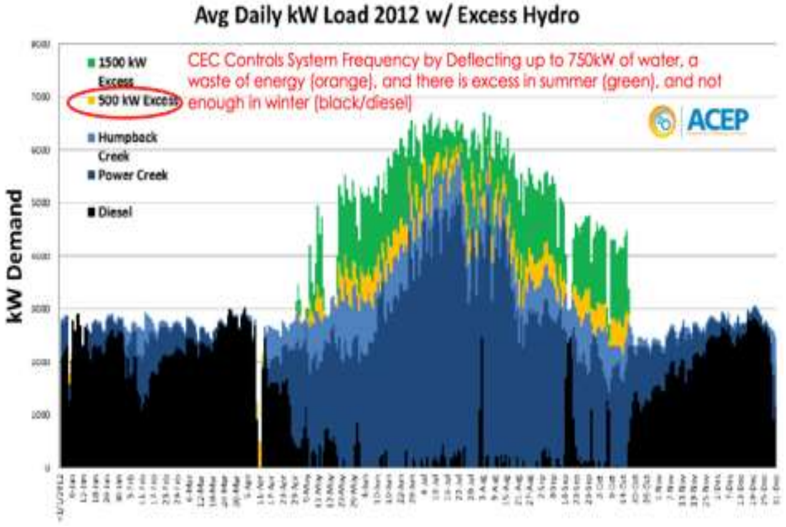


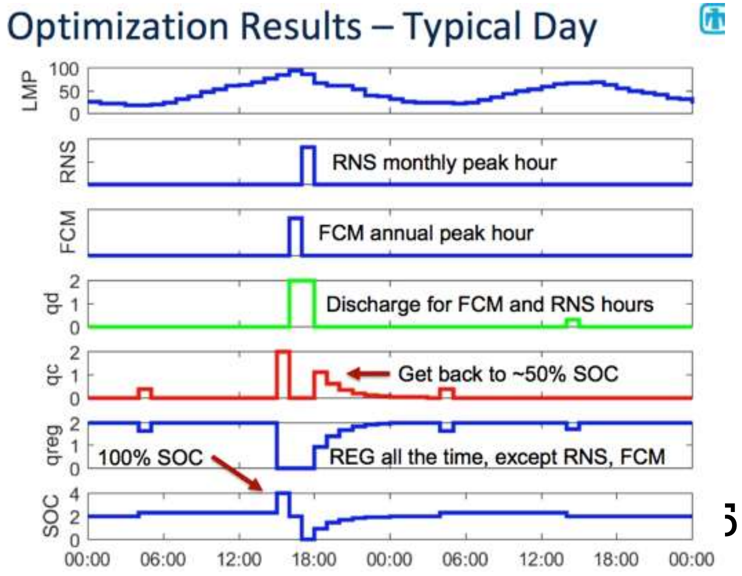
NOTE: Important to have single entity responsible for the ESS integration.

SNL ENERGY STORAGE PROJECT PROCESS

Traditional project methods

Project Stages (Design Build)	Sandia Contributions
PROJECT DEVELOPMENT	Analysis – Location, Application, System Size, ROI , Technology, Technical RFP
Conceptual DESIGN	Codes, Standards, Best practice – FP, Controls, DAS
PROCUREMENT/ CONSTRUCTION/	RFP, Design, permits, proposal, contracts, procurement, installation
FACTORY TEST and COMMISSIONING	controls and system commissioning, base-line, testing
SHAKEDOWN/ OPERATION/. PUNCHLIST CLOSEOUT	Safety system check, Operation monitoring and analysis, learnings





PROCUREMENT – SYSTEM OWNERSHIP DECISIONS

System Ownership	Pros	Cons
Owner/Operator Owner pays for developer to build system, or to provide a turnkey system. Owner will operate system.	Complete control of system installation and operation. Ability to adjust operating load profiles and applications as markets warrant.	Owner assumes risk and only have contract requirements, warranty or O&M agreements to solve operational issues. Will need to perform maintenance not covered by warranty or maintenance agreements.
Lease (w/Option to buy) Customer leases ESS from owner for specified time at monthly rates. Customer will operate system within parameters of lease.	Control of system within lease parameters. Some ability to adjust operations if needs/markets change. Maintenance burden usually borne by ESS owner. Tax appetite considerations.	Lack of ownership. Storage customer bears some operational risk, and is responsible for maximizing benefits.
Power Purchase Agreement 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.

Procurement – Contract Delivery 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. This is 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

CONTRACT COMPONENTS

Contractor/Integrator Responsibilities

Safety Program

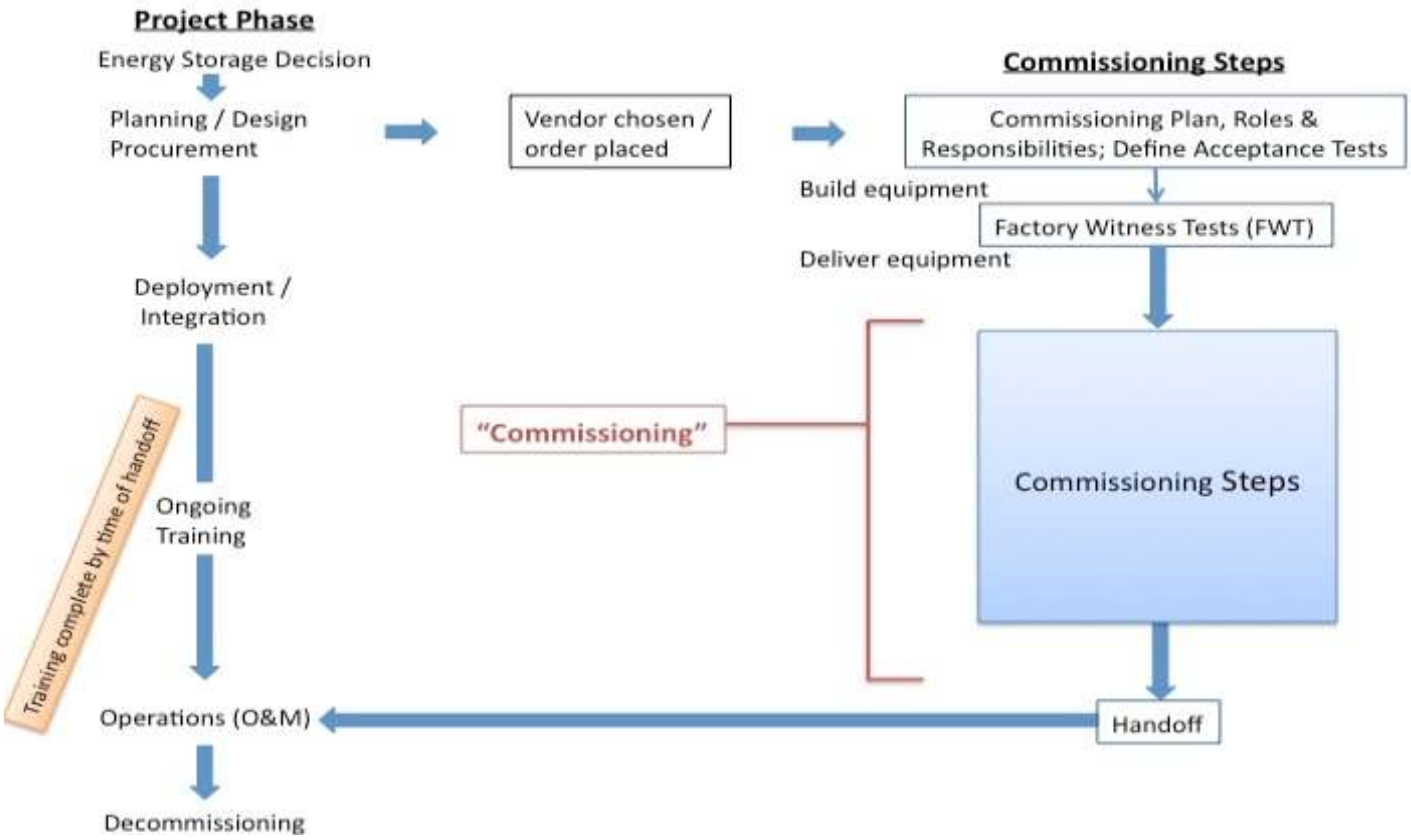
Construction sequencing/Schedule

Testing/Commissioning

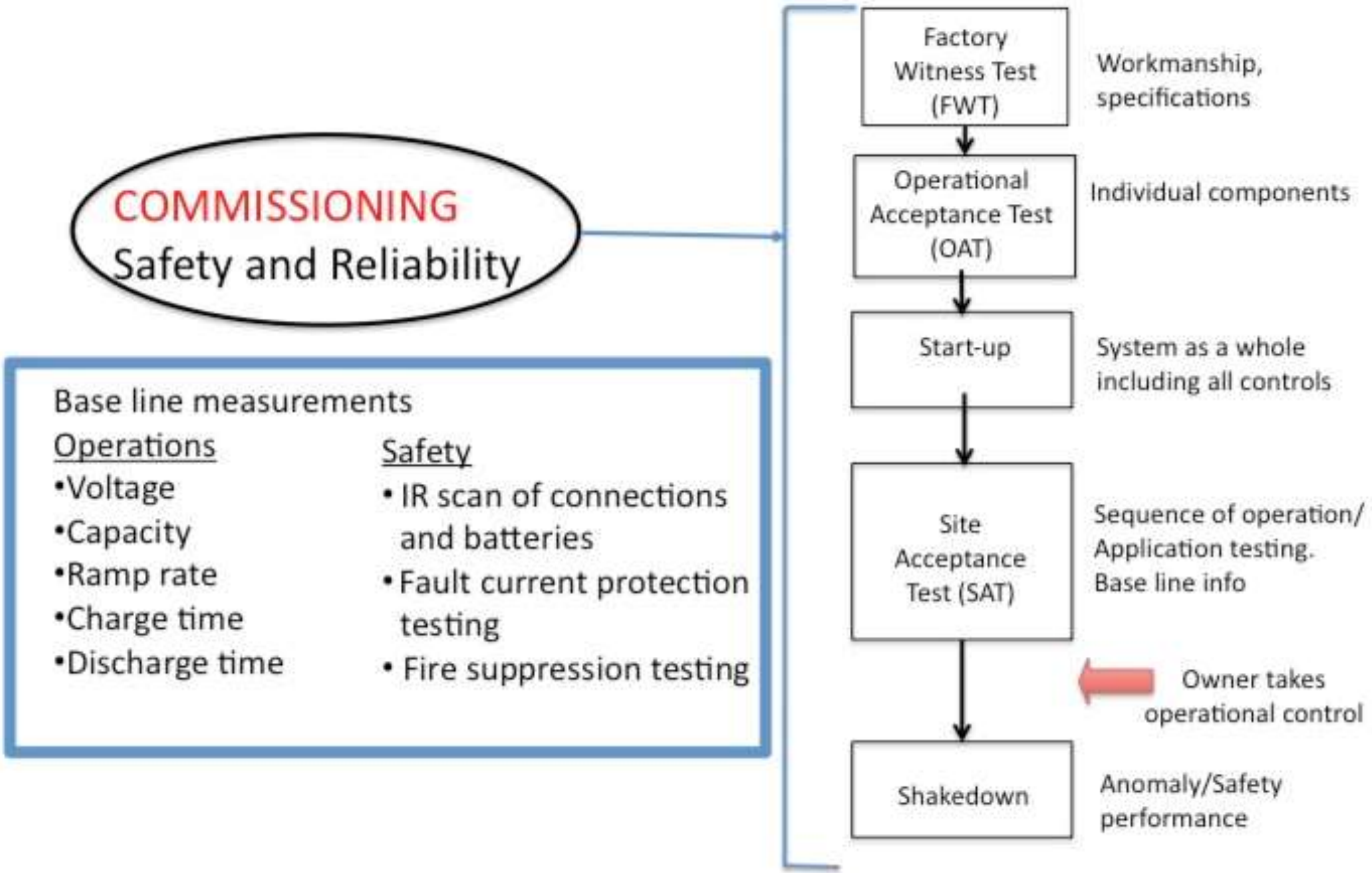
Performance Guarantee

Maintenance

COMMISSIONING PROCESS STARTS AT RFP



COMMISSIONING / TESTING PROCESS DETAILS



LESSONS LEARNED - COMMISSIONING

Things to check

- Controls
- Data acquisition
  - Points of interest
    - Capacity fade
    - Operational parameters
- Base-line IR scan
- Safety system check out
  - Does system behave when bad things happen?

A FEW POINTS ABOUT SAFETY – DAVID ROSEWATER WILL SAY MORE

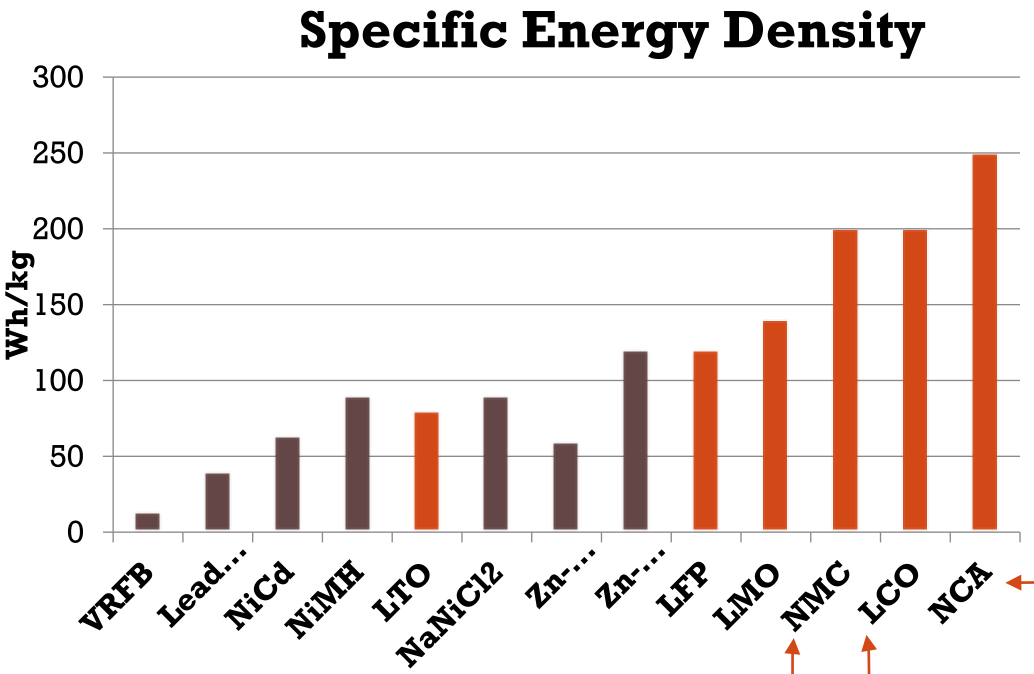
- Safety systems _what works what doesn't, what's the latest in design
  - Smoke exhaust,
  - louvers for ventilation during fire
- Communication and Training of first responders, operation/maintenance

MORE LESSONS LEARNED

- Integration is complex and should have one owner
- Integrate and test at Factory
- Warranties and maintenance need to be factored into ROI
- Multi-port inverters can limit your output
- Software Updates to one part may impact another
- Detail all possible operations for microgrid (e.g., storage + PV) during design to avoid retrofit.
- RFP details are important
  - Load Profile
  - Applications – Depth of Discharge impact cycle life
  - Cycle life for given application(s)
  - Type of storage i.e., batteries, other
    - Chemistry of battery – six types of li-ion + hybrids

BONUS SLIDE - Technology Selection

BATTERY TECHNOLOGIES AND THEIR ENERGY DENSITIES



Tesla

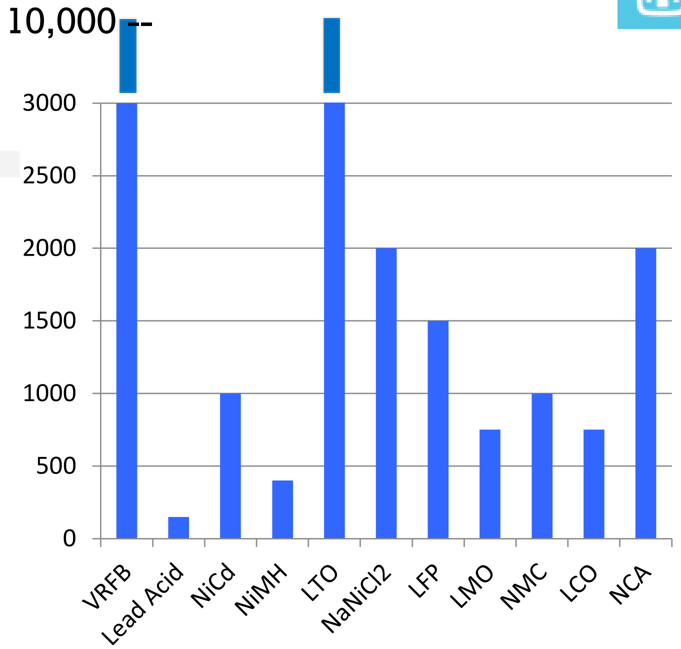
I-Phone

LG/Volt

Not listed:
NaS: 150 - 240 Wh/kg

Abbreviation	Name
VRFB	Vanadium Redox Battery
Lead Acid	Lead Acid
NiCd	Nickel Cadmium
NiMH	Nickel Metal Hydride
LTO	Lithium Titanate
LFP	Lithium Iron Phosphate
LMO	Lithium Ion Manganese Oxide
NMC	Lithium Nickel Manganese Cobalt Oxide
LCO	Lithium Cobalt Oxide
NCA	Lithium Nickel Cobalt Aluminum Oxide
Zn-MgO2	Zinc Manganese Oxide
NaNiCl2	Sodium Nickel Chloride (Zebra)

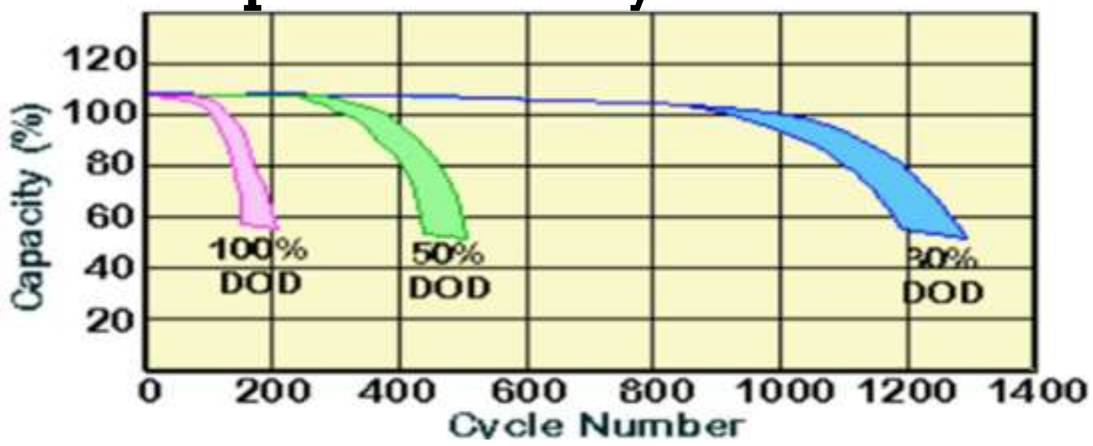
li-ion varieties



Cycle life of different batteries

Not listed NaS = 4500

Representative Cycle life vs. DoD



Curtesy of: Battery University

SUMMARY

Murphy's Law:

= ((U+C+I) x (10-S))/20 x A x 1/(1-sin(F/10))

Where:

U=urgency, C=complexity, I=importance, S=skill, A=aggravation and F=frequency

Newatlas.com

Resources:

Of Interest:

Expression of Interest (EOI)

Issued by: Clean Energy States Alliance (CESA)

For the Implementation of Innovative Energy Storage Pilot Projects
Issue Date: June 1, 2021
Response Deadline: July 15, 2021

Provides support to the nation engaged in developing energy storage projects.

For EOI details:

https://www.cesa.org/projects/energy-storage-policy-for-states

THANK YOU

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PROJECT DEVELOPMENT – FOCUS ON PRE-CONSTRUCTION

Steps

ANALYSIS

DESIGN

PROCUREMENT DECISIONS

CONSTRUCTION COMMISSIONING HAND-OFF

Issues

Goals, Size **optimization**, (Power rating, energy capacity, frequency of use)

SELECT ES TECHNOLOGY

Interconnection, Controls, Data Acquisition, **Safety C&S**

Ownership type; Contract type; Issue **solicitation / RFP**

CONTRACT INTEGRATOR OR VENDOR