DOE-OE Energy Storage Technology Advancement Partnership (ESTAP) Webinar

Commissioning an Energy Storage System:
Lessons Learned in the Field

September 7, 2022

U.S. DEPARTMENT OF ENERGY

Sandia National Laboratories

Clean Energy States Alliance

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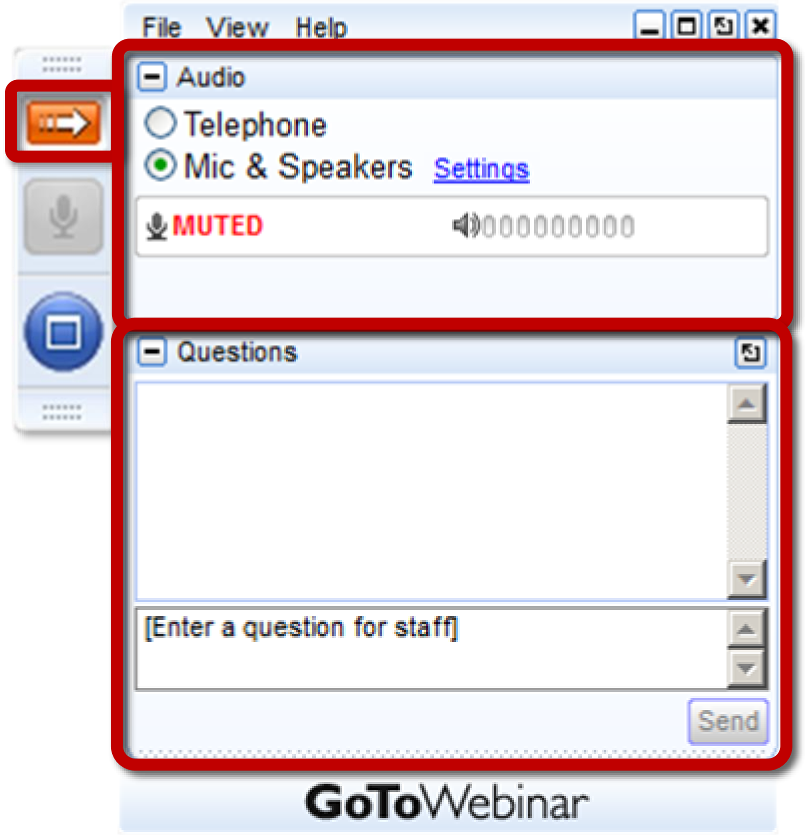

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Clean Energy States Alliance

State of California Energy Commission

Connecticut Green Bank

Department of Energy & Environment

Energy Trust of Oregon

IPA Illinois Power Agency

Governor's Energy Office (Maine)

Maryland Energy Administration

Massachusetts Clean Energy Center

EGLE Michigan Department of Environment, Great Lakes, and Energy

mn Commerce Department

State of New Hampshire Department of Energy

BPU New Jersey's Clean Energy Program njcleanenergy.com

New Mexico EMNRD Energy, Minerals and Natural Resources Department

NYSERDA

State of Rhode Island Office of Energy Resources

SMUD Powering forward. Together.

Vermont Department of Public Service Clean Energy Development Fund

Virginia Energy

Washington State Department of Commerce

OEI Wisconsin Office of Energy Innovation

Connecticut Energy Environment

Illinois Commerce Commission ICC

Inclusive Prosperity Capital

DOER Massachusetts Department of Energy Resources

MassDEP

NREL National Renewable Energy Laboratory

Commissioner Stephanie Garcia Richard New Mexico State Land Office

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Oregon Department of Energy

Prairie Island Indian Community in the State of Minnesota

Rhode Island Commerce Corporation

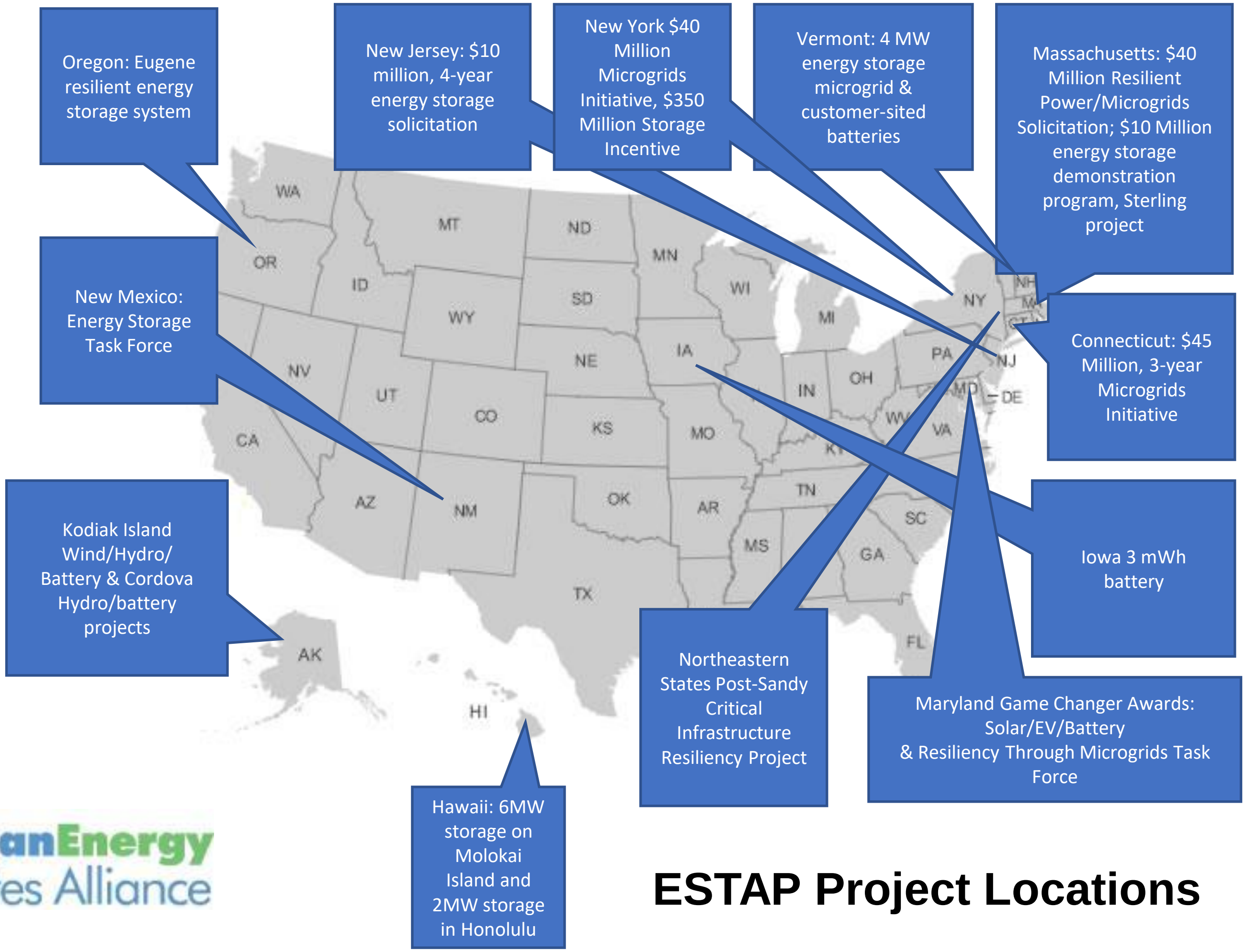
Smart Electric Power Alliance

DOE-OE Energy Storage Technology Advancement Partnership

The Energy Storage Technology Advancement Partnership (ESTAP) is a US DOE-OE funded federal/state partnership project conducted under contract with Sandia National Laboratories.

ESTAP Key Activities:

1. Facilitate public/private partnerships to support joint federal/state energy storage demonstration project deployment
2. Disseminate information to stakeholders
   - ESTAP listserv >5,000 members
   - Webinars, conferences, information updates, surveys.
3. Support state energy storage efforts with technical, policy and program assistance



ESTAP Project Locations

U.S. DEPARTMENT OF ENERGY

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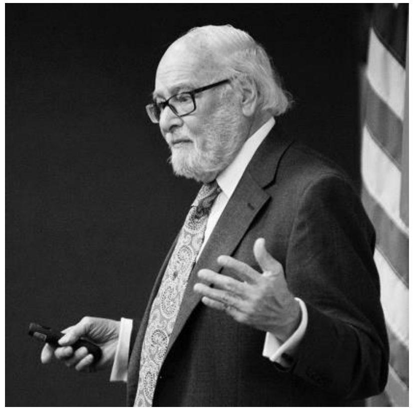
Clean Energy States Alliance

Thank You!



Dr. Imre Gyuk
Director, Energy Storage Research,
U.S. Department of Energy

U.S. DEPARTMENT OF ENERGY

Dan Borneo
Engineering Project/Program Lead,
Sandia National Laboratories

Sandia National Laboratories

Webinar Speakers

Dr. Imre Gyuk

Director of Energy Storage Research, DOE Office of Electricity

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Dave Galarowicz

Lead Engineer, Alliant Energy

Clay Koplin

CEO, Cordova Electric Cooperative

Todd Olinsky-Paul

Senior Project Director, Clean Energy States Alliance (moderator)

U.S. DEPARTMENT OF ENERGY

Sandia National Laboratories

Alliant Energy

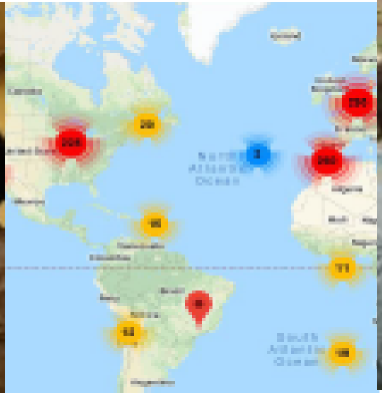
CEC

Clean Energy States Alliance

Commissioning an Energy Storage System: Lessons Learned from the Field

Sandia National Laboratories

ESTAP Webinar Series
September 7, 2022

PRESENTED BY Dan Borneo – Sandia
Susan Schoenung – Longitude 122 West

SAND2022-11761 PE

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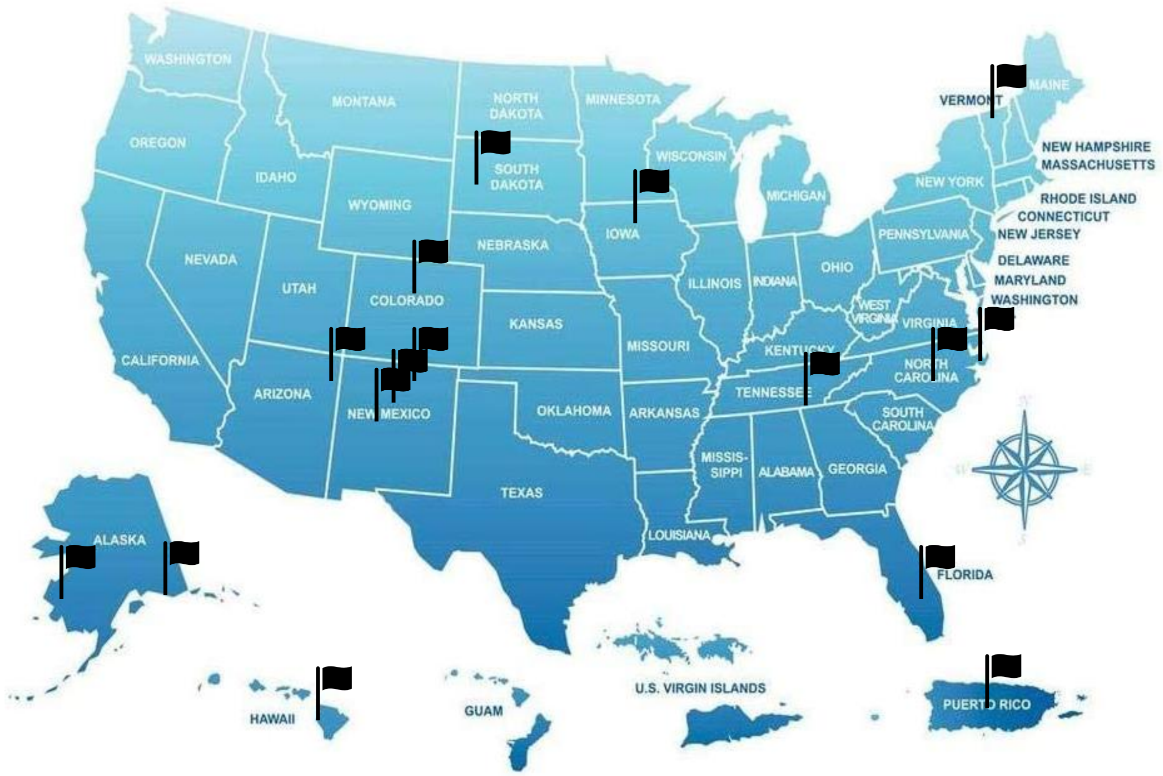
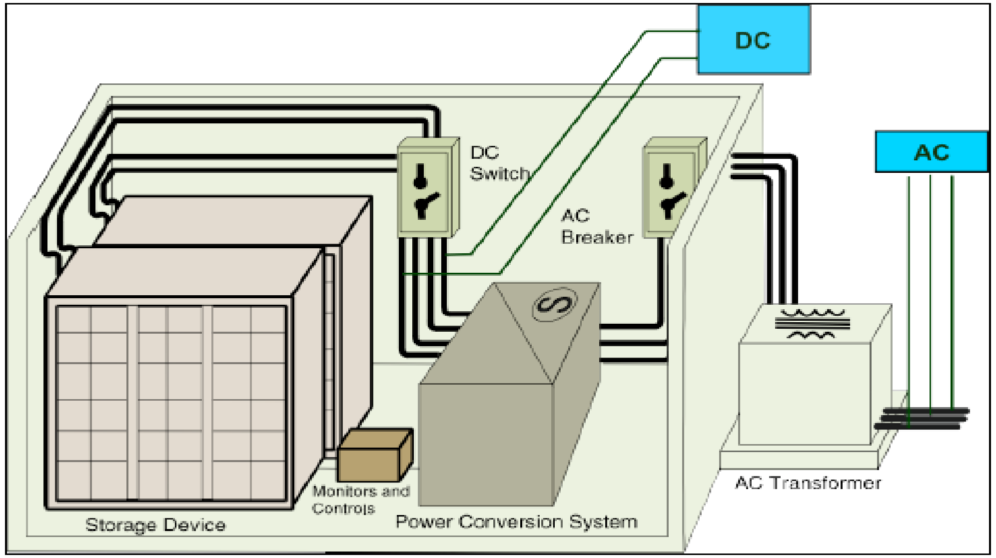
Sandia team and 2021-22 DOE-OE Sponsored Projects

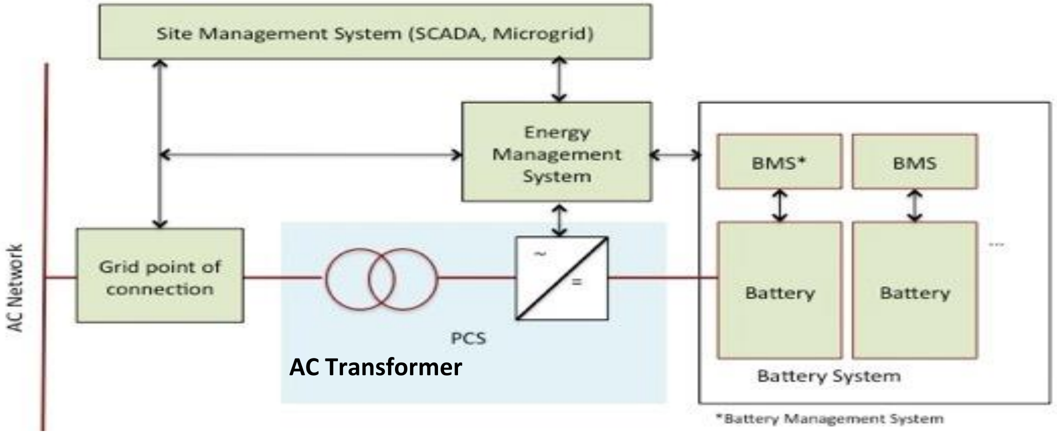
State or Territory	Partner
Alaska	Cordova Electrical Cooperative (CEC)
Alaska	Alaska Village Electrical Cooperative (AVEC)
Arizona (x3)	Navajo Tribal Utility Authority (NTUA)
Colorado	Poudre Valley Rural Electrical Association (PVREA)
Florida (x4)	Seminole Tribe
Hawaii	Natural Energy Laboratory of HI 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)

Energy storage system overview (ES is one Part of Whole)





Commissioning begins with RFP

Project Flow

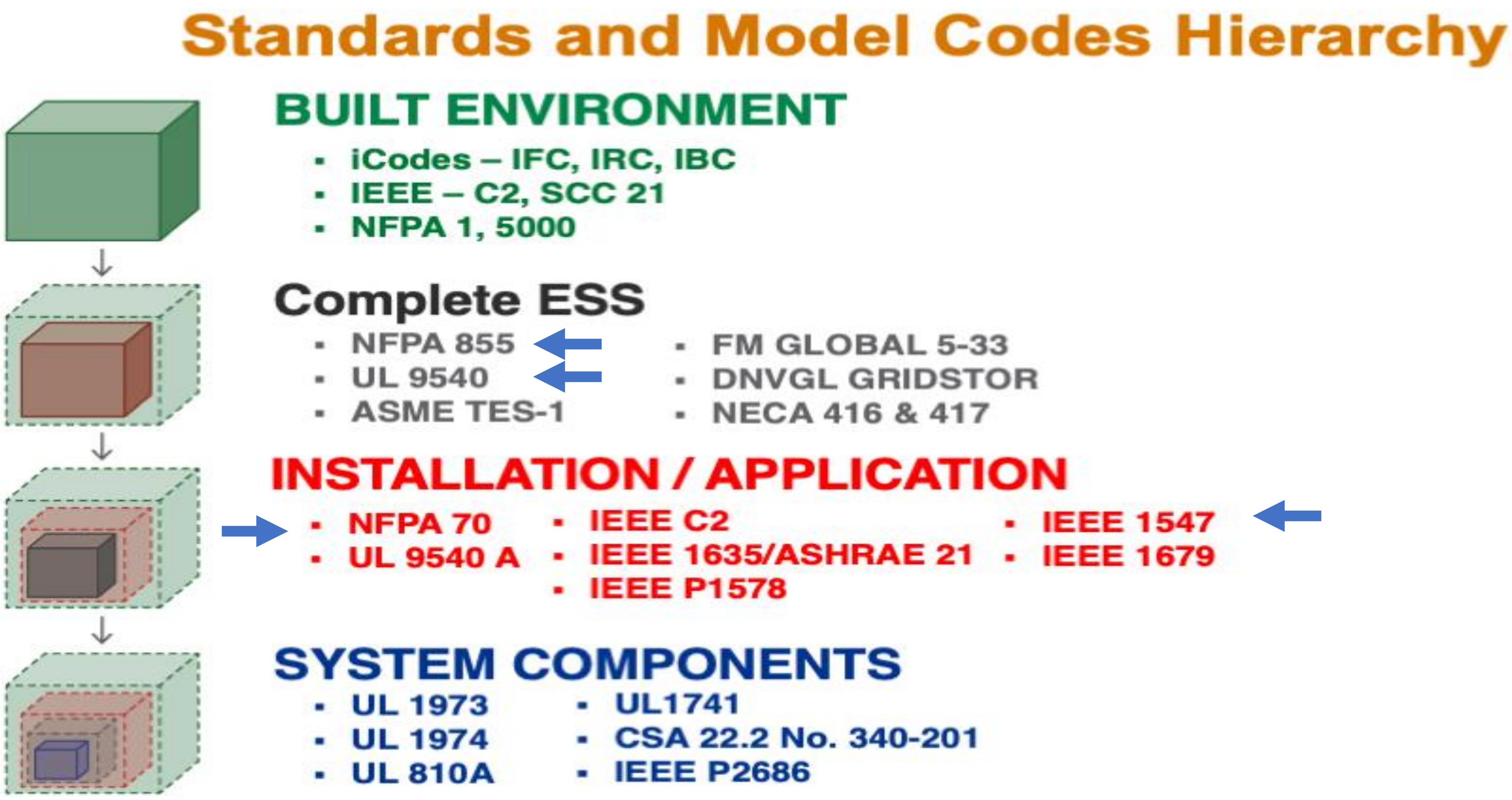
Construction Project Stages	Design/Construction Activities	Commissioning Activities
Project Initiation	Analysis, Application(s) and sizing	**Applications lead to Sequence of Operation (SOO)**
Project Development & Design	Refine conceptual design with details for RFP , Include load profile and Sequence of Operation (SOO)	**Load Profile drives system performance need. SOO will drive commissioning activities, interconnection design and permitting**
Procurement	Develop **RFP with codes, standards, &specifications**	**Proposal to include commissioning plan, code requirements for safety, roles – one commissioning owner, warranty**
Construction	Site work, system installation, interconnection, Factory testing precedes installation	**Testing at factory nice to have but hard to do:** • **Off shore manufacturing.** • **System components from different vendors meet at the job site**
Commissioning	Commissioning / acceptance testing checking that system meets **specifications, SOO**	**One owner; Baseline measurements; Safety system checkout**
Operations & Maintenance	Project in-service	**Collect operational data; track performance and capacity fade; Predictive tools - IR scan.**

The Project Team includes

★ **Involved with commissioning**

Team Member	Project Responsibility
Owner ★	Programming, Financing, contracting and ownership strategies. Developer or Facility
Design Engineer ★	Design, Load profile, application(s), codes/standards/specifications, Procurement RFP, Inspection,
Utility ★	Interconnection autorization, Point of connection work
Site Construction team/installer ★	EHS / Site Safety Plans (SSP) and Safety Meetings, Site prep, permits, system delivery, Construction, all BoP
Vendor ★	Factory Witness Testing, Shop drawings, On-site connections, start-up, troubleshooting, Warranty
AHJ	Code adherence, Design verification
System integrator, or Commissioning Agent ★	OWNS COMMISSIONING. Plan, Construction inspection, Operational Acceptance Testing (OAT), Integrated System Startup (S/U), Functional Acceptance Testing (FAT), shakedown, Training, as-builds, Commissioning Closeout
Fire Department	Design review, Participate in training

Codes and Standards Related to Energy Storage Installations (*beware of new requirements*)



Acceptance Testing is the heart of Commissioning

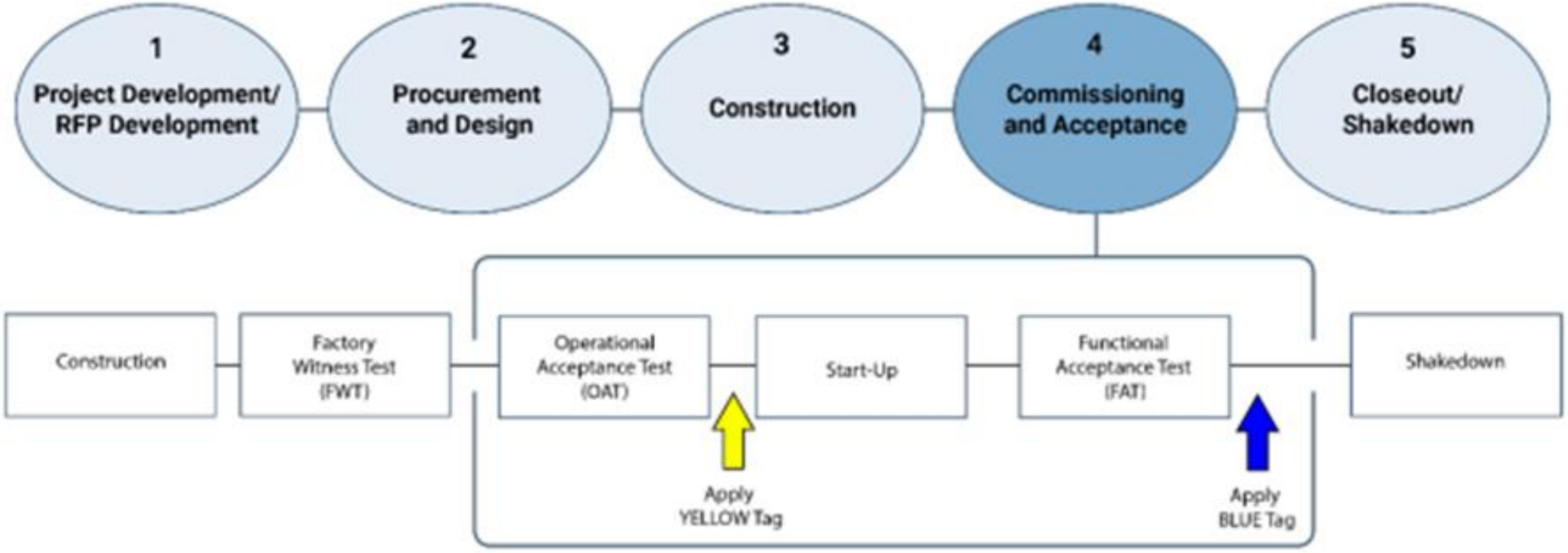


Figure 3. Commissioning process steps

https://www.sandia.gov/app/uploads/sites/163/2021/09/ESHB_Ch21_Commissioning_Schoenung.pdf

Acceptance Testing of ES Components and Subsystems

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

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

Applications
- Utilize SOO

Testing procedures

Balance of Plant (Environment, Safety Systems):
- Enclosure data:
  - Temperature, humidity
  - IR scan
- 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 Connection – POC)
  - Voltage, current

Lessons Learned (It always takes longer than you think)

- Interconnection Request & Approval
  - *It can be a long process – start early, make contact with the Utility, follow through*
- BESS Siting (Location)
  - *Know your installation Standards/Codes consideration*
- 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.*
  - *Load Profile and Application identification*
- Bid Analysis: Need to understand who is supplying which component of the BESS
  - *Who does what and who is in charge. 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*
- Communications/Data Acquisition
  - *Collecting **ES data for monitoring** can be complex and scales in complexity with the size of the system, number of 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 (Continued)

- Training of operations and first responders
- IT / data collection – What to measure and does it work
- Fun Facts (unless you are there)

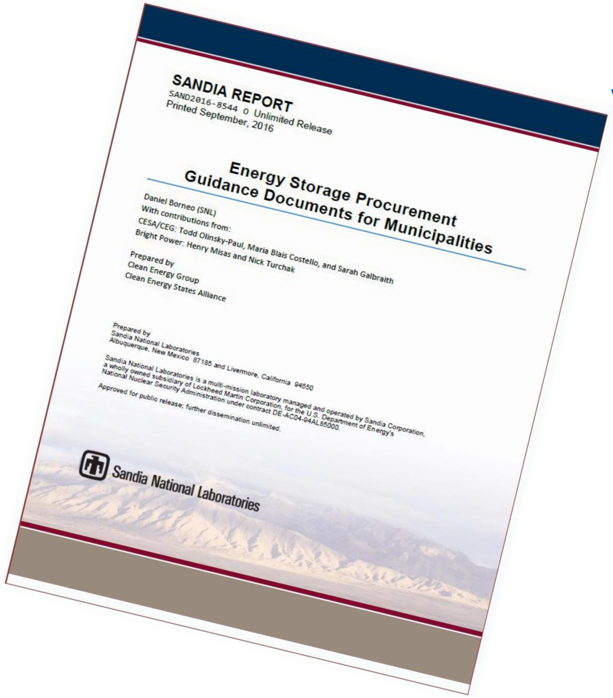
  - Red hot bolts – Not torqued
  - Failed Cables – Not meggered
  - Breakers inadvertently tripping – Not coordinated properly
  - Distribution Equipment Failure – Not installed correctly
  - Over heating - Ventilation not sized correctly
  - Water Leaks – Piping connections not tested
  - Controls - Adequate testing procedure
  - Application – Sequence of Operations (SOO) not well thought out

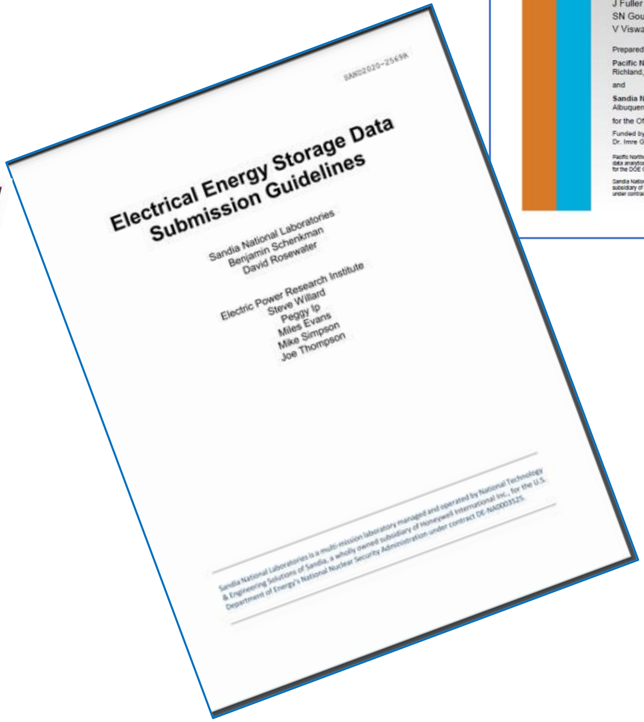
Questions that Bother Me So

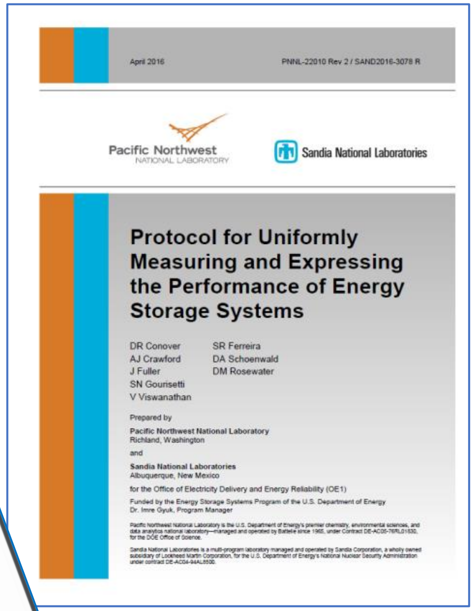
- Who leads Commissioning and how to identify/request in RFP
- What if Equipment is delayed?
- Which State and Federal codes/Standards need to be followed
- What's an interconnection agreement?
- How long will the battery realistically last?
- Predictive measurements of battery to indicate performance?
- Given today's economic environment how realistic are the cost and delivery estimates?

Conclusions

- Commissioning can be described as
  PAYING ATTENTION to the DETAILS
- Energy Storage resources available online
- SNL and EPRI developing updated commissioning guide for year-end release







Thank you

This work is funded by the DOE OE Stationary Energy Storage program, directed by Dr. Imre Gyuk.

Daniel Borneo drborne@sandia.gov

Courtesy: PNNL - Matt Paiss, Charlie Vartanian, SNL - Waylon Clark; 2022

Case Study - Decorah

Great project, but…

Commissioning delayed by difficult access to vendors for data…

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)

Commissioning an Energy Storage System

Lessons Learned from the Field

September 7th, 2022

Decorah Design

Decorah Battery Project

Alliant Energy, with EnelX (integrator) and Samsung-Sungrow (Mfr)

Location: Leased Land in City Park - Decorah, IA

What: NMC Li-Ion Battery, 2.5 MW, 2.9 MWH

Why: Increasing Hosting Capacity (Ability to Accommodate DG)

When: RFP issued: Spring 2019

Contract placed: Fall 2019

Installation complete: Summer 2021

Commissioning complete: June 2021

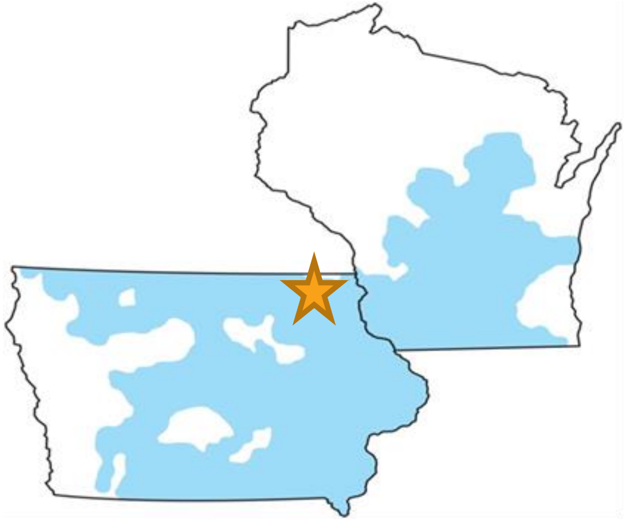
- *Pending Field Certification*
- *Pending Final Fire System Testing*

Turnover and operation

How much:

Total Estimated cost: $2.9 MM

DOE Cost share (equipment only): $250,000



Module Installation

Visual Screening

Decorah Commissioning

Post Manufacture Certification

- Corrected labeling of devices and container
- Field certification
  - Long lead times for scheduling of inspectors (>3 months)
  - In progress for water ingress testing

Site Commissioning Actions Taken

- Implemented non-zero power setpoint to minimizing open / close cycles on the DC contactors
- Encountered frequent battery fans failures, which have been replaced
- Animal ingress was addressed early in the design process and has not posed an issue.
- Implemented automated alarms and e-mail notification for loss of communications and availability

Site Commissioning Improvements (1)

- Ensure that EMS can issue reset commands to the BMS / PCS remotely as allowed by BMS manufacturer
- Coordinate with EMS manufacturer to integrate aftermarket off-gas detection systems
- Verify connectivity and system functionality in advance of system performance testing.

Site Commissioning Improvements (2)

- Request commissioning checklist/plan to review and provide feedback
  - Should test operational processes including starts/stops/alarm resets/setpoint tracking
- Test alarms from the field through to SCADA

QUESTIONS?

Presenter

- Dave Galarowicz, P.E.
  - Dave Galarowicz has spent 13 years in the utility sector. He has worked extensively in power generation and fossil units in both engineering and operations roles. He is currently working on pilot scale projects, deploying new technologies to evaluate their value and potential to integrate into the Alliant Energy system.

Procuring and Commissioning an Energy Storage System- Cordova Electric Cooperative

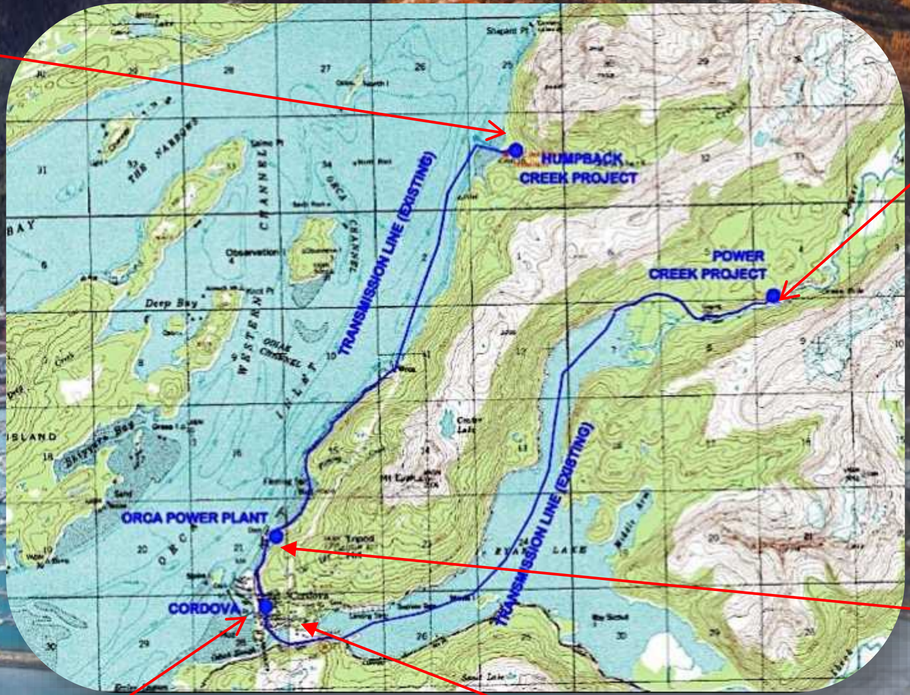
Energy Storage Technology Advancement Partnership (ESTAP)
DOE-OE-ES Clean Energy States Alliance   CESA Webinar
September 07, 2022

Cordova, AK (aerial view)

Cordova Electrical Grid

Humpback Creek Hydroelectric Plant
1250kW (2 x 500 kW + 1 x 250 kW)
17 000 foot UG and submarine transmission line

Power Creek Hydroelectric
6278kW (2 x 3124 kW)
25 kV transmission ties to Eyak Substation Inflatable dam



City of Cordova
1 566 customers
18MW
One Substation
78mi UG distribution lines

Battery Energy Storage System
1 MW 1MWh
ABB/SAFT at
Eyak Substation

Orca Power Plant
10.8 MW Diesel
Control Center
CEC

Procurement – Start in the Right Place

(Dr. Imre Gyuk Director of Energy Storage Research Office of Electricity)

- **US DEPT OF ENERGY-SANDIA-ACEP INITIAL MODELLING TO RIGHT-SIZE**
- **SANDIA AND NRECA – DRAFT SPECS AND PROCUREMENT DOCS**
- **CEC INTERNAL SPECS AND INTEGRATION - USE CASE!**
- **SHARE FINAL DOCS BACK TO NRECA AND SANDIA FOR TRANSFER**
- **CRITICAL; MEETING OF THE MINDS WITH SAFT/ABB**

Office of ELECTRICITY

NRECA America's Electric Cooperatives

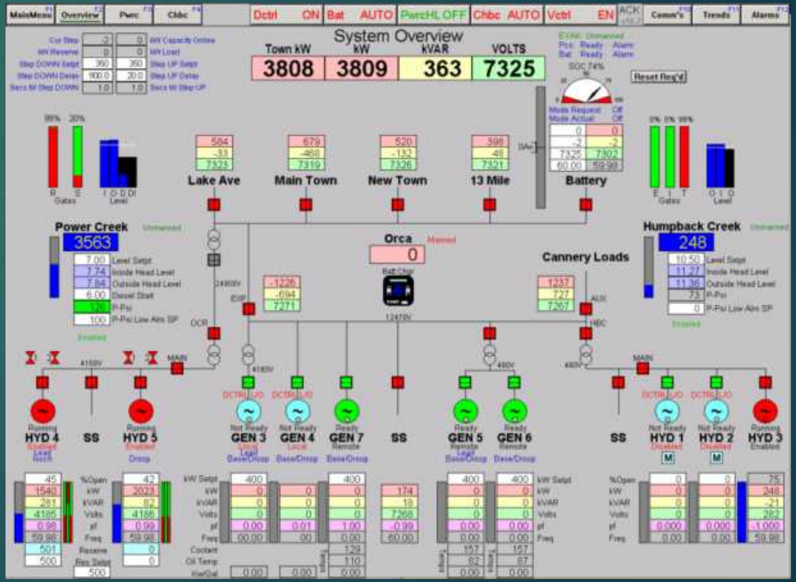
ACEP Alaska Center for Energy and Power

Sandia National Laboratories

CEC

A little more detail: Commissioning Planning

- **MANUFACTURERS HAVE STANDARD COMMISSIONING PLANS AND PROTOCOLS**
- **STRUCTURE YOUR COMMISSIONING AROUND YOUR USE CASE AND INTEGRATION**
  - Communications Integration – compatible protocols handshaking etc.
  - Controls Integration – serial vs. parallel comms (Modbus TCP vs. Modbus RTU)
  - Operational Integration – “bumpless” state change ramp rates mode transfers



BATTERY – POWER CONVERTER – CEC SCADA SYSTEM HANDSHAKING

CEC Commissioning Docs

Map all I/O – test everything – follow through follow through follow through…

A	B	C	D
	Customer Site Acceptance Steps	Notes	Date Tested
1	Verify that there are no mechanical defects or physical damage from factory or shipping	Fire Alarm on the Battery was damaged and the air conditioner was dented	6/17/2019
2	Verify all the components that we ordered are present and in good condition	Invintoried upstairs at ORCA	8/24/19
	Power up station service devices (lights, Fans, Fire system, Etc) and ensure they all are working properly	The air conditioner on the battery needed troubleshooting and repair, this was completed by Ed on 6/10/19.	6/10/2019
2	Verifty that the fire alarm bypass is working i.e. test it during fire supression test	NOT A BYPASS! NEED TO VERIFY OPERATION WHEN FIRE ALARM CONTRACTOR IS HERE	
3	Verify that transformer alarms are paralleled onto EYAK PLC I/O card	They are not, THEY ARE POLLED BY PWRC OVER TCP FROM ABB AND DISPLAYED ON SAFT/ABB DETAIL PAGE	Week of 6/18/2019
4	ABB, CEC and SAFT to complete their site integration work	Abb still needs to implement final iteration of soc limit ramping to 0. Emailed after second comissioning trip.	
4-1	Power up control/ comm devices and ensure they all are working properly	A control relay in the PCS e-stop string was faulty upon startup and had to be replaced this was done by Nate and Isak on 6/6/19. Some Ribbon cables from the Master PCS controller to the inverters were not working theese were replaced by Nate and Isak and Allen on 6/6-7/19. The MBMM was faulty and needed reprogramming this was done by Ed on 6/8/19 and 6/10/19. The vaucum alarm on the main stepup transformer is faulty and needs to be repaired or replaced. the Master control in the PCS is faulty and needs to be repaird or replaced. The modbus rtu communication from the ABB Plc to the CEC Plc is Very slow (about 1-3 seconds between good reads) and needs to be repaired. the ABB Plc would not communicate at all without using two stop bits. The setting should be one stop bit this needs to be repaired, Sometimes the modbus rtu communication to and from the CEC Plc and ABB Plc will just stop this needs to be repaired. sometimes the communicationnto and from the ABB plc and Saft plc will just stop. this needs to be repaired.	8/23/2019
4-2	Verify Communication settings (ip, programmable switch settings)		Week of 6/18/2019
4-3	Verify communication is working between all CEC, ABB, Saft devices.	Ping all devices	Week of 6/18/2019
5	Verify ramp rates of 10kW/s for all configurable settings	How? Look over Isak's sholder	Week of 6/18/2019
6	Verify that 15 second trip on loss of comms is disabled, i.e.let the battery ramp when dead or full	Unplug the comms while it is running at 500 kw and watch the ramp. COMM LOSS TRIP IS DISABLED AS OF 8/23, STILL NEED TO SEE SAFT BATTERY SOC PROTECTIVE RAMP	
7	Get modbus alarm register details from saft and abb	Get the location of these per trevers email on 4/28	4/28/2019
8	Additional verifications before CEC ties to their grid.....	Phase Rotation? Breaker Operation? E-stop operation? Protective device settings?	Week of 6/18/2019
9	ABB SAFT team to manually test each register in PCS	CHECK COMISSIONING DOCUMENT TO SEE IF THIS WAS DONE	
10	Tie BESS to CEC Buss through fused disconnects		Week of 6/18/2019
11	Verify all comm interface registers from Pcs to Eyak are correct		Week of 6/18/2019
12	Verify all comm interface registers from Eyak to Pcs are correct		Week of 6/18/2019
13	Tie to grid		Week of 6/18/2019
14	Run system locally from Pcs hmi. Verify each mode, and each setpoint, and confirm it is seen on CEC hmi. Mode Requested 0=Off 2=Csi(Baseload) Charge/Discharge Setpt (-1000 to 1000), Positive = Discharging, Negative = Charging Kvar Setpt (-1000 to 1000) pos = inductive, neg = capacitive 1=Vsi(Isoch) Voltage Setpt - 7000 - 7600 Frequency Setpoint - 5900 to 6100	What to do with the system	
14-1	Put the BAT in off mode on the panel and look at Scada and see if it registers. =yes do nothing. =no troubleshoot and fix it.	Nothing	

Meeting of Minds
(highly recommended)

- High level discussion between project partners and vendors to carefully articulate the use case the operating environment the operating modes and purpose. The discussion pushes on the applications and capabilities of individual components in various operating modes and environments and discusses weather electrical system dynamics communications controls handshaking with SCADA / automation system. All should leave with a clear pictures of the application and a working list of items to test or confirm for the application to minimize the inevitable challenges during installation commissioning and operation

Site Work – May/June 2019


485





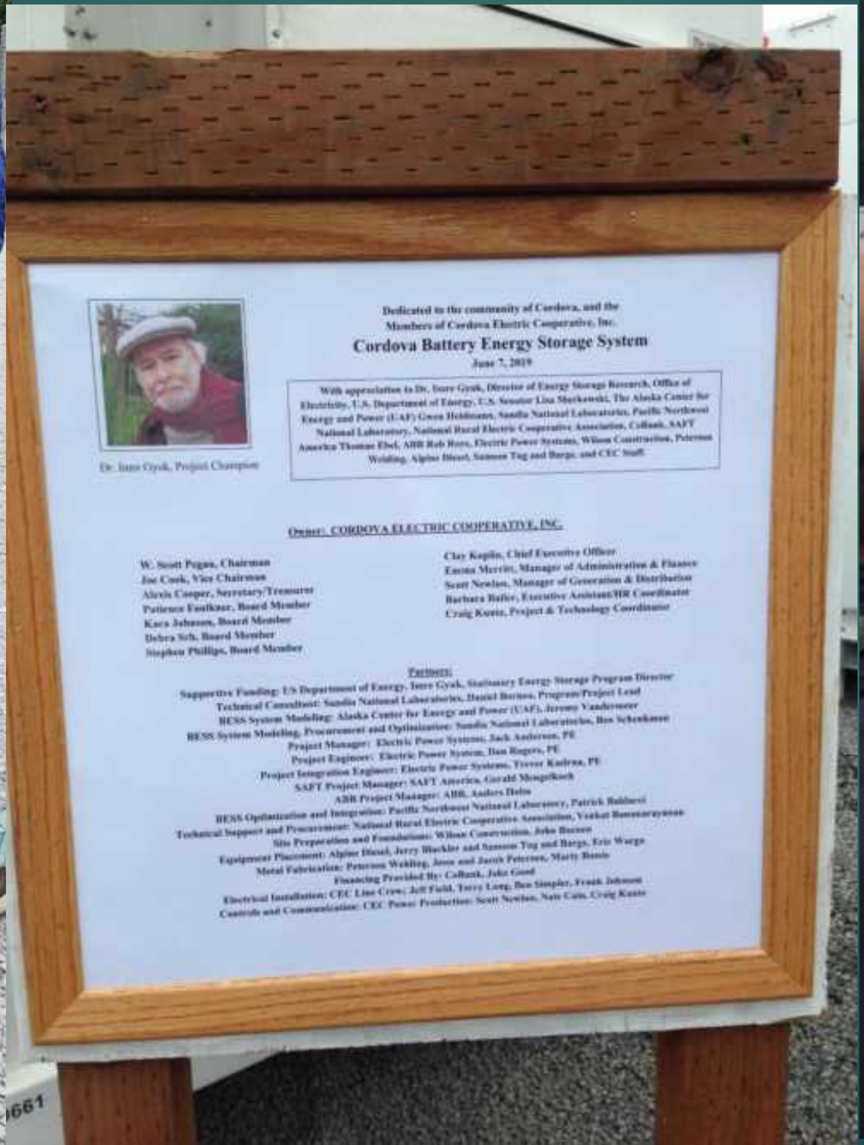
INSTALLATION / COMMISSIONING

July 2019 – Manual Operations Commence

TIMELINES

- 2007 – CEC System Loads Exceed Hydro Capacity and diesel peaking creates a “valley of death”
- 2012 – CEC partners with ACEP and recognizes the benefits of energy storage to CEC Grid
- 2015-16 ACEP Approaches Dr. Gyuk with CEC use case/opportunity and rich CEC data set
- 2016 Dr. Gyuk initiates phase 1 modelling of CEC energy storage via Sandia Laboratories
- 2017 Modelling and analysis indicates a right-sized right-located Lithium Ion solution for CEC
- 2018 Dr. Gyuk sponsors phase 2 specification and procurement of BESS
- October 2018 CEC BESS Ordered
- May 2019 BESS arrives on site
- June 2019 BESS Installed
- July 2019 BESS Operational
- November 2019 Fully integrated and automated saves $10 000 over 2-day Thanksgiving Holiday
- November CEC achieves 94% hydro crushing all previous records
- December 2019 CEC achieves 86% hydro crushing all previous records
- April 2020 CEC goes 100% hydro 3 weeks early and starts automated electric boiler heating
- 2021: Saved 50 000 gallons of diesel directly with BESS 14 000 gallons indirectly with e-boiler
- 2022: Delivering more hydro upgraded diesel heat loops to save 25 000 gallons with e-boiler
- 2022: New valves unleashed more hydro; extending heat loops and EV charging with excess hydro

RIBBON CUTTING
June 7 2019



CEC BESS Commissioning – Takeaways

- Conduct a meeting of minds and document functional items – project teams can change
- Understand the ecosystem – a microgrid does not have an infinite bus / fault current
- Make sure vendors close the gap between sales staff and field installers
- Details matter – bumpless switching between power converter modes was/is challenging
- Pay attention to alarms – lots of internal alarms may have value to vendor but not the client
- Pay close attention to warranties and PMs a big challenge in Alaska and a work in progress


Questions?

Webinar Speakers – Q&A

- **Dr. Imre Gyuk**, Director of Energy Storage Research, Office of Electricity, US Department of Energy
- **Dan Borneo**, Engineering Project/Program Lead, Sandia National Laboratories
- **Dave Galarowicz**, Lead Engineer, Alliant Energy
- **Clay Koplin**, CEO, Cordova Electric Cooperative
- **Todd Olinsky-Paul**, Senior Project Director, Clean Energy States Alliance (moderator)

This webinar was presented by the DOE-OE Energy Storage Technology Advancement Partnership (ESTAP)

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Upcoming Webinar

Advancing Solar for Manufactured Homes through Community Solar

Wednesday, September 14, 2-3pm ET

Panelists will share more information about how community solar can be used to bring the benefits of solar to manufactured homes; how to engage with the U.S. Department of Energy's National Community Solar Partnership; and successful examples of community solar projects that have benefitted manufactured homes and communities.

Read more and register at: www.cesa.org/webinars