Energy Storage

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4/5/16

Agenda

- Introduction to Snohomish County PUD
- Energy Storage Project Overview
- MESA Standards
- MESA 1 Project Overview
- Project Photos
- Lessons Learned

Snohomish County PUD

Total Electrical Customer: 332,000

Energy Sales: 8,812,294 MWh

Generating Capacity: 120 MW

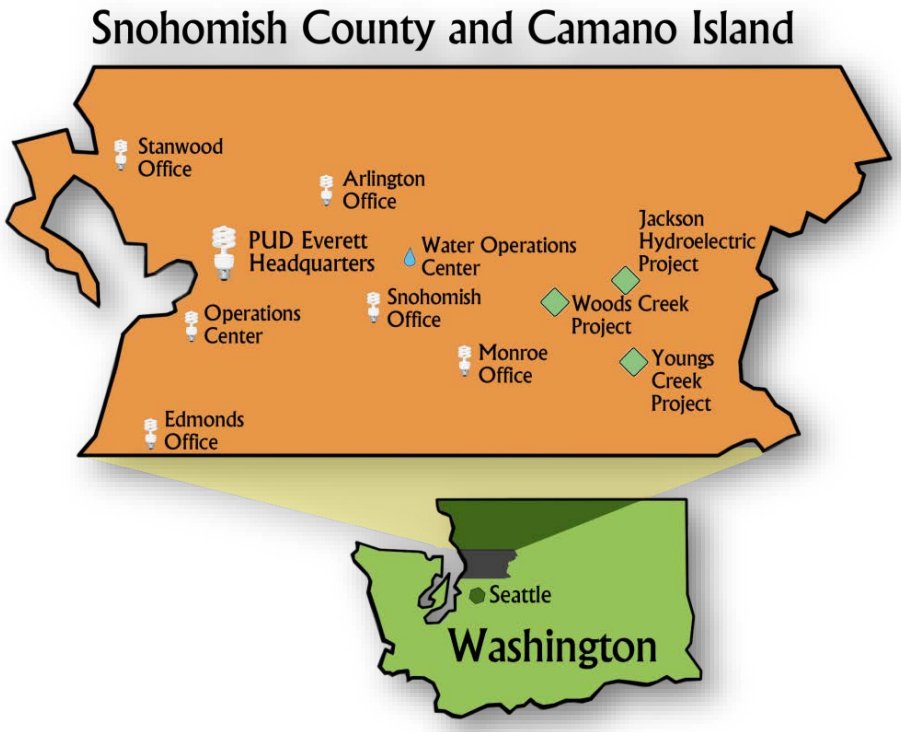
Residential Rates: 9.9¢ per kWh

# of Substations: 88

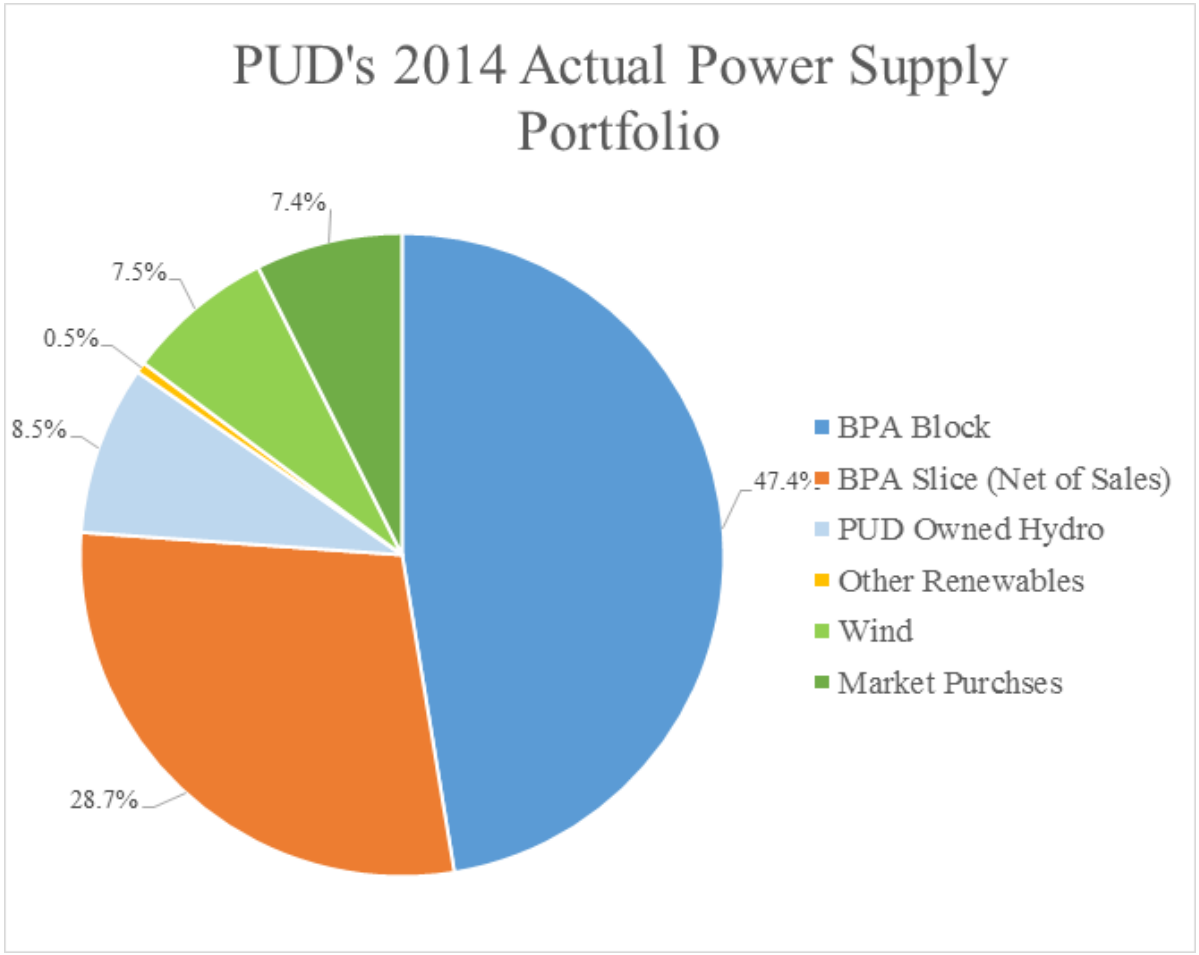
# of Circuits: 400

Resource Mix: 8% Renewables

Average # of Employees: 980



Why is Energy Storage needed?



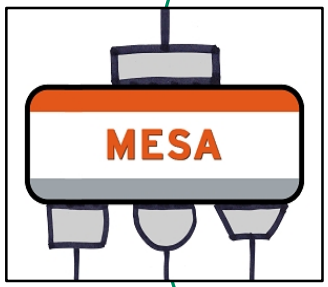
Challenge:
Meet load growth and renewable portfolio standard requirements without the use of fossil fuels

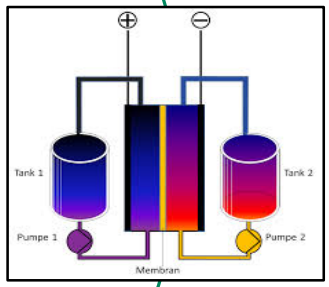
Current Energy Storage Projects

MESA 1A
1MW/.5MWh
Li-Ion

MESA 1B
1MW/.5MWh
Li-Ion

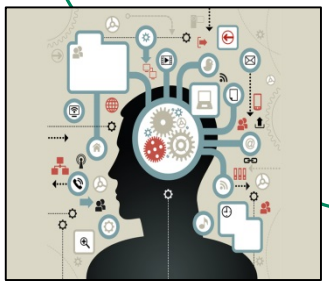
MESA
Standards
Alliance





MESA 2
2.2MW/8MWh
Vanadium Flow

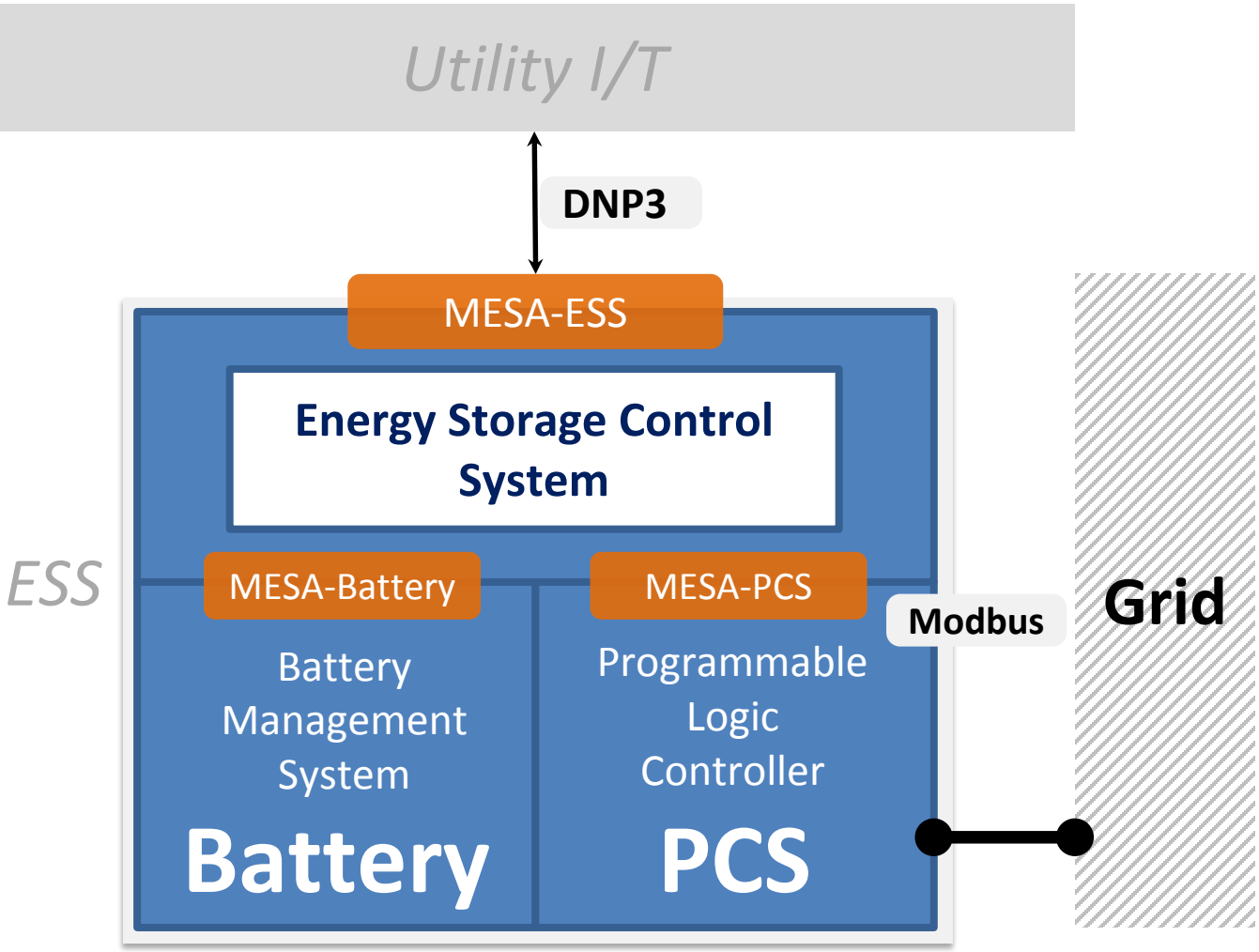
Analytics –
Measurement
and Verification



Controls
Integration -
Optimization

Projects partially funded through Washington State - Clean Energy Fund

Component-Based ESS, Enabled by MESA

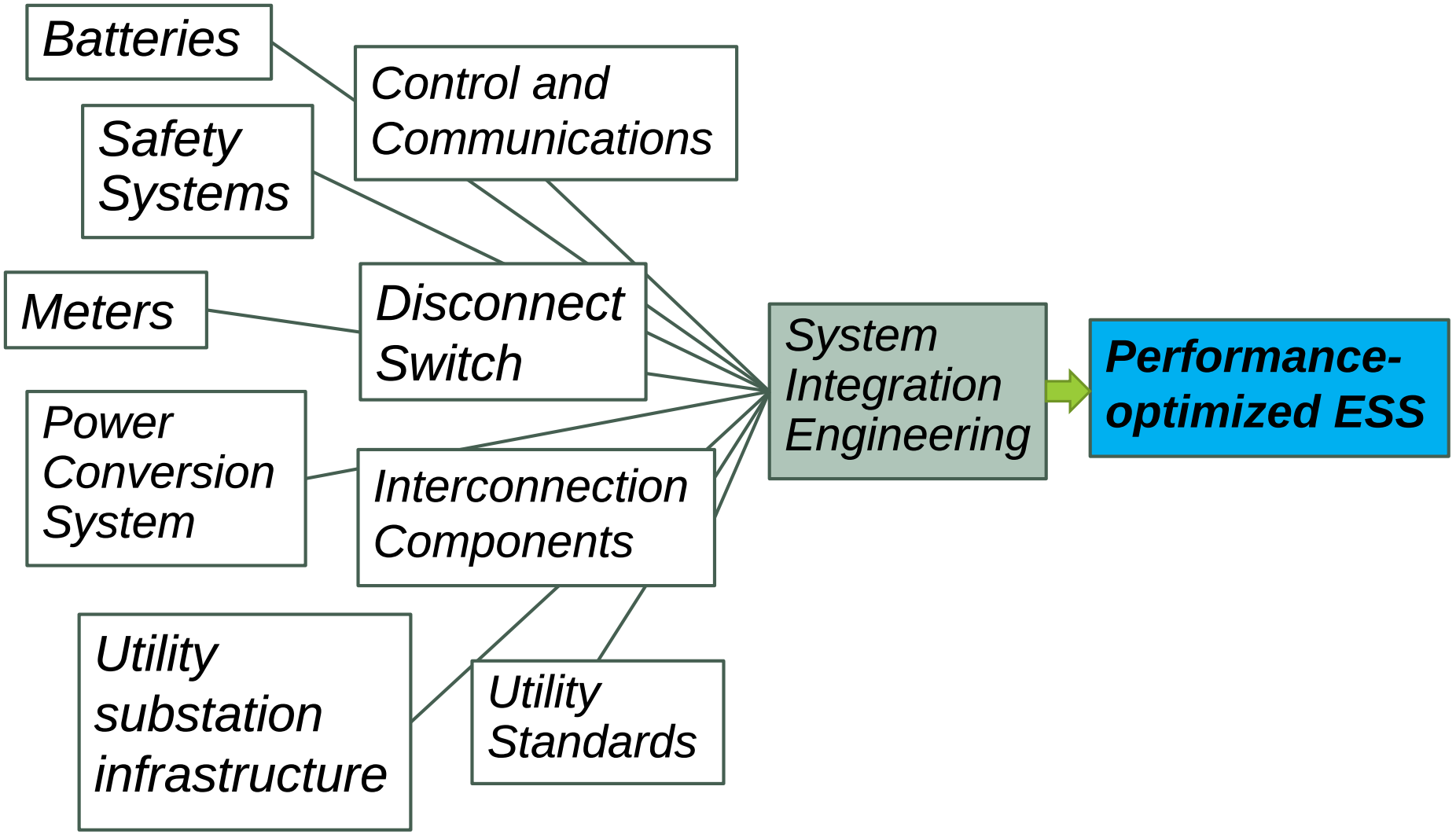



MESA
Open Standards for Energy Storage
LG Chem
PSE
PUGET SOUND ENERGY
SNOHOMISH COUNTY PUD
PUBLIC UTILITY DISTRICT NO. 1
ALSTOM
SMUD
1energy SYSTEMS
ALEVO
REDEFINING ENERGY
NUVATION
Parker
AUSTIN ENERGY
Seattle City Light
DUKE ENERGY
Pacific Northwest
NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965
Win Inertia
NEC
NEC ENERGY SOLUTIONS
Blue Pillar
Digital Energy Network
greenlots
UET
AMBER_KINETICS
SAMSUNG
NEXTera ENERGY RESOURCES
ViZn ENERGY
greencharge networks

MESA 1 Project Scope

- Develop scalable energy storage solutions based on Modular Energy Storage Architecture
- Field deploy and test MESA based Energy Storage System at a District Substation
- Integrate Energy Storage System into District communication networks to communicate end-to-end with the District Control Center and Power Scheduling Systems

ESS: A Single, Integrated System



System Design and Project Plan

- Specifications
  - Performance Requirements
- Drawings
  - Schematics
  - Wiring
  - Civil package
- Bill of Materials
- System Integration Plans
- Hazard Analysis
- System Testing and Verification Plans
- Factory Acceptance Test
- Commissioning Plan
- Acceptance Test
- Hazardous Material Management Plan

Broad Utility Engagement

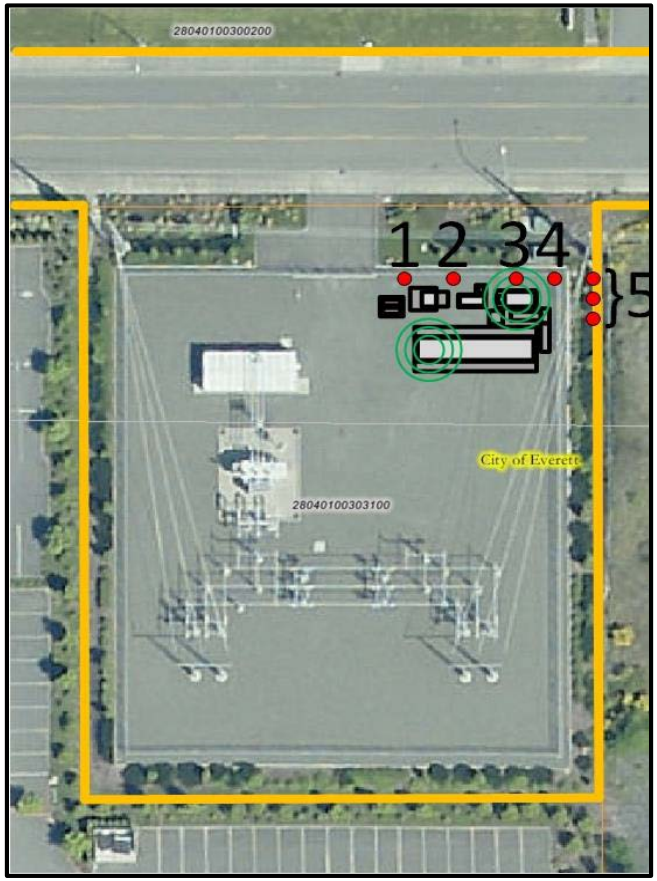
- Substation Engineering / Construction
- Communications
- SCADA
- System Planning and Protection
- Environmental and Safety
- Power Scheduling
- Facilities
- Information Technology
- Cyber Security
- Steering Team

Testing

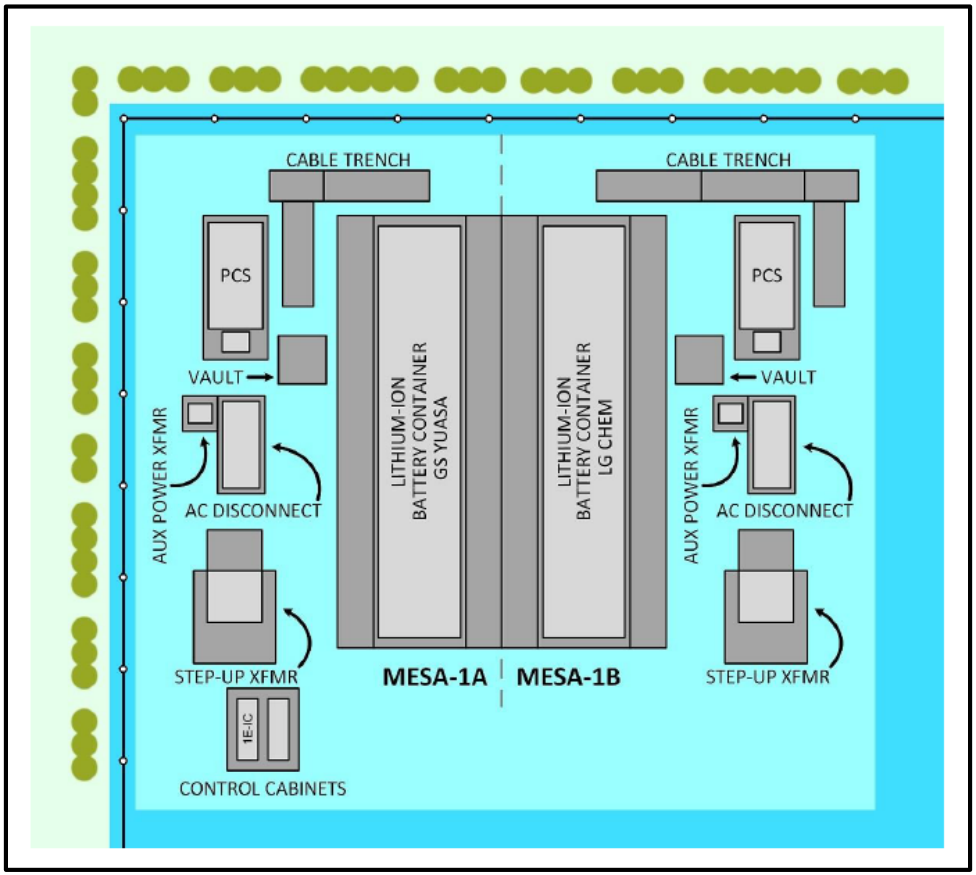
- Factory Acceptance Testing
  - Tested complete battery and power conversion system
  - Failure Modes and Event Analysis
- Commissioning
  - Complete check out of all systems
  - System charging/discharging at full capacity within 1 week
- Site Acceptance Testing
  - Repeat testing of select Failure Modes and Event Analysis
  - Testing of all control modes
  - Testing of control mode scheduling

System Integration Engineering

Site Physical



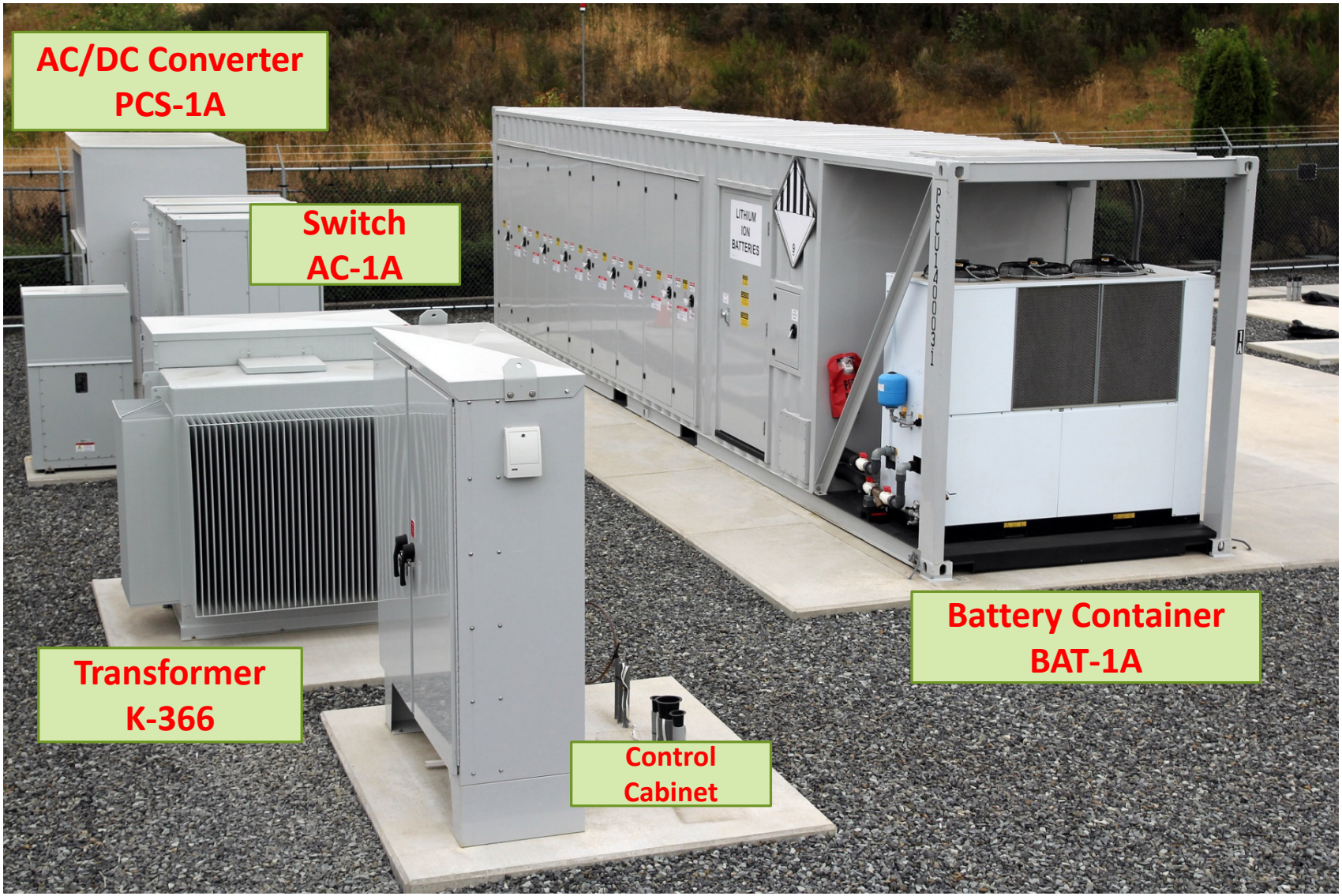
MESA 1A site physical arrangement.



MESA 1A and 1B site physical configuration.

MESA 1

MESA 1A Equipment

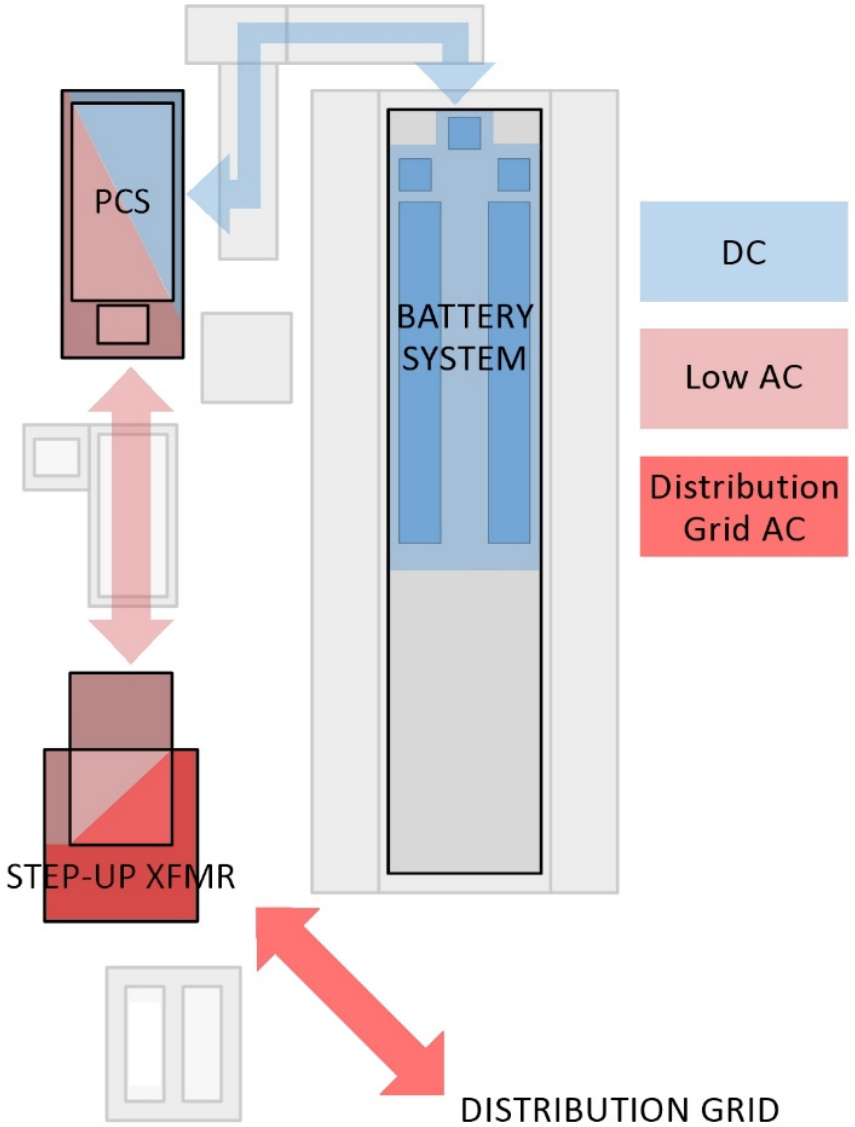


Modular ESS System Design at Hardeson

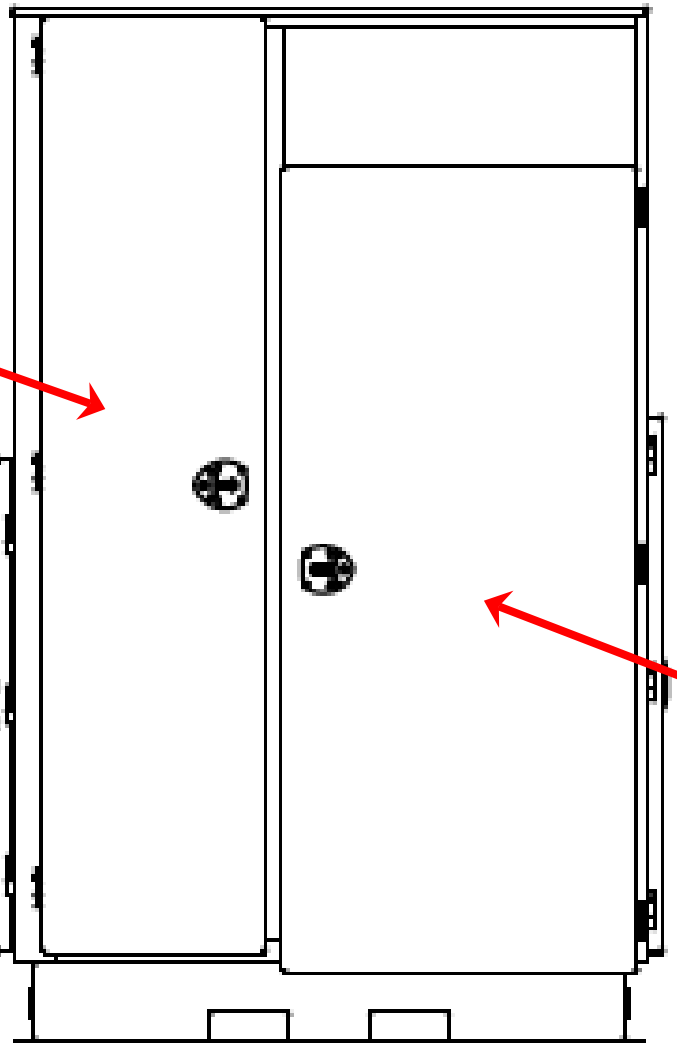
Battery System (two):
- 540 kWhr each
- 1080 kWhr total
- 1000 VDC

PCS (two):
- 1 MW
- 480 VAC

Step-up Transformer (two):
- 1.5 MVA
- 480 V – 12.96 kV

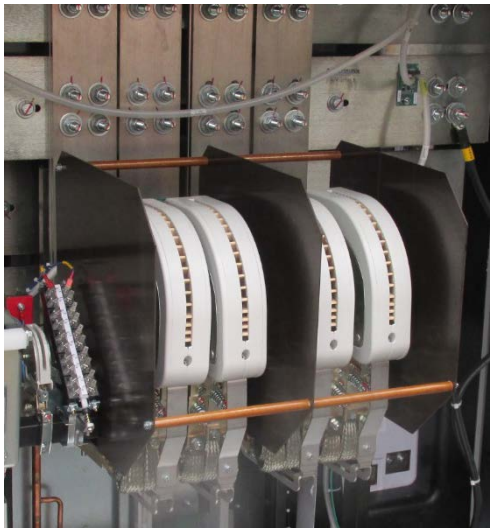


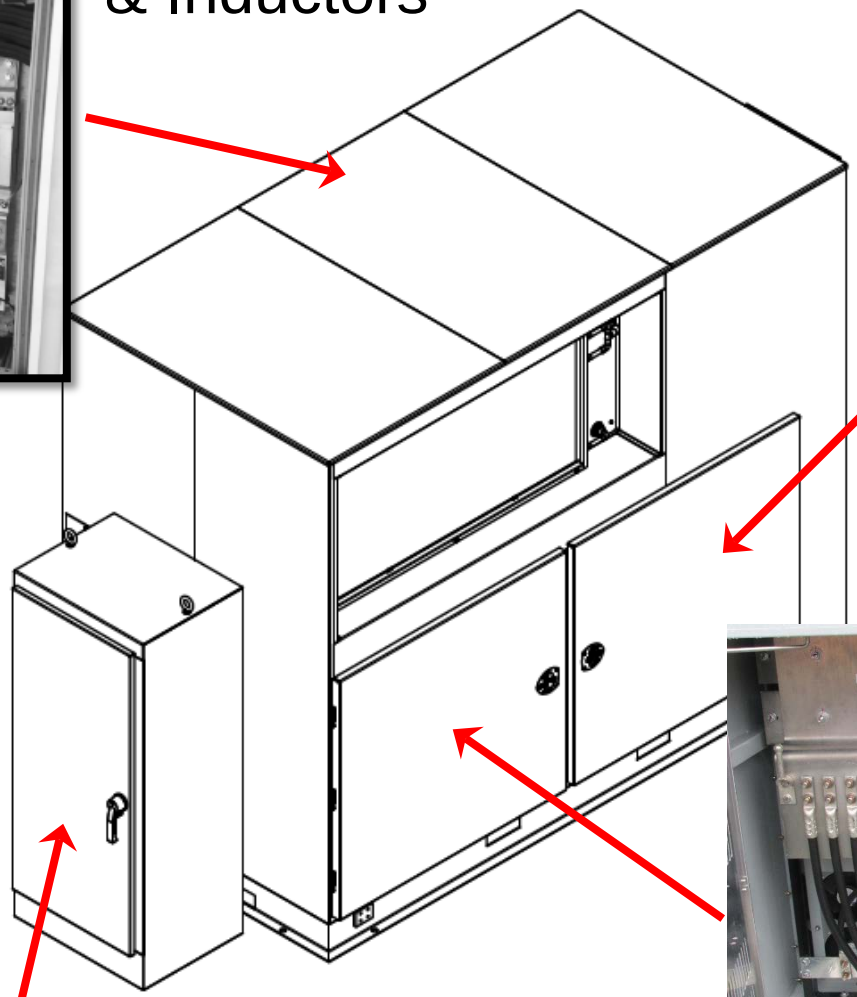
HMI and
Controls Cabinet



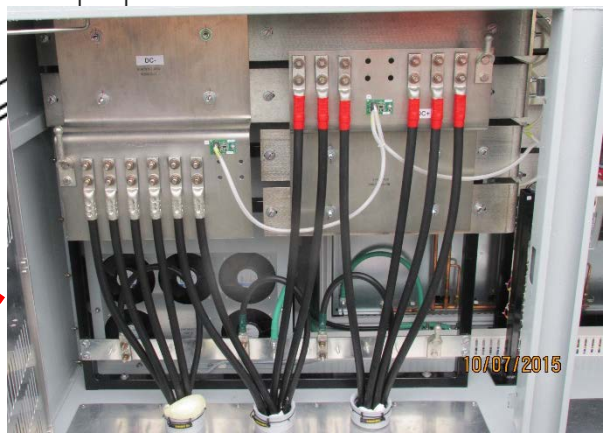
Inverter
Power Stack

Filter Capacitors
& Inductors





DC Contactors



AC Connections
And Breaker

DC Battery Power
Connections

Chiller

Battery Container HMI

DC Connection Cabinet

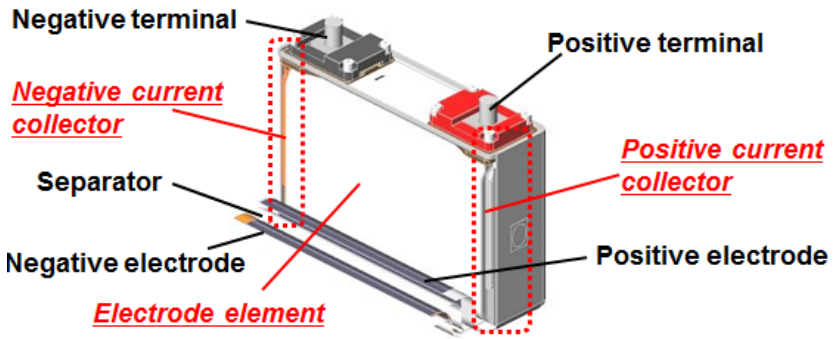
Air Handler

Battery Racks

DC Switch

Lithium-Ion Battery Modules

- A module is built from 12 or 28 individual cells
- Cell Voltage ranges from 3 to 4V
- Built-in monitoring for individual cell voltage, current and temperature
- Approximately 80lbs
- Design lifetime is 10-13 years




11/03/2014


09/24/2015


10/07/2015


CAUTION
FUMES MAY BE PRESENT
DANGER
FLAMMABLE LIQUIDS


DANGER
CAUTION
PUD

Control Cabinet Layout

1Energy HMI

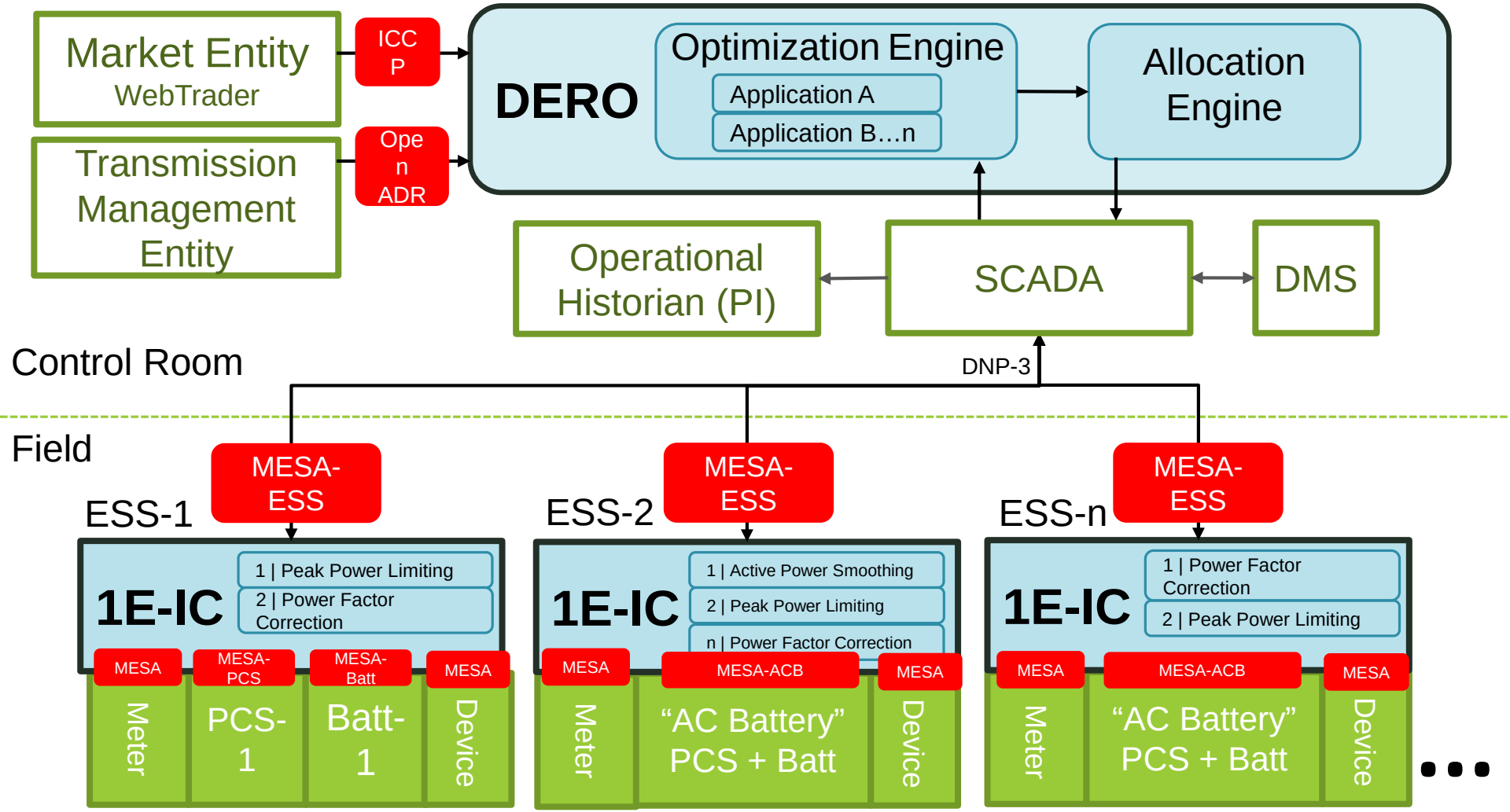
Comm gateway

Meters ION 8650

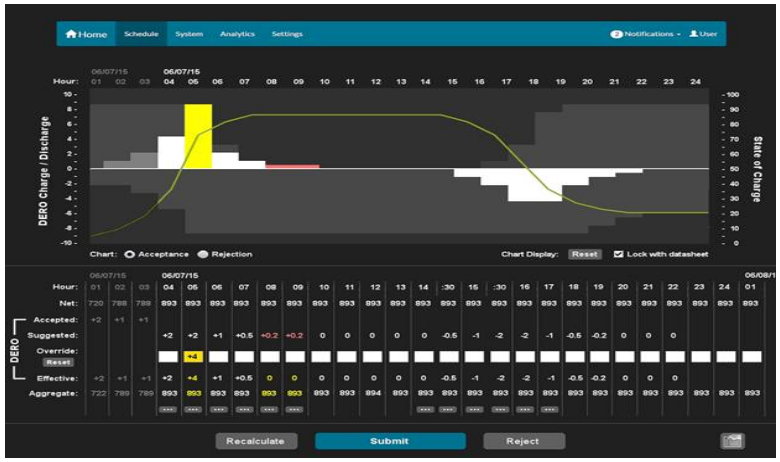
Relays SEL-751

Test Switches

MESA Enables Optimal Fleet Control Strategy

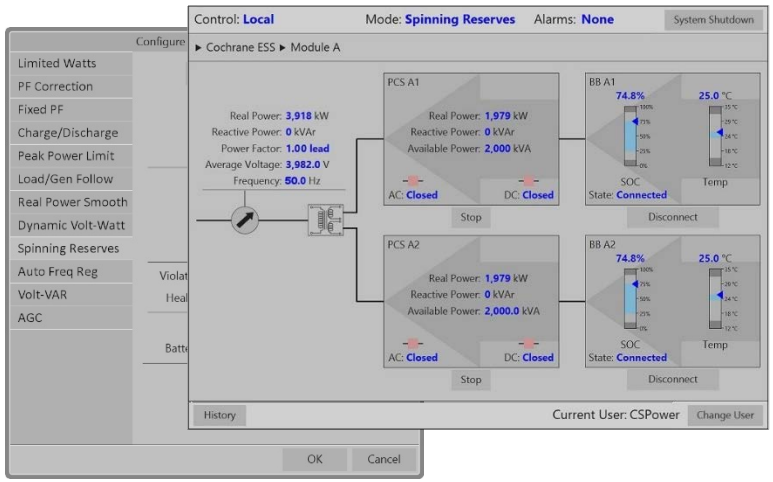


Coordinated, Hierarchical Control Platforms



Bulk system, centralized

Applications
Market Participation
Transmission Congestion Relief
Unfavorable Market Avoidance
Energy Imbalance Mitigation
Frequency Response
…and more based on customer needs



Local circuit, autonomous

Operating Modes
Peak Power Limit
Load/Generation Following
Power Factor Correction
Real Power Smoothing
Spinning Reserves
Volt-VAR
…and a number of others
…and more based on customer needs

Lessons Learned

Test Lab

FAT Testing

Site Acceptance Testing

One Prime Contractor

In house Engineering

Specific about Charge/Discharge requirements and Energy storage capacity

Insurance Company verification

HMMP

Complete set of wiring diagrams, Bill of Materials

Questions

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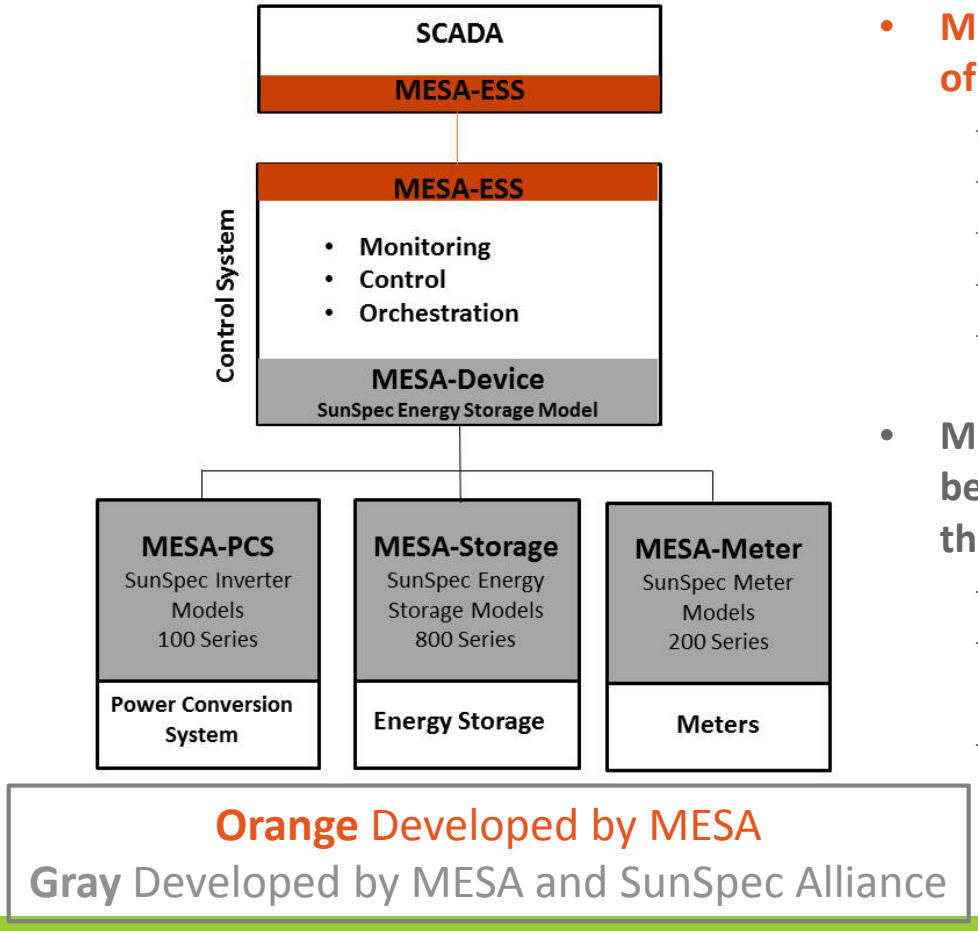
Overview of MESA Specifications

MESA is currently developing two specifications: MESA-ESS and MESA-Device/SunSpec Energy Storage Model.



Orange Developed by MESA

Gray Developed by MESA and SunSpec Alliance

- **MESA-ESS Specification for direct utility control of ESS built on the DNP3 Protocol**
  - Operational Management
  - Monitoring
  - Control Functions
  - Smart ESS Modes
  - Scheduling
- **MESA-Device Specifications for connections between components within the ESS built on the Modbus Protocol**
  - MESA-PCS: Power Conversion Systems
  - MESA-Storage: Batteries (lithium-ion & flow models to date)
  - MESA-Meter: Meters