ENERGY STORAGE PROJECT DEVELOPMENT

Sandia National Laboratories

Illinois Commerce Commission
Energy Storage Webinar Series
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PRESENTED BY

Dan Borneo/Susan Schoenung

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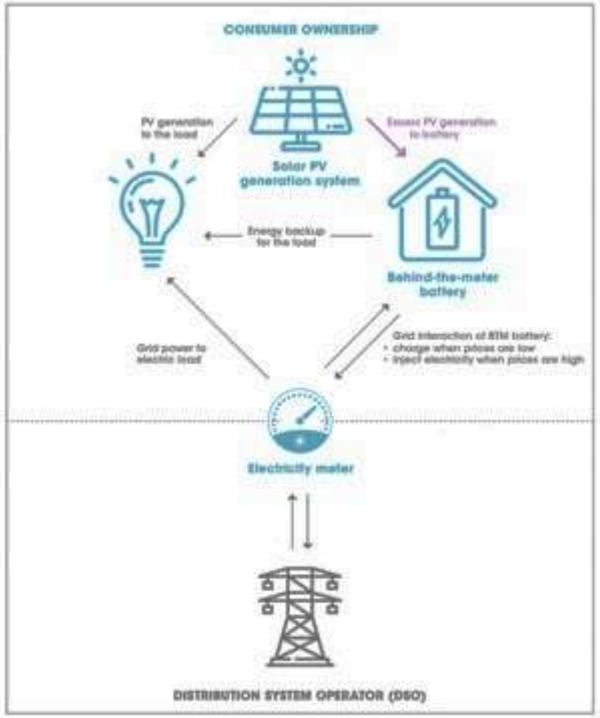
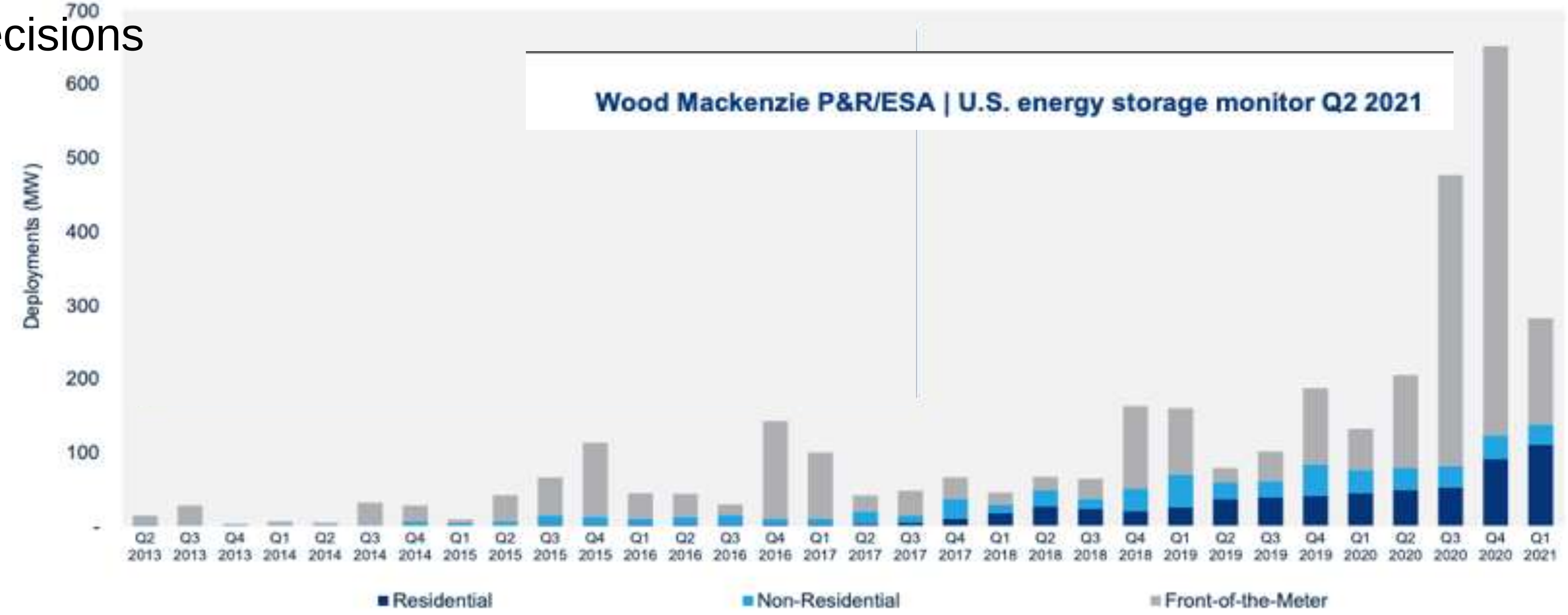
TODAY'S TALK –

This talk focuses on project development process and commissioning

- Introduction
- Technology
  - System Components
  - Technologies
- Developing and installing a system - Process
  - Process Flow
  - Applications
  - Ownership and contracting decisions
  - Commissioning
- Lessons Learned
- Safety





DEMONSTRATION PROJECTS – WHAT WE DO AND WHY

- Provide project implementation support from initiation thru operation.
  - Engineering analysis
  - Design, procurement, construction consulting
    - RFP development, vet technologies, review construction documentation
    - Safety design
  - Commissioning and operation support
    - monitoring
    - Installation best practices
    - Training
- Public outreach through papers, Webinars, Presentations
- WHY IS THE PROGRAM IMPORTANT?
  - To Help develop more safe, effective, and reliable systems
    - Demonstrate benefits
    - Inform codes and standards & best practices for installation and operation
    - Operational data gathering and analysis
    - Learn…Learn…Learn!!

DOE/SNL ENERGY STORAGE PROJECTS

FY21 ~ 17 Projects

Santa Fe Community College

GMP/VEC

Isle au Haut

California Energy Commission(CEC)

NYSERDA

UEP-CCNY

NRECA
Fort Bragg
Ellsworth AFB
Pouder Valley
Rose Acre NCEMC

Navajo Tribal Utility Authority(NTUA)

Electric Power Board

Cordova Electric

AVEK

Alliant Energy

HELCO/NELHA

Villalba

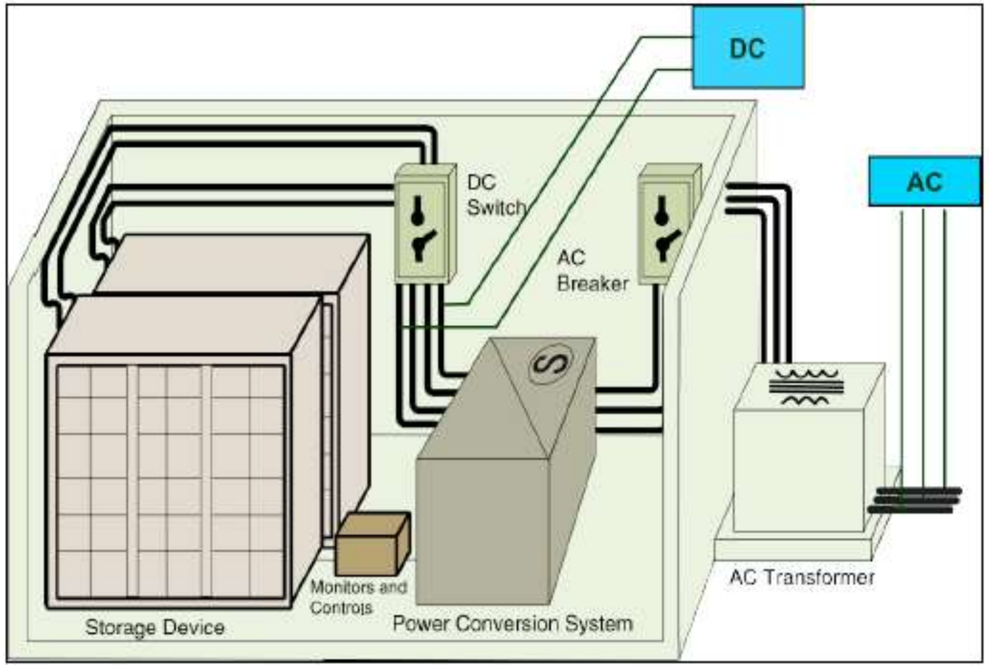
ABQ Public Schools

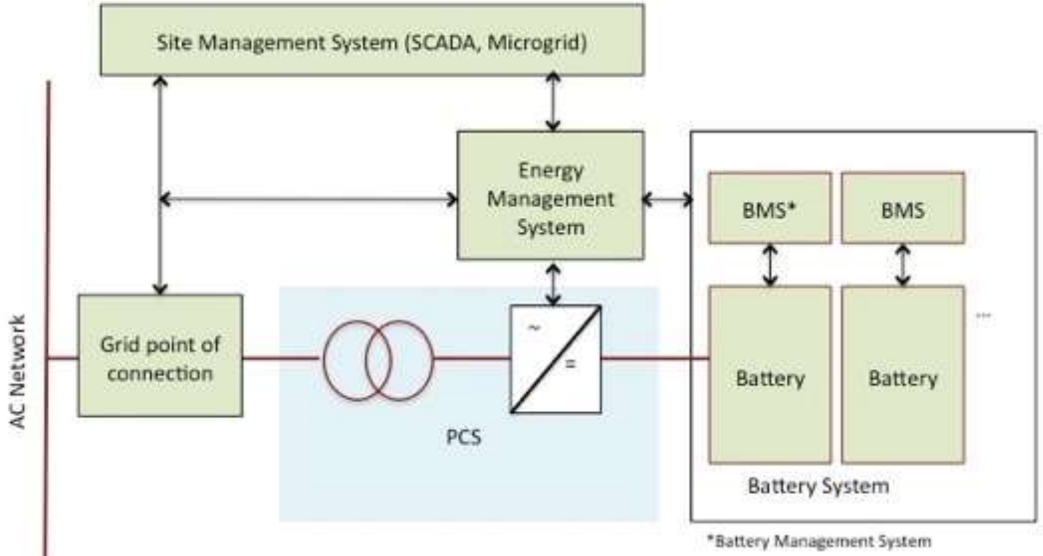
SYSTEM ELEMENTS => DESIGN DECISIONS

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.

ENERGY STORAGE SYSTEM OVERVIEW (ES IS ONE PART OF WHOLE)



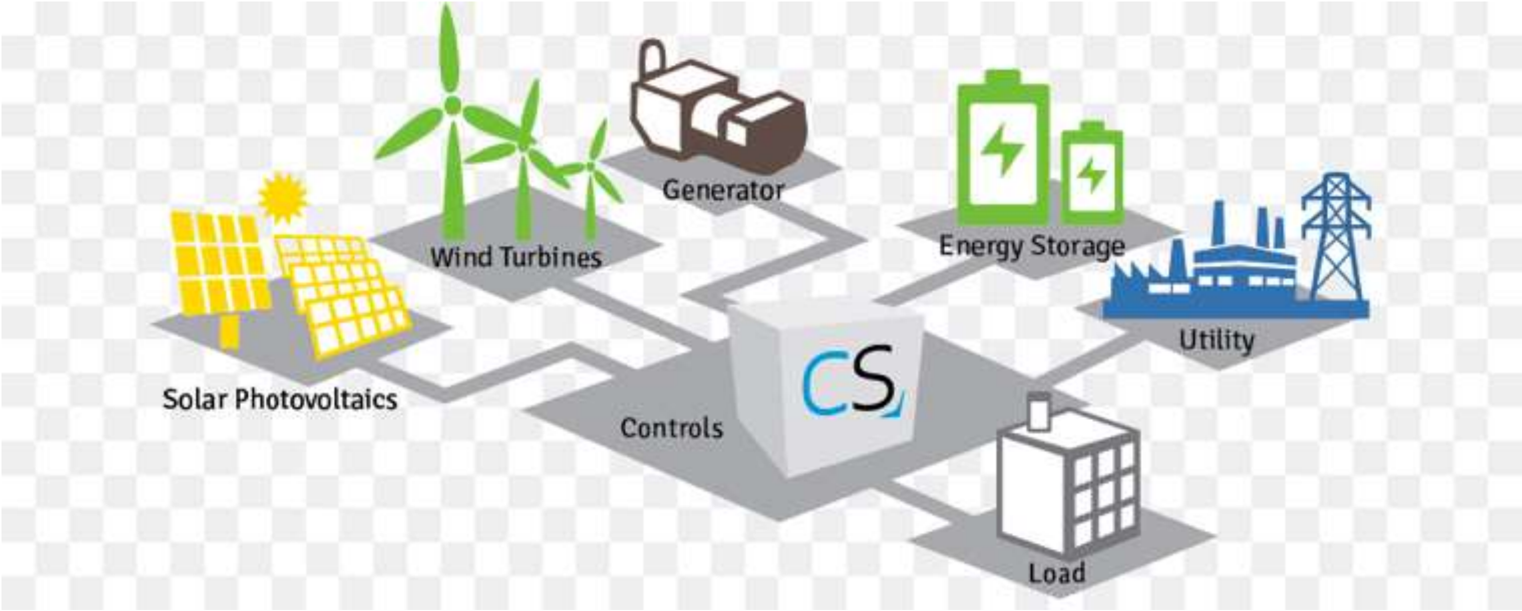


THE MICROGRID

Integrated into grid systems

- Designed for Applications
- Sized for Applications
- Focus on Battery, Renewable AND Traditional Generation

Cost Considerations Suggest Traditional Components



TECHNOLOGIES

Technology	Typical Size Available	Suitable for onsite?
Ultra-Capacitors	17.5 kW, 140 Wh max	Power quality applications – Short durations
Flywheel (energy)	36 kW, 120 kWh	Peak shaving
Flywheel (power)	160 kW, 15 min	Power quality, frequency control
Ice Energy	No longer in business	Cooling, load management
Lead Acid Battery	1-10 MW, up to 8 hrs	Peak shaving, back-up
Li-ion Battery	100 kW – 1 MW+, 1-8+ hrs	Short to mid-duration Peak shaving, back-up
Sodium Sulfur Battery	10 MW, 6 hrs (min)	Grid scale peak shaving, load control
Zinc manganese battery	13 kWh pilot at SNL	Good potential for onsite power
Vanadium Redox	100 kW – 1 MW, 2-12 hrs	Commercial scale in development
Fuel cells	100 kW – 2 MW	With hydrocarbon or hydrogen fueling


Ultracapacitor module


Flywheel


Sodium-sulfur

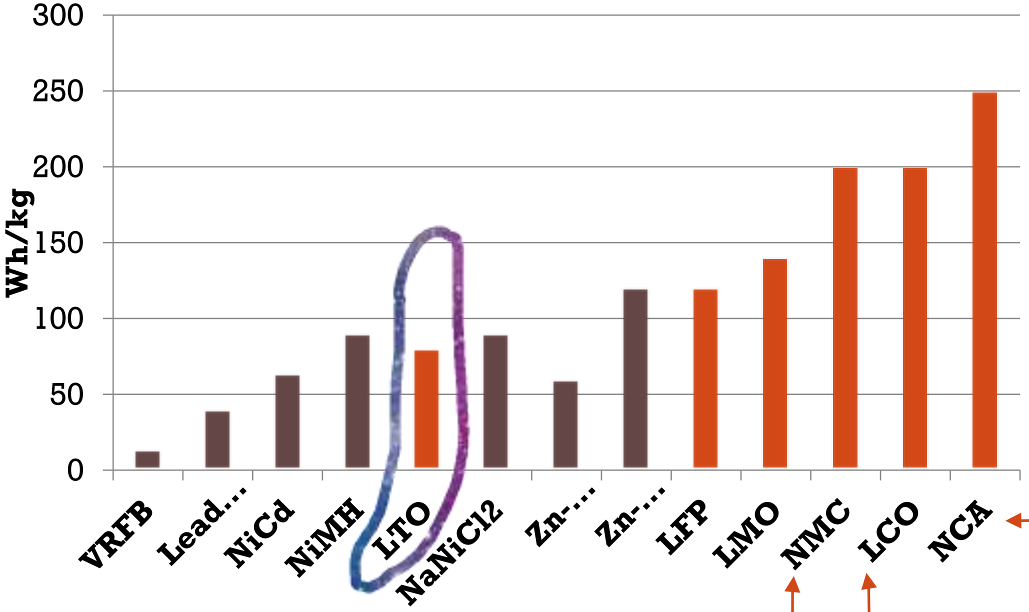

Li-ion battery


Fuel cell

BATTERY - Technology Selection

BATTERY TECHNOLOGIES AND THEIR ENERGY DENSITIES

Specific Energy Density



Tesla

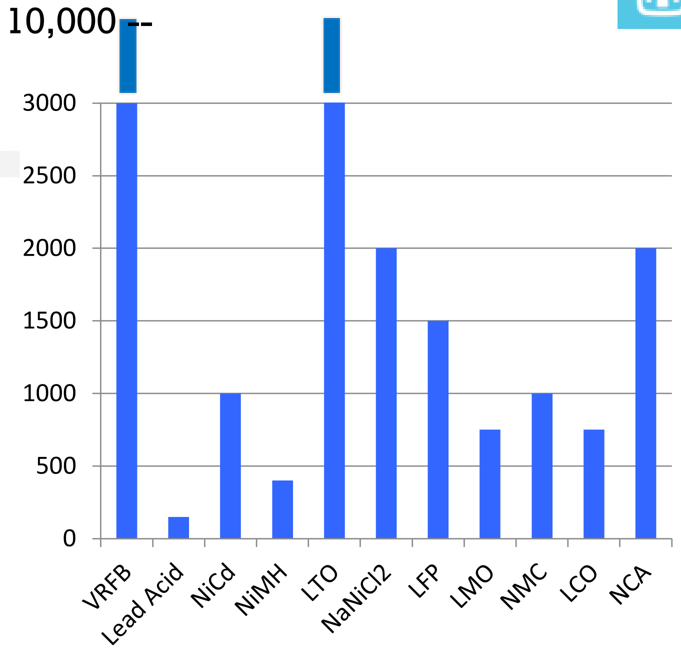
I-Phone

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)

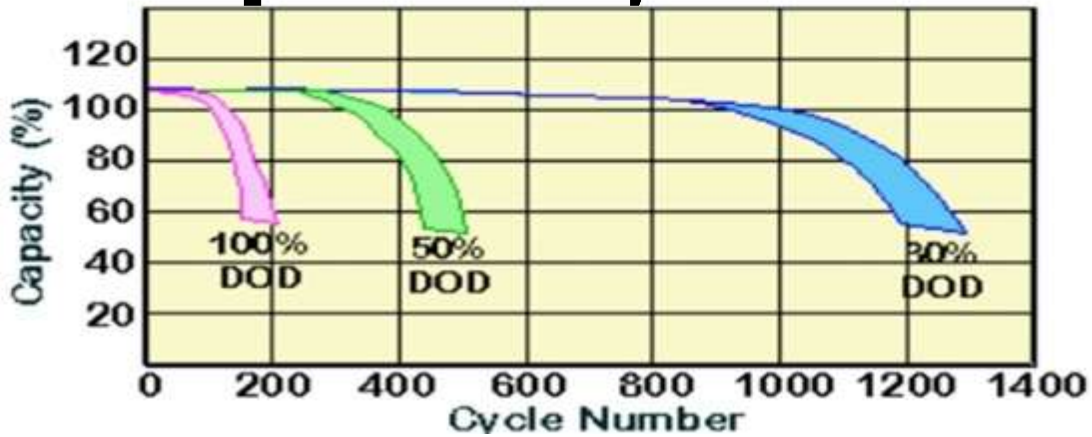
li-ion varieties



Cycle life of different batteries

Not listed NaS = 4500

Representative Cycle life vs. DoD



Curtesy of: Battery University

ENERGY STORAGE PROJECT PROCESS

Project Stages (Design Build – Owner Operator)

ANALYSIS IS KEY to DESIGN

PROJECT DEVELOPMENT

Analysis – Location, Application, Load Profile, Size, ROI, Technology

Conceptual DESIGN

Safety Codes/Standards, Specs, interconnection,
Best practice – Controls, DAS, FP

Commissioning Starts:

Develop Team, R&R, Schedules,

Procurement

RFP, Design, permits, proposal, contracts, commissioning plan

Operations involvement, procedures and checklists

Construction

installation, responder notification, Commissioning Planning, Factory Test

COMMISSIONING
(See Separate Chart)

Controls and system commissioning, base-line testing

SHAKEDOWN/ OPERATION/. PUNCHLIST CLOSEOUT

Safety system check, Operation monitoring and analysis, learnings, responder involvement

PROJECT DEVELOPMENT – PRE-CONSTRUCTION

Steps

ANALYSIS

↓

DESIGN

↓

PROCUREMENT DECISIONS

↓

CONSTRUCTION
COMMISSIONING
HAND-OFF

Issues

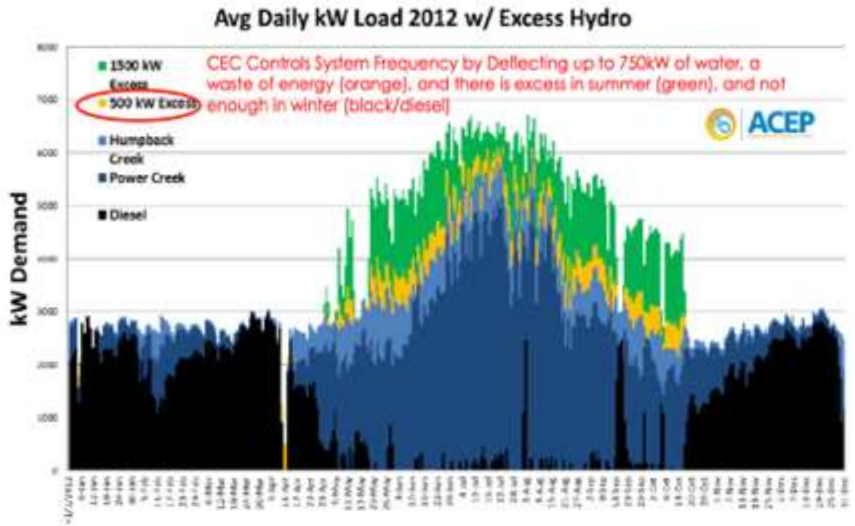
Goals, Size **optimization**, (Power rating, energy capacity, frequency of use)

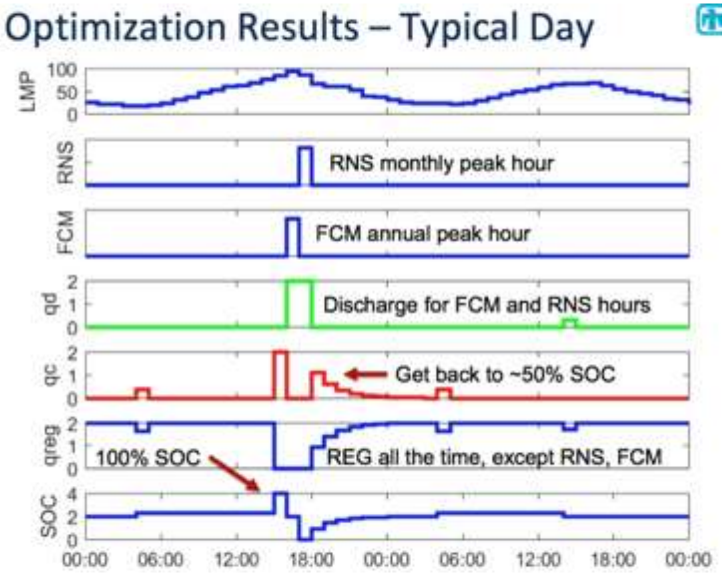
Interconnection, Controls, Data Acquisition, **Safety C&S**

Ownership type; Contract type; Issue s**olicitation / RFP**

SELECT ES ECHNOLOGY

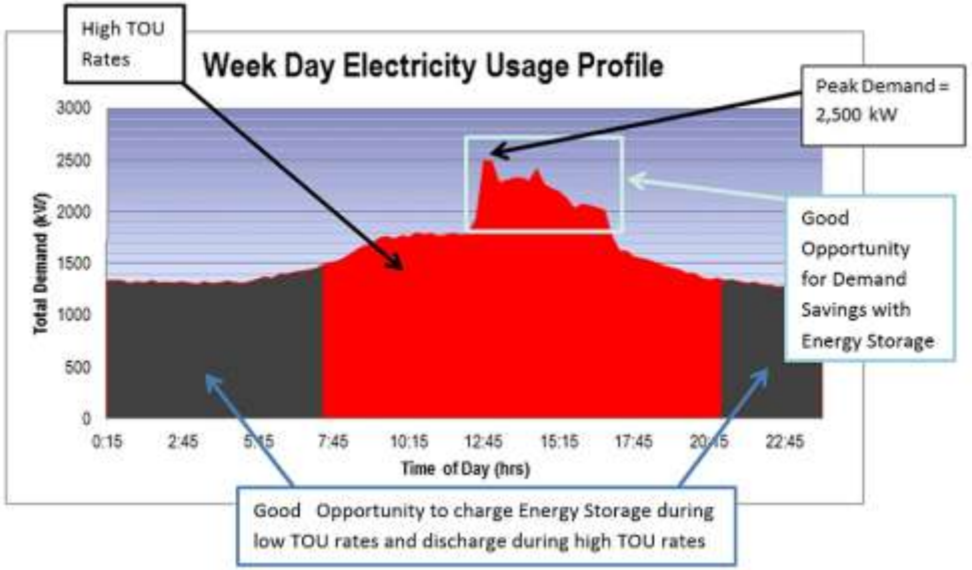
CONTRACT INTEGRATOR OR VENDOR





ENERGY STORAGE APPLICATIONS

- Peak shaving to reduce time-of-day rates or demand charges; can take advantage of on-site renewables (PV)
- Reliability, resilience or back-up power
- Power Quality
- EV charging for fleets or employees
- Combined-heat-and power in some climates
- Not UPS



Atrisco HS, Albuquerque, NM

PROCUREMENT – SYSTEM OWNERSHIP DECISIONS

System Ownership	Pros	Cons
Owner/Operator Owner contracts to build system, & will own and operate.	Control of system installation & ability to adjust operations as markets warrant.	Owner assumes risk Warranty or O&M agreements to solve operational issues. PM requirements
Lease (w/Option to buy) Customer leases ESS from owner for specified time (PPA), & will operate system within parameters of lease.	Control of system within lease parameters - Some ability to adjust operations. 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.

Procurement – Contract Methods

Contracting Strategy	Description	Comments
Design / Bid / Build (DBB) or Engineer/Procure/Construct (EPC)	Contract with a design firm or developer, • design is put out to bid for procurement and installation.	Allows the owner more control, between design and construction.
Design / Build (D/B)	ES system provider or developer designs and builds the ESS project - turnkey system.	Convenient when limited engineering and/or construction management resources.
Hybrid	Owner separates the infrastructure (design and installation) from the ESS design and installation	Owner coordinates the interface between infrastructure and ESS, i.e., conduits, cabling, electrical distribution. • Integration may be a hassle

COMMISSIONING - DETAILS

COMMISSIONING
Safety and Reliability

Base line measurements

Operations
- Voltage
- Capacity
- Ramp rate
- Charge time
- Discharge time

Safety
- IR scan of connections and batteries
- Fault current protection testing
- Fire suppression testing

Factory Witness Test (FWT) — Workmanship, specifications

↓

Operational Acceptance Test (OAT) — Individual components

↓

Start-up — System as a whole including all controls

↓

Site Acceptance Test (SAT) — Sequence of operation/ Application testing. Base line info

↓ ← Owner takes operational control

Shakedown — Anomaly/Safety performance

Poudre Valley 140 kW-3 hr

KEY TAKE-AWAYS - CONTRACT COMPONENTS

- Scope
- Owner/Operator Responsibilities
- Contractor/Integrator Responsibilities
- Codes and Standards
  - NFPA 855
  - UL 9540/9540A
- Safety Program and training
- Lead-Time
- Testing/Commissioning
- Performance Guarantee
- Load Profile
- Maintenance/Warranty

LESSONS LEARNED - COMMISSIONING

Things to Know, Do and Watch Out For:

- Location/Location/Location
- Integration isn't automatic
- Base-line testing
  - IR scan
  - Capacity
- Data acquisition
  - Points of interest
    - Capacity fade
    - Operational parameters
- Involve AHJ and First Responders early on.
- Safety system check out
  - Does system behave when bad things happen?
  - Training for operators and first responders

MORE LESSONS LEARNED

- Warranties and maintenance need to be factored into ROI
- Detail all possible operations for microgrid (e.g., storage + PV) during design to avoid retrofit.
- RFP details are important
  - Problem Statement
  - Scope
  - Load Profile
  - End of Life Requirements
  - Applications
- Labeling and Signage
- Code adherence
- Contracting Strategies

Typical module in a Rack

EPC inverter at NELHA

HIGHLIGHTING SAFETY – OTHERS WILL PROVIDE DETAILS

PAY ATTENTION

- Codes and Standards
- Safety systems _what works what doesn't, what's the latest in design
  - Smoke exhaust
  - louvers for ventilation during fire
  - Early smoke detection
- Communication and Training of first responders, operation/maintenance
- Fire protection
  - Dry-pipe water
  - Clean Agent (i.e., Novec 1230)
- Signage

SUMMARY

Murphy's Law:

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

Where:

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

Newatlas.com

Resources:

ABB Inverter line-up at Cordova

THANK YOU

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Daniel Borneo drborne@sandia.gov

Supporting Cast:
Susan Schoenung
Susan.schoenung@longitude122west.com

EXAMPLE - SYSTEM DESIGN APPROACH

Decorah Battery System Design

- 2.5 MW, 2.9 MWH system

  Power (flow rate) | Energy (size of tank)

  Duration
  2.9 MWH ÷ 2.5 MW = 1.16 HRS

- Larger power rating → more flexibility
  - *Voltage managed with reactive power (Vars)*
  - *Power Flows managed with real power (Watts)*
- Samsung / Sungrow Integrated Solution from EnelX
  - Lithium Ion (NMC Chemistry)

Application: Provides support for additional PV on the grid