Energy Storage

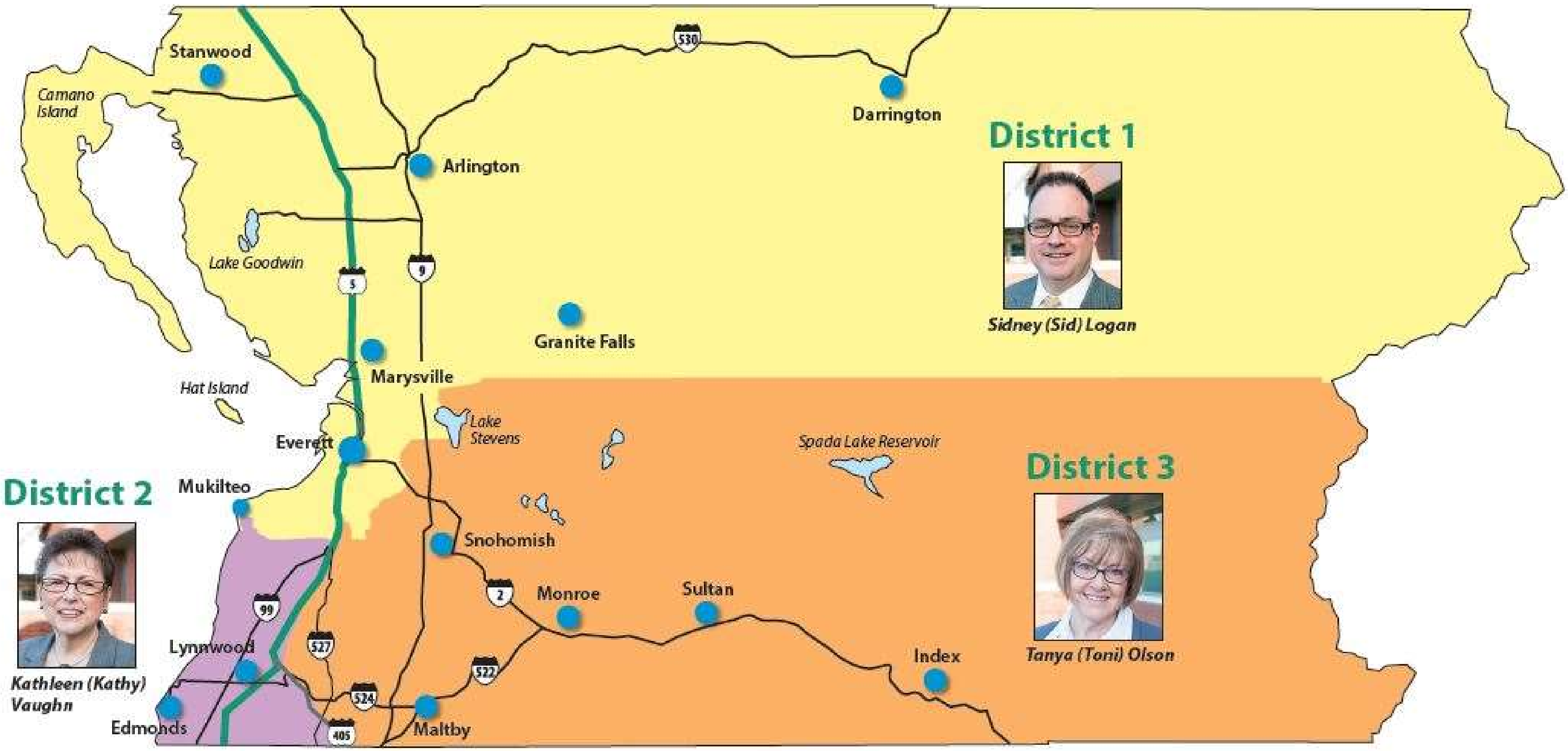
ARTURAS FLORIA

9/28/17

Agenda

- Introduction to Snohomish County PUD
- Energy Storage Project Overview
- MESA Overview
- MESA 1 Project Overview
- MESA 2 Project Overview
- DERO Overview

PUD Commission Districts



Three commissioners elected by customers to six-year terms

PUD Quick Facts

- Began operations in 1949 following a public vote
- Second largest public utility in the Northwest
- 341,000 customers & growing
- 2,200 square mile service territory
- 6,200 mile network of distribution lines
- Boeing is our largest customer.

Snohomish County PUD

Annual System Peak Demand: 1,365 MW

Energy Sales: 8,522,538 MWh

Generating Capacity: 120 MW

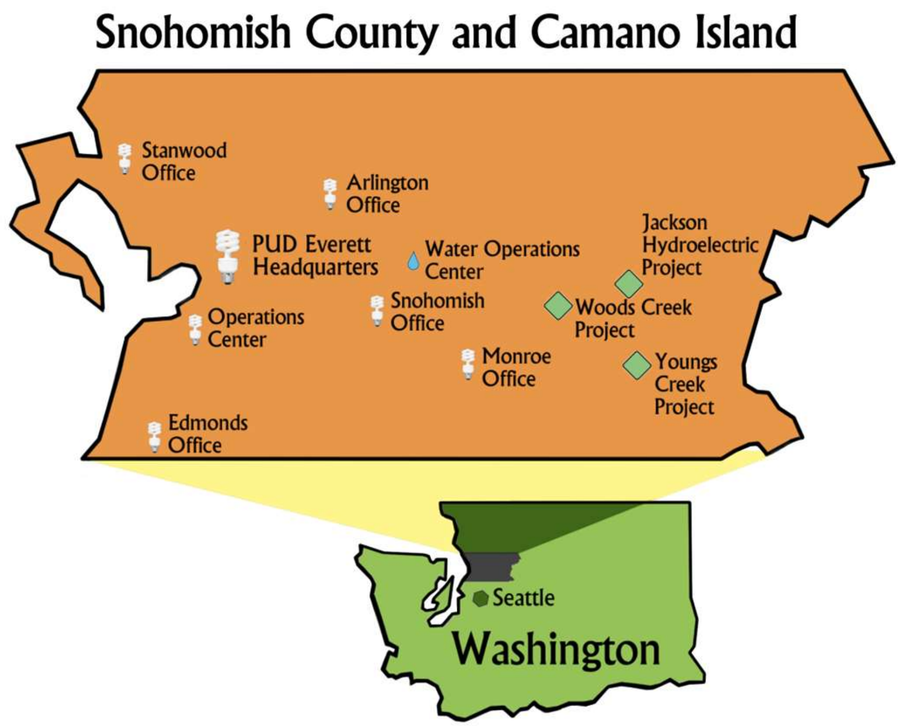
Residential Rates: 10.2¢ per kWh

# of Substations: 94

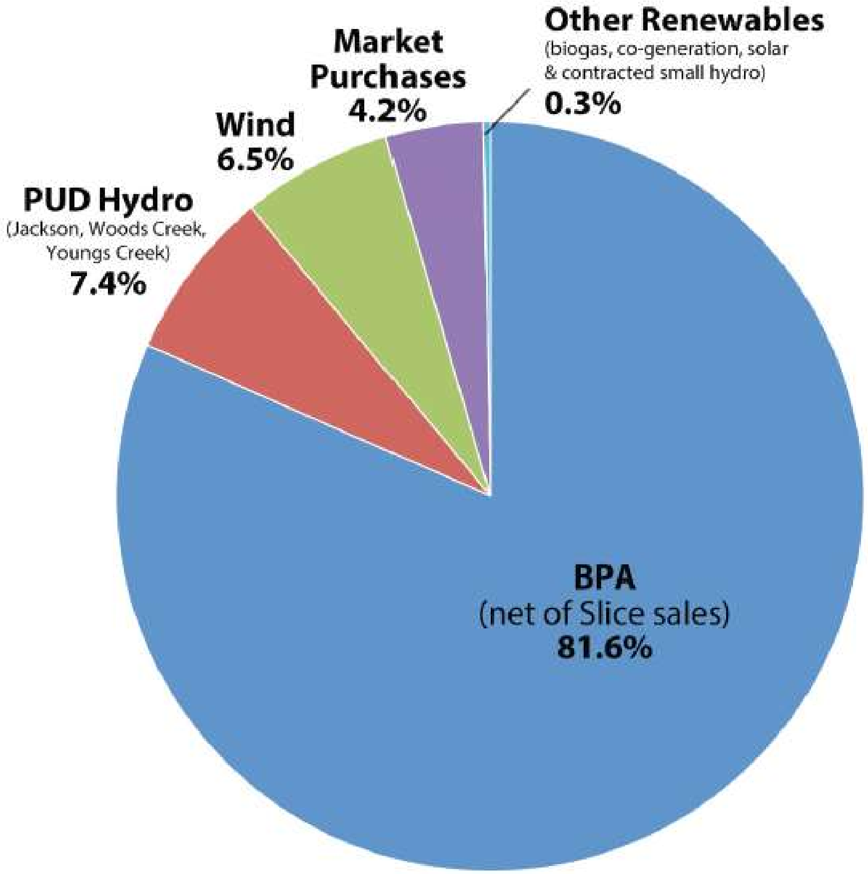
# of Circuits: 400

Resource Mix: 8% Renewables

Average # of Employees: 1,002

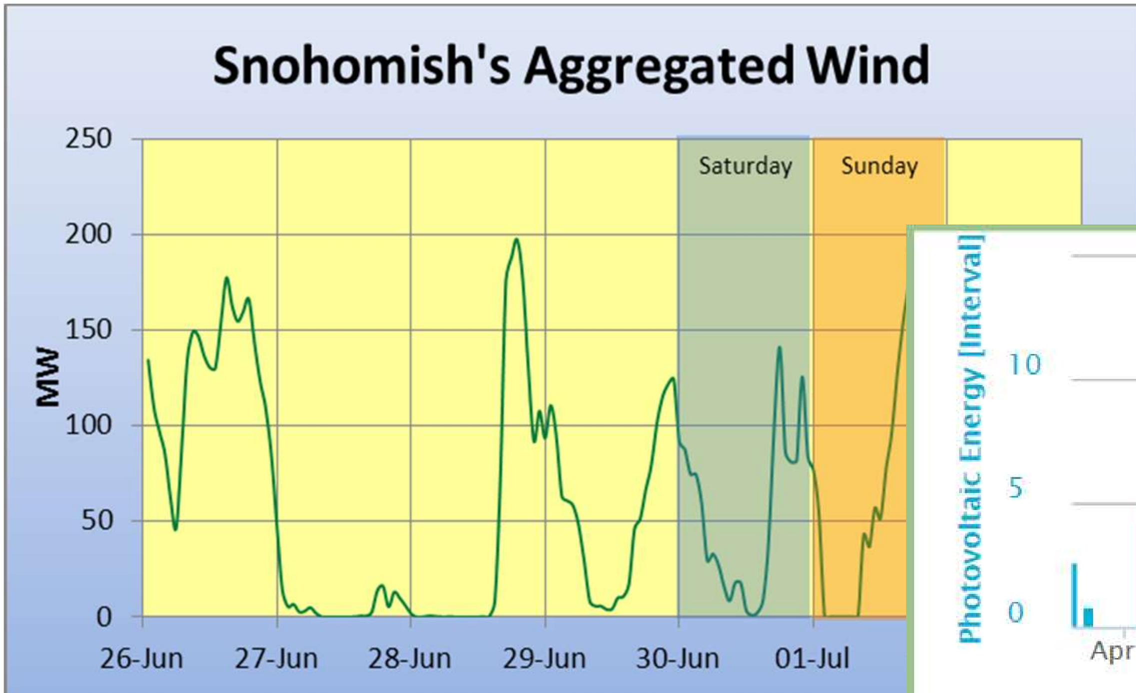


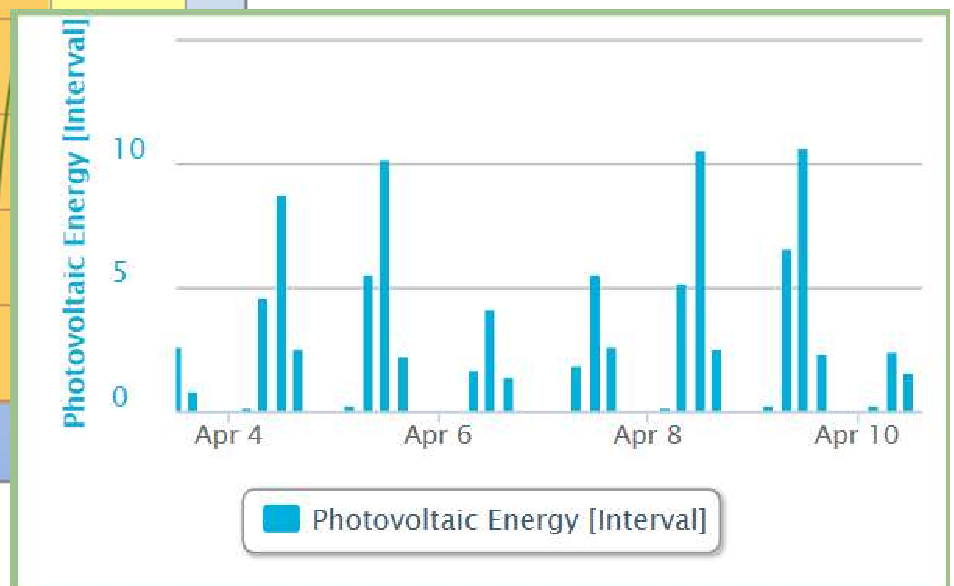
Power Supply Portfolio



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

Intermittent and Variable Renewable Energy





The ongoing addition of intermittent and variable renewable energy sources to the region’s power supply mix will drive more interests and investment in the development and application of storage technologies and demand response.

SNOHOMISH COUNTY PUD PUBLIC UTILITY DISTRICT NO. 1

Energy Storage Outlook

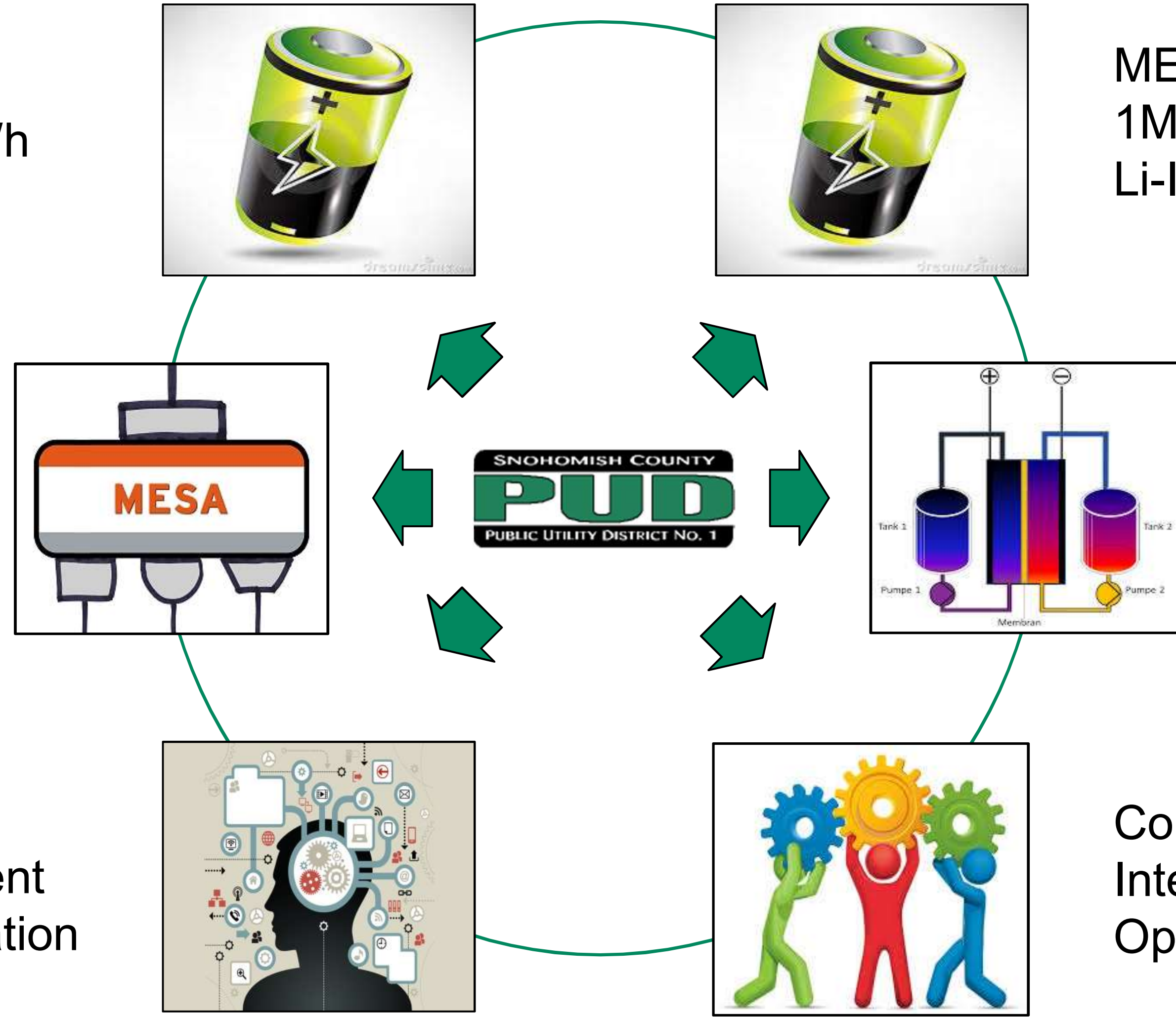
- Energy Storage will become an integral part of the electrical grid.
- Energy Storage can meet many emerging utility needs.
- Flexible Energy Storage solution – battery agnostic.
- ***Energy Storage costs are declining but remain the single largest barrier to utility adoption.***

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

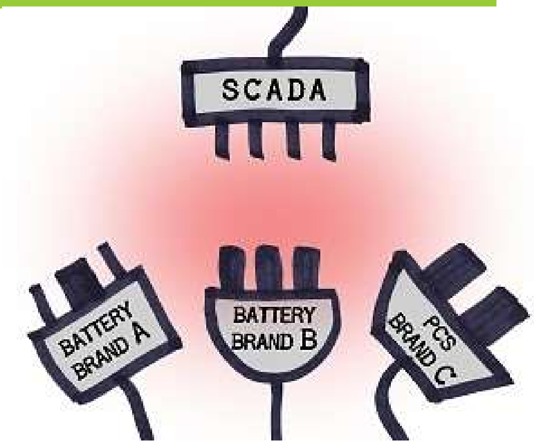
Analytics –
Measurement
and Verification

Controls
Integration -
Optimization

Projects partially funded through Washington State - Clean Energy Fund

Modular Energy Storage Architecture (MESA)

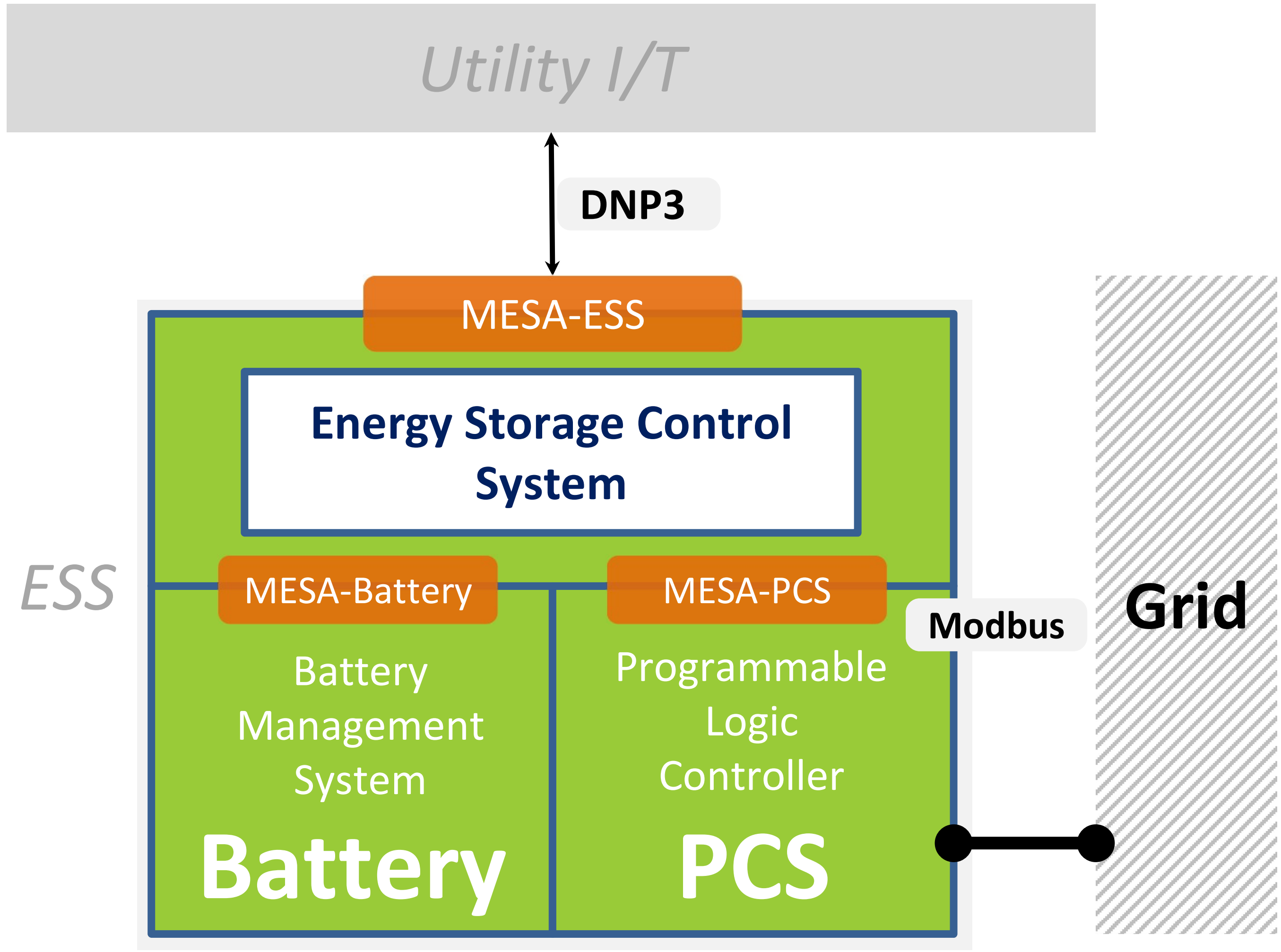
Each proprietary plug requires its own custom socket



Current grid energy storage offerings

- Expensive ($100k for 25kWh system)
- Lack modularity
- Lack interoperability
- Lack scalability
- Lack standardization
- Monolithic; vendors operate beyond core expertise
- Large gap between battery manufacturers and utilities
- Core suppliers cannot easily serve core customers

Component-Based ESS, Enabled by MESA



PLASPO

MESA
Open Standards for Energy Storage

SOUTHERN CALIFORNIA EDISON®
An EDISON INTERNATIONAL® Company

stem

PSE PUGET SOUND ENERGY

SNOHOMISH COUNTY PUD
PUBLIC UTILITY DISTRICT NO. 1

Seattle City Light

LG Chem

NUVATION ENERGY

DOOSAN
Doosan GridTech™

ALEVO™
REDEFINING ENERGY

GreenCharge

Parker

AUSTIN ENERGY®

greenlots®

SMUD

DUKE ENERGY®

Pacific Northwest
NATIONAL LABORATORY

destin
Destin Power

NEC
NEC ENERGY SOLUTIONS

EATON

UET

Energport

NEXTera® ENERGY
RESOURCES

SAMSUNG
SAMSUNG SDI

IHI
Realize your dreams

AMBER
KINETICS

Sinexcel

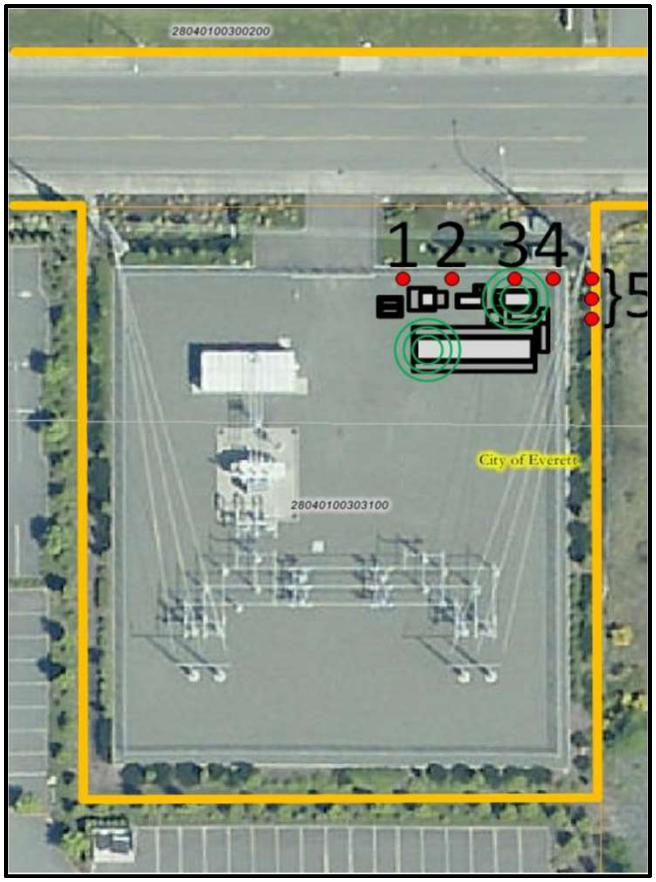
MESA 1 Project

SNOHOMISH COUNTY PUD PUBLIC UTILITY DISTRICT NO. 1

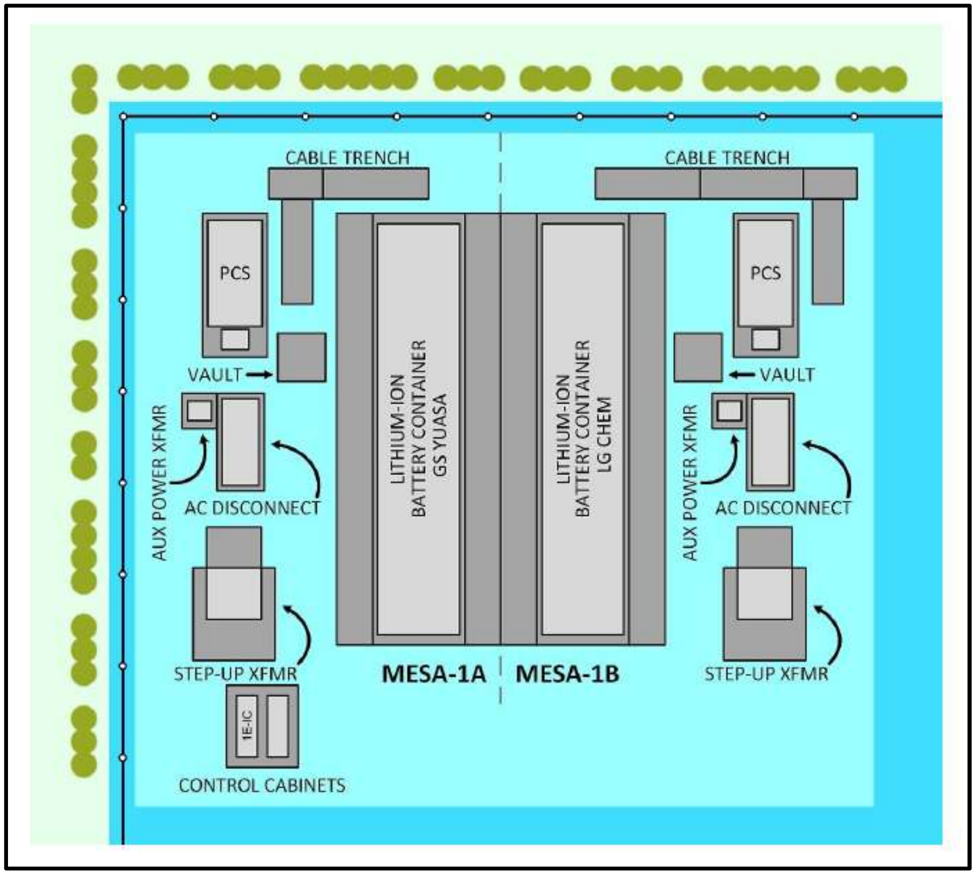
MESA 1 Project

- 2MW/ 1MWh Li-Ion ESS (MESA-1A and MESA-1B)
- Installed at Hardeson Substation
- MESA-1A has battery from GS Yuasa
- MESA-1B has battery from LG Chem
- Based on MESA framework
- Received WA State Clean Energy funds

Site Layout



MESA 1A site physical arrangement.



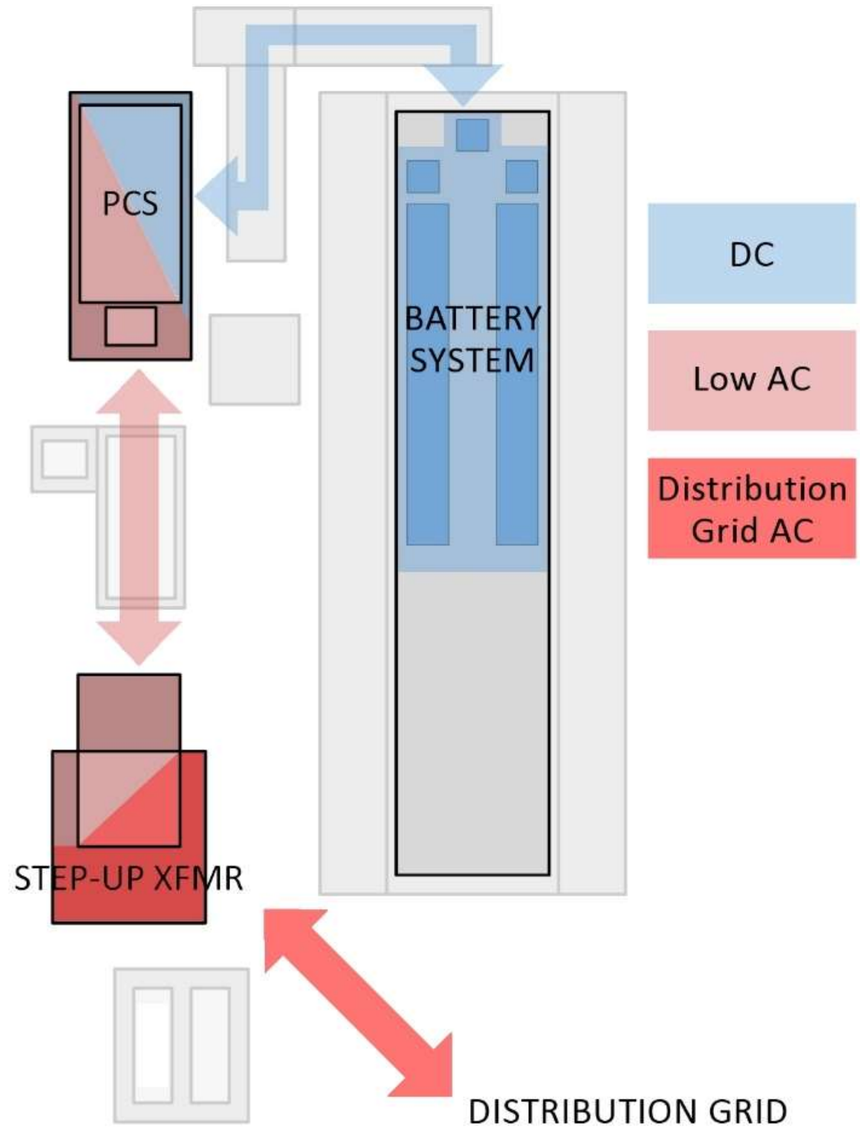
MESA 1A and 1B site physical configuration.

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

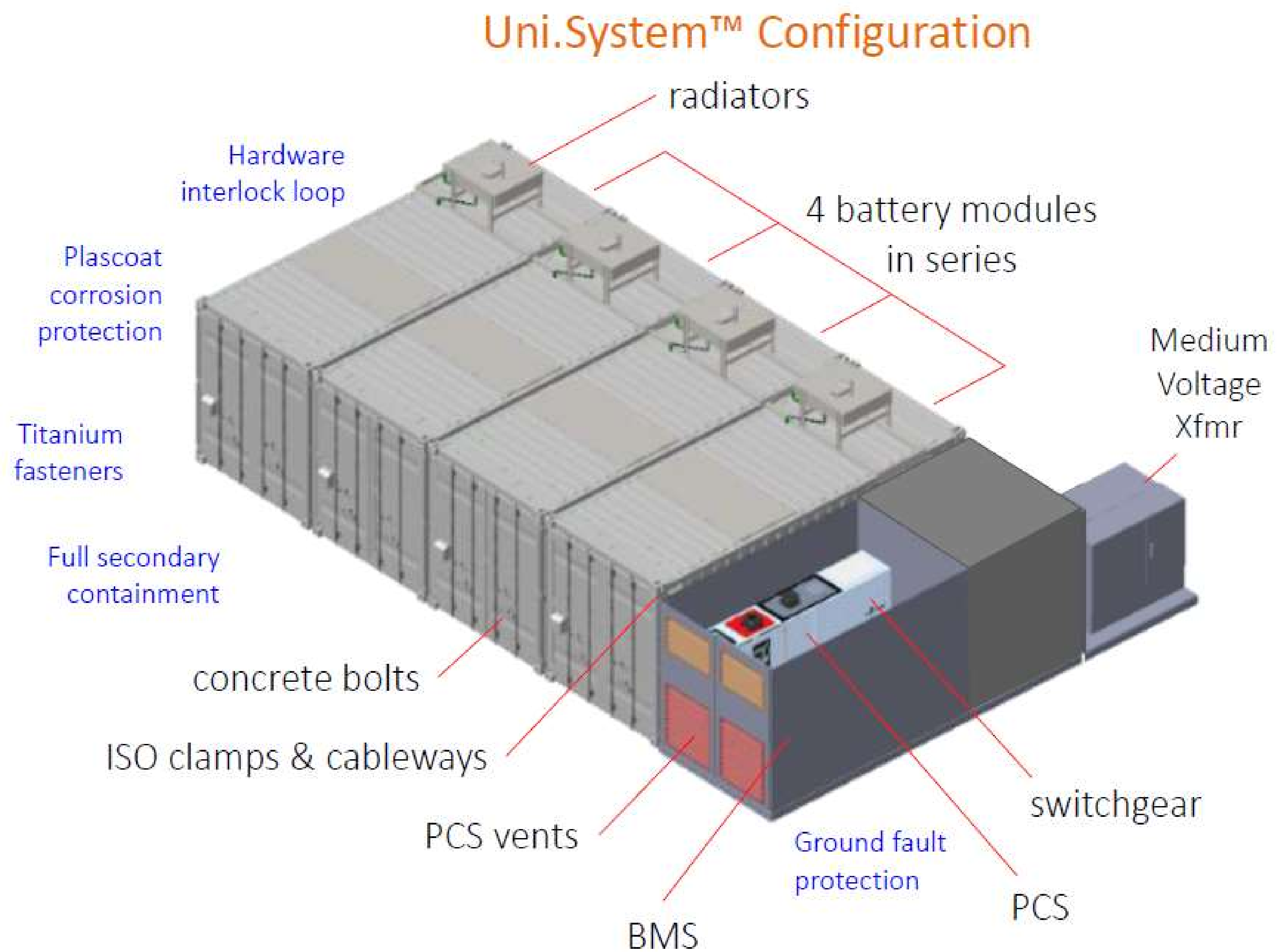


MESA 2 Project

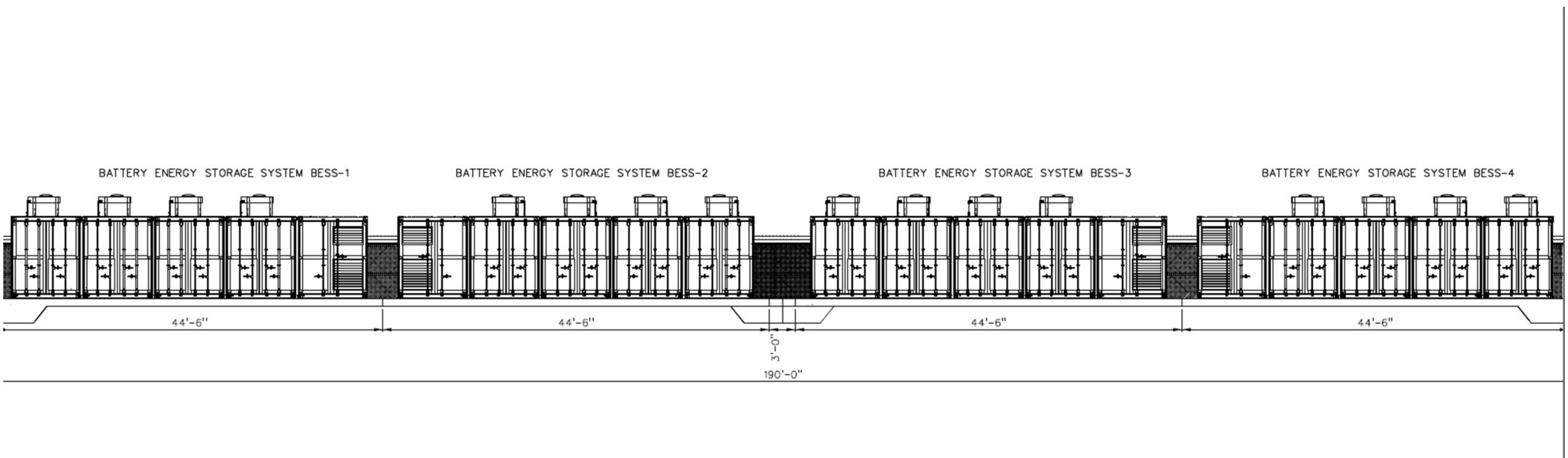
MESA 2 Project

- 2.2MW/ 8MWh VRFB ESS
- Installed at the Everett Substation
- ESS based on MESA framework
- ESS part of WA State Clean Energy Fund
- ESS has bi-directional communication with Energy Control Center (ECC) and Power Scheduling

One Battery String

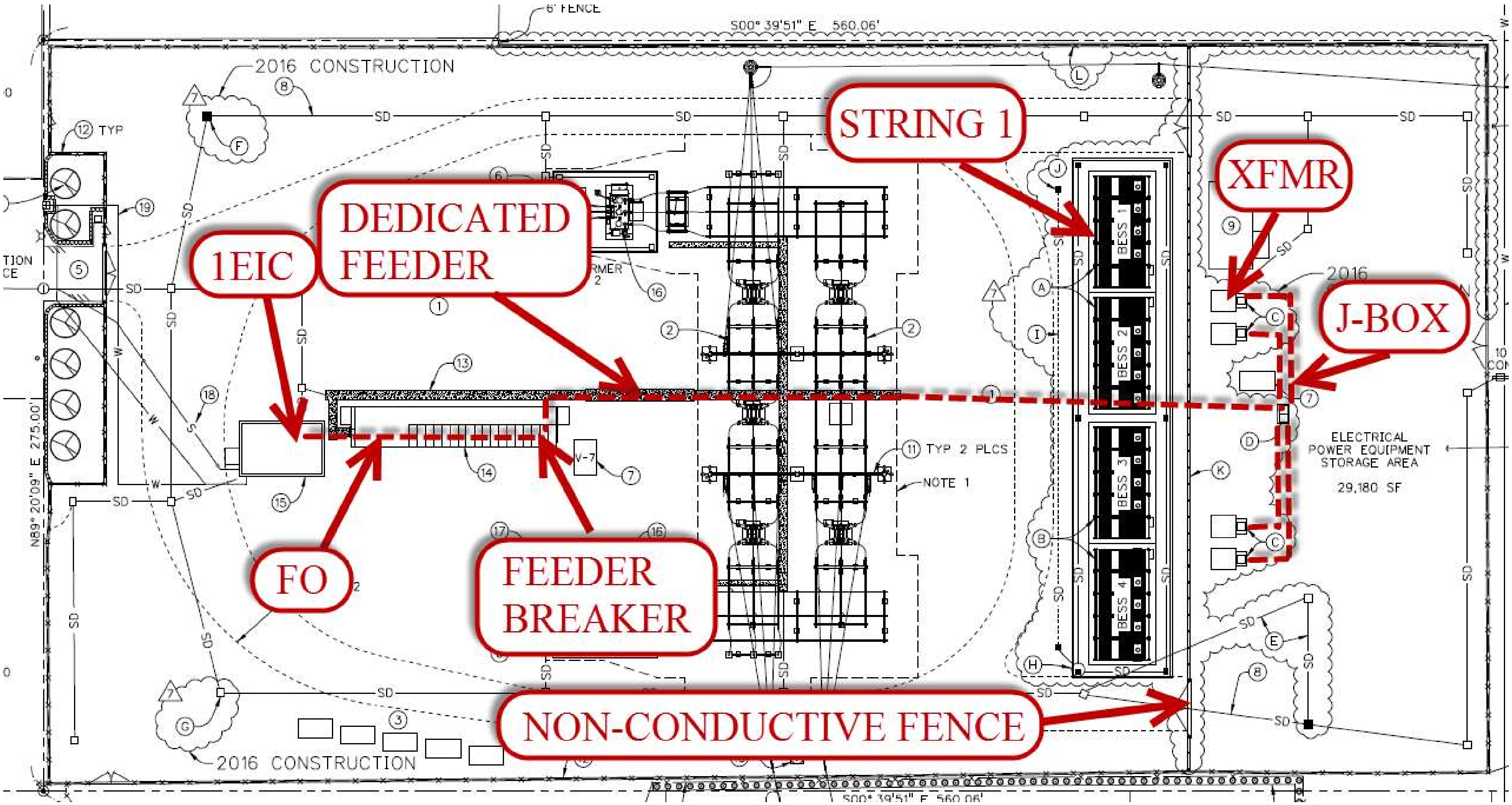


MESA 2 Battery Elevation



SNOHOMISH COUNTY PUD PUBLIC UTILITY DISTRICT NO. 1

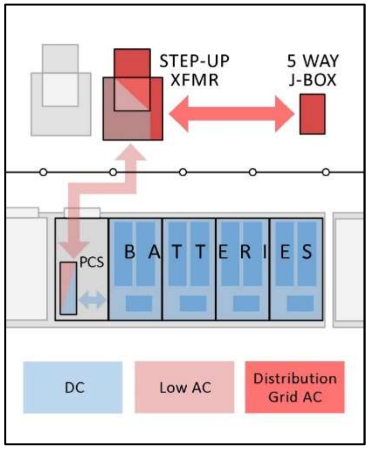
Everett Substation Layout

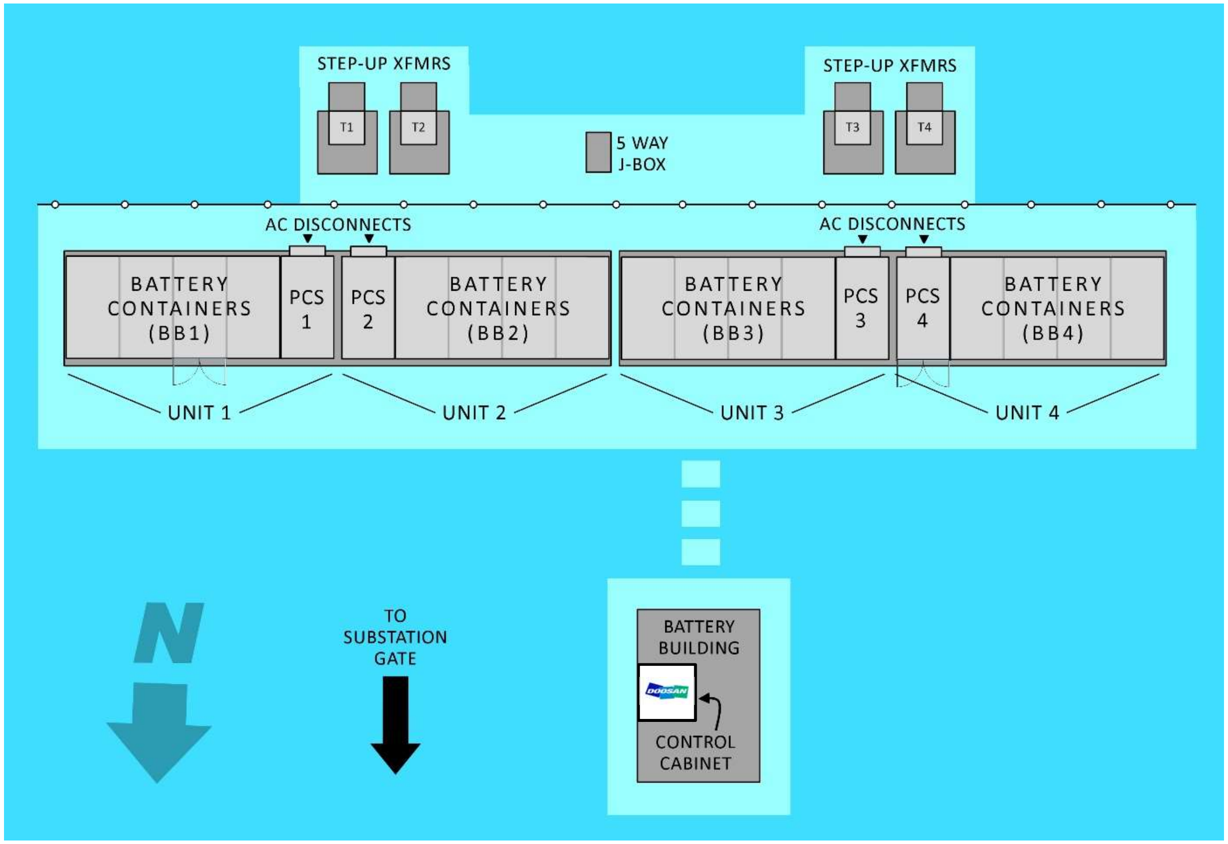


Major Components

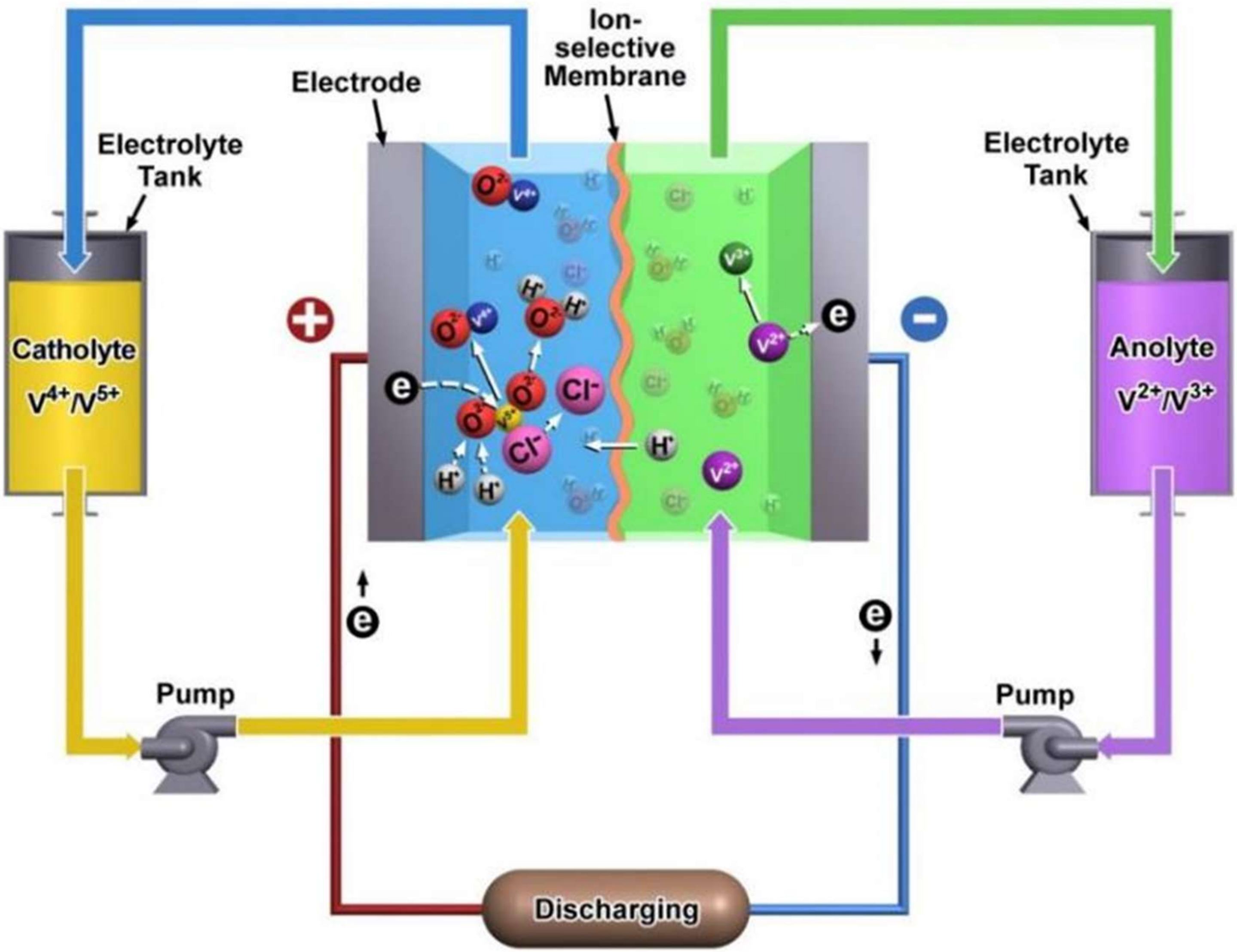
Major Components in four strings:

- 4 x Battery Containers
- 1 x Power Conversion System (PCS)
- Step-up Transformer
- DG-IC Control inside the battery building

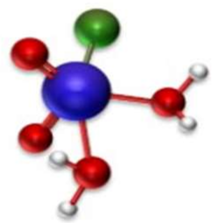




VRFB - Technology



VRFB Features



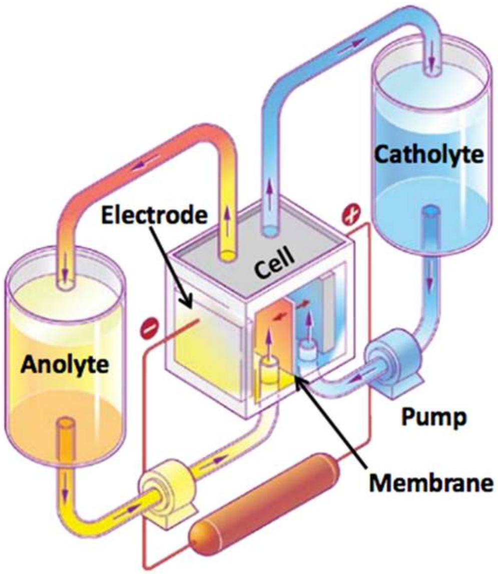
$VO_2Cl(H_2O)_2$

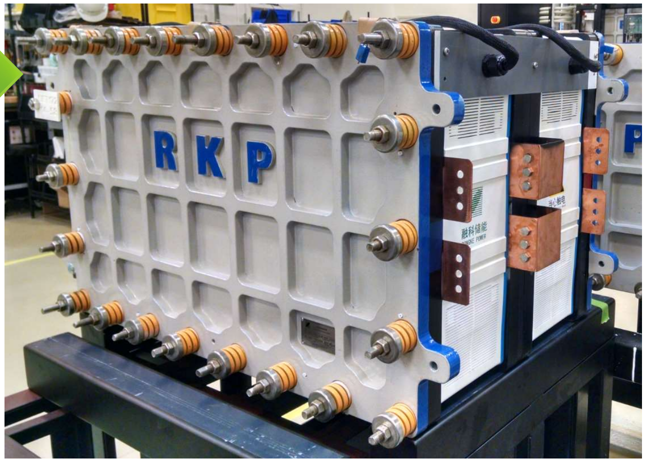
- No Thermal Runaway
- Unlimited Cycles over lifespan
- Efficiency 65-70%
- 100% Recyclable
- 100% SOC available
- pH=0

Design Overview

Cell Stacks

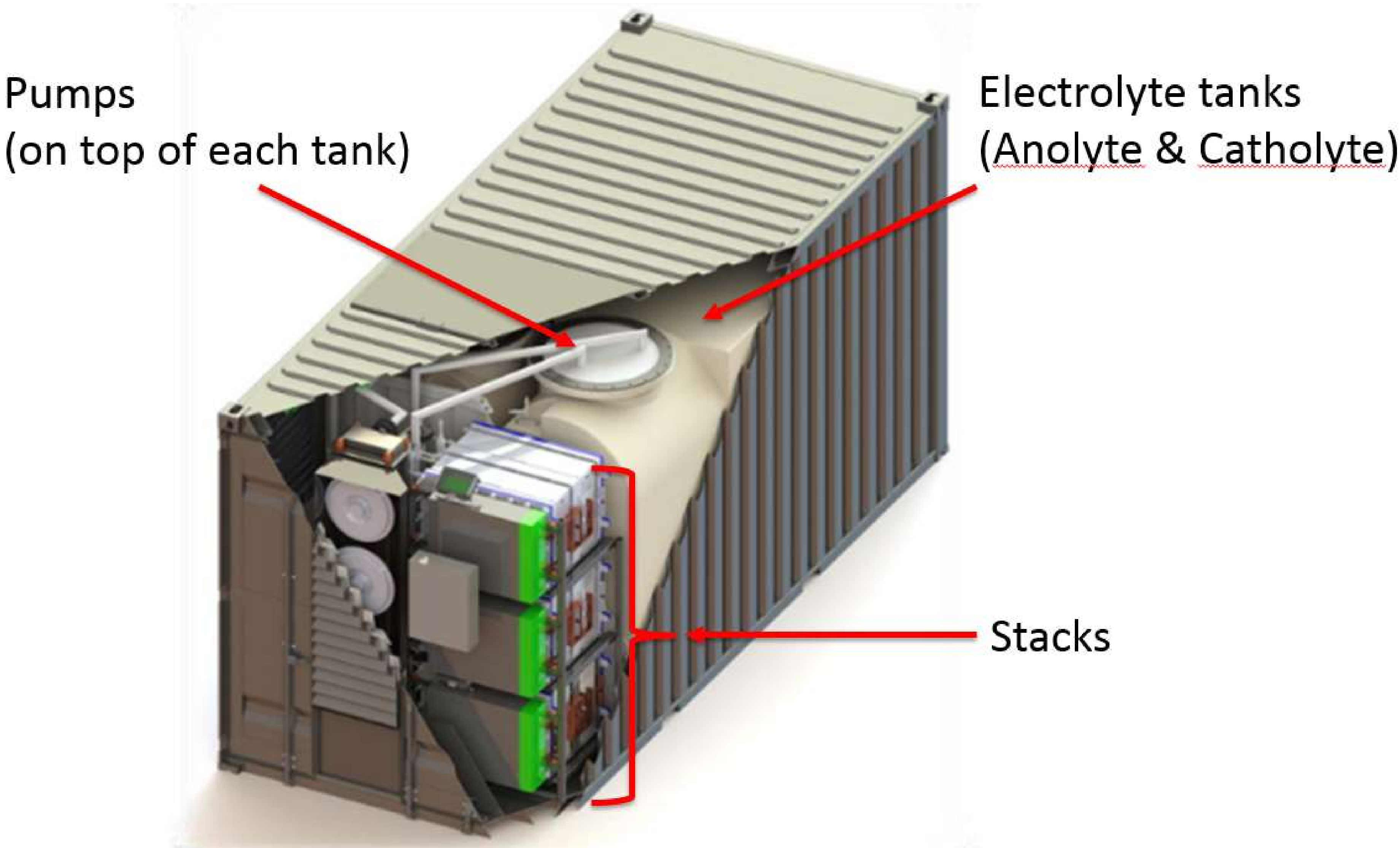
50 Cell Stack ~ 75V





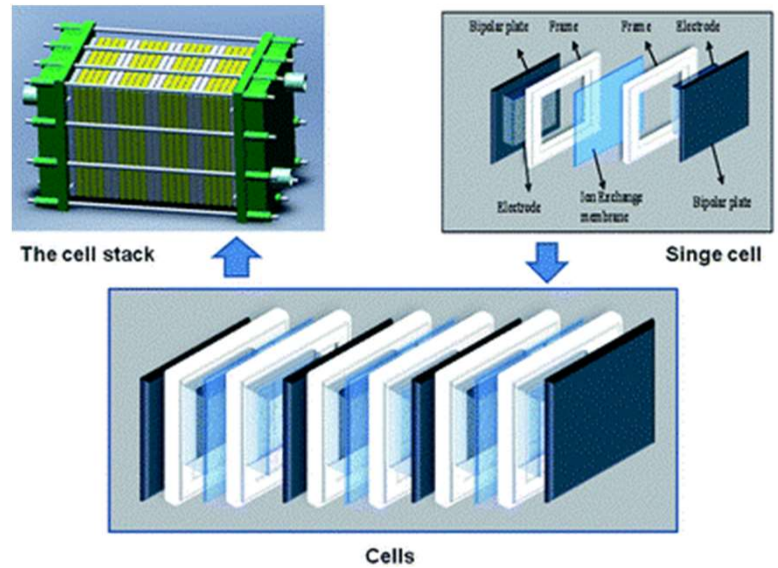
150 Cell Skid ~ 225V

Battery Stacks



Battery Stacks continued

- (3) Stacks per Container
- (50) Cells per Stack
  - 0.8-1.6 VDC per Cell
  - 40-80 VDC per Stack
  - 120-240 VDC per Container
  - 480-1000 VDC per String
  - Approx. 2.75 kW per Cell



- Built-in Monitoring for individual stack voltage, temperature, pressure

System Specification

Parameter	Value
Nameplate and Peak Power, AC	2.2 MW, 2.4 MW
Maximum Energy, AC*	8.0 MWh
Rated Power:Discharge Duration, AC*	2.2 MW:continuous cycling, 2.2MW:2 hr, 1.6 MW:4 hr, 1 MW(ave):8 hr
Efficiency	65-70%, AC round trip at the inverter
Self-Discharge	<2%, in standby mode
Cycle Life	Unlimited cycles within system design life
System Design Life	20 years
DC Voltage Range	465 V-1,000 V DC
AC Voltage Output	Medium Voltage (4,160 V – 34.5 kV)
Standards Compliance includes	IEEE 519, IEEE 1547 available
Ambient Temperature	-40°C to 50°C, active cooling for extended operation >35°C
System Footprint	4,360 ft^2 (single container layer, 2 rows of 10 containers w/front doors facing each other and 13' aisle between)
Availability	96%, no stripping etc. required

*for 20' containers. Higher energy capability options available using 30' and 40' containers.

System Specification

Energy Storage Discharge Capabilities

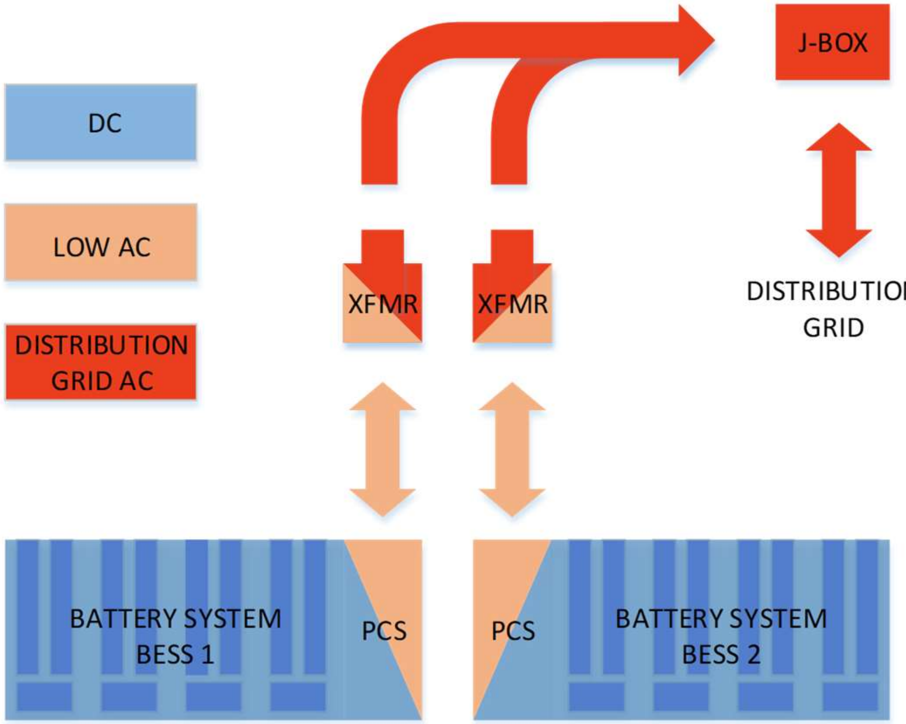
C Rate	Power		Energy
	(per string)	total	total
C 0.125 (8h discharge rate)	250 kW AC	1.0 MW AC (Average)	8 MWh
C 0.25 (4 h discharge rate)	400 kW AC	1.6 MW AC	6.4 MWh
C 0.5 (2h discharge rate)	550 kW AC	2.2 MW AC	4.4 MWh

Energy Storage Charge Capabilities

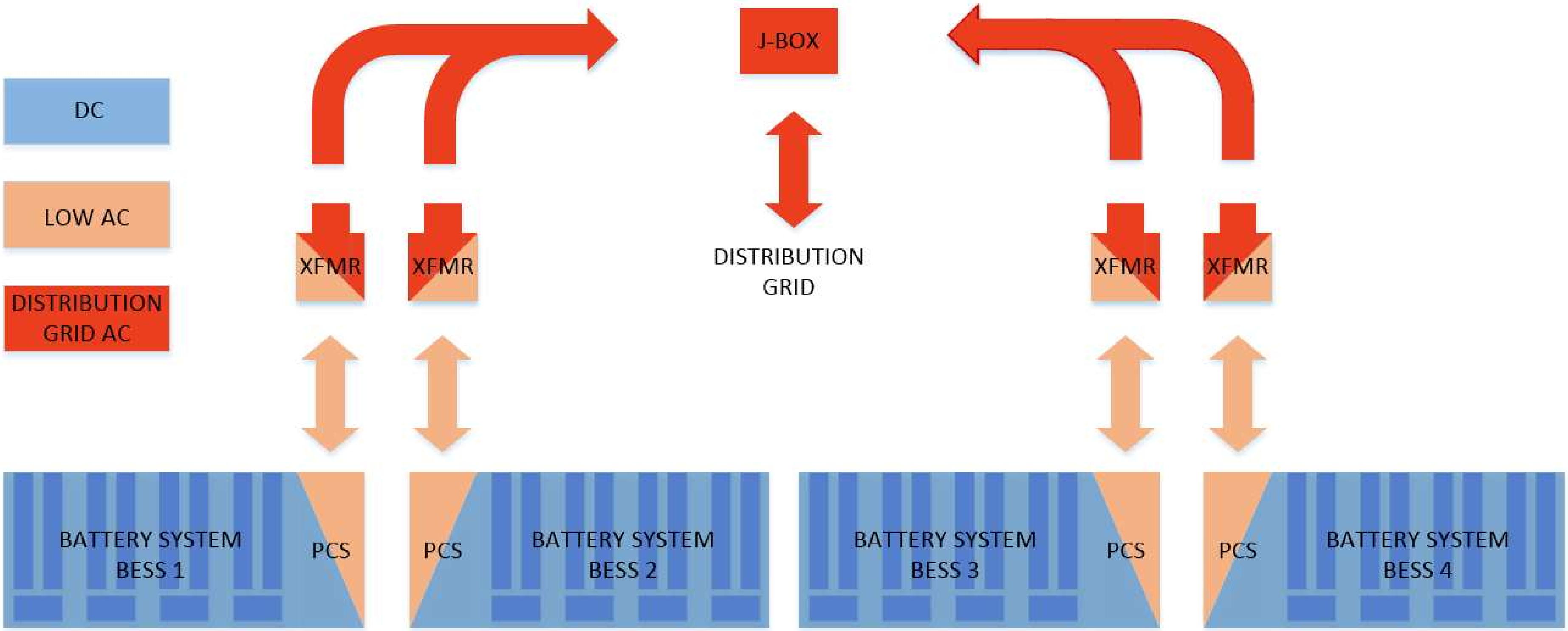
C Rate	Power	Energy
0.25	1.6 MW	6.4 MWh
0.125	1 MW (avg.)	8 MWh

Modular ESS System Design

- Battery System (4)
  - 2MWh Each
  - 8MWh Total
  - 1000 VDC
- PCS (4)
  - 550 kW Each
  - 2.2 MW Total
  - 283 VAC
- Step-Up Xfmr (4)
  - 750 kVA
  - 283 V / 12.47 kV
- J-Box (1)
  - 3ϕ 5 Way j-box
  - 12.47 kV



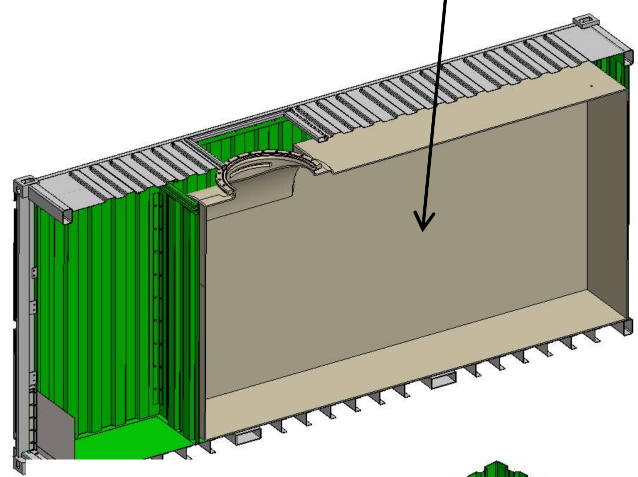
MESA-2 System Power Flow

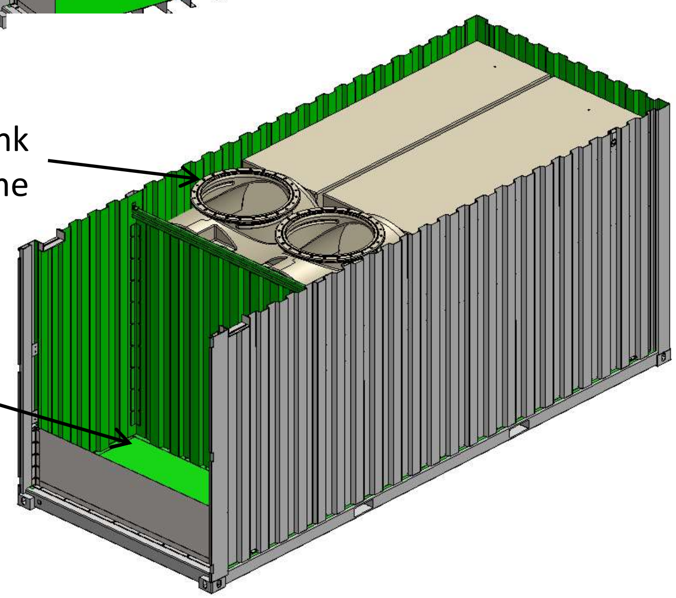


Battery Containers Containment

Liquid Containment:

- 1st level – electrolyte tanks and pipes
- 2nd level – chemical resistant liner
- 3rd level – painted and seal ISO container
- 4th level – concrete basin underneath batteries

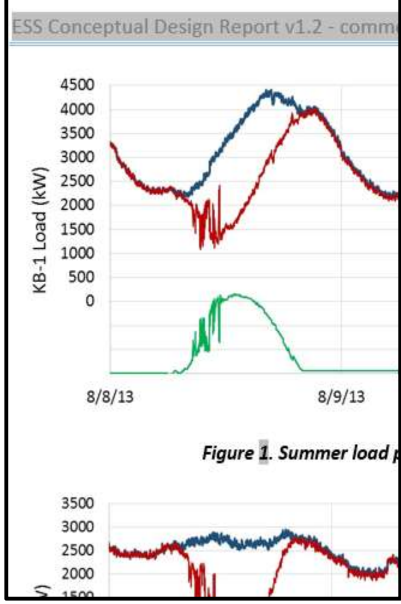




Design & System Integration Components

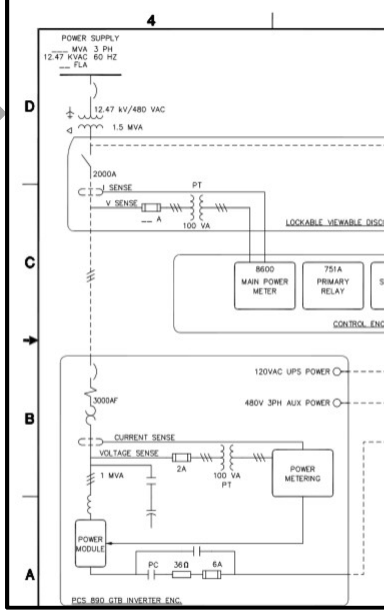
System Design

- Electrical
- Civil
- System Integration



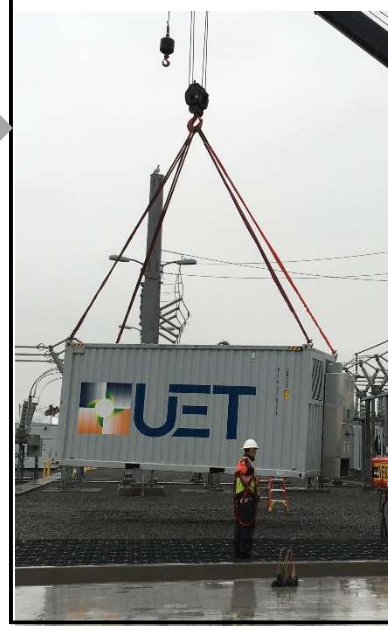
Procurement and FAT

- Batteries
- PCS
- Containers
- Transformer



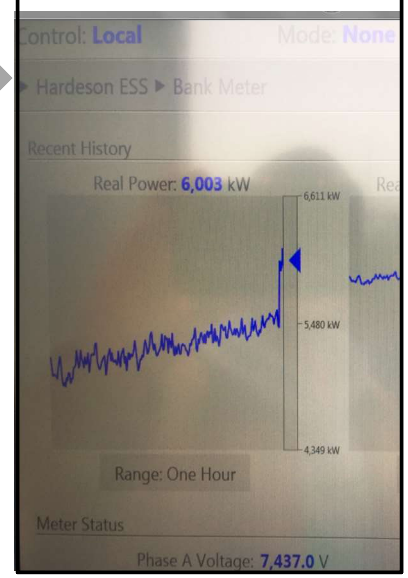
Installation and Commissioning

- Site management
- Installation
- Field Testing

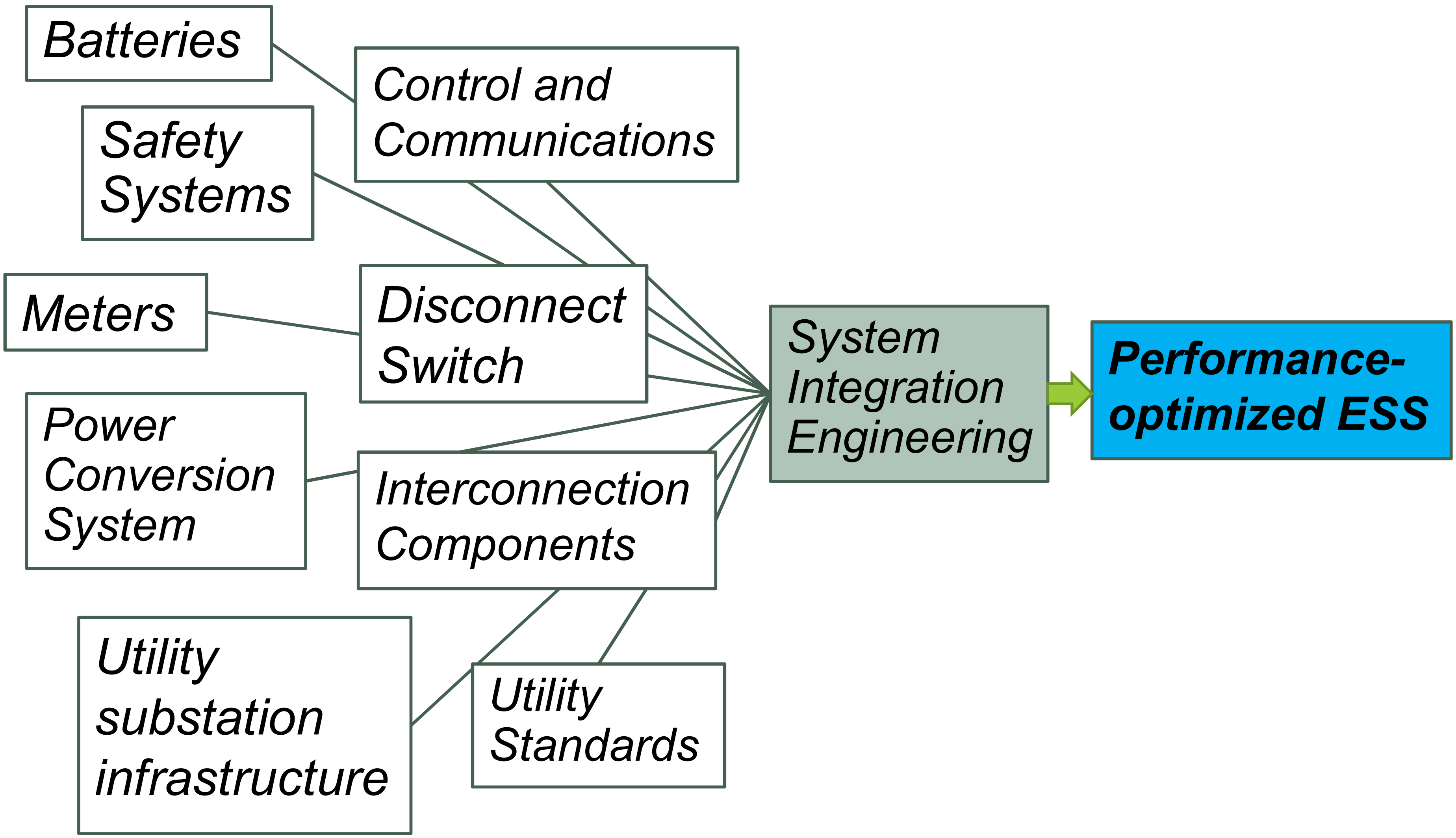


Certification and Performance

- Integration into utility operations
- Configuration for optimal performance



ESS: A Single, Integrated System



SNOHOMISH COUNTY PUD PUBLIC UTILITY DISTRICT NO. 1

Reports, Studies and Analysis

S&C ELECTRIC COMPANY
Excellence Through Innovation

Project: 8804
Document: E-850 Rev. 2
Page 1 of 38

BATTERY ENERGY STORAGE SYSTEM
FOR MESA-2
SNOHOMISH COUNTY PUD

PROTECTIVE DEVICE COORDINATION, AND
ARC-FLASH INCIDENT ENERGY ANALYSIS
FOR 1 ENERGY SYSTEMS

Document No. SN2-ES-08
S&C Project No. 8804
Page 1 of 12

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MESA 2 - BESS ENERGY STORAGE

SNOHOMISH COUNTY, WA
1ENERGY SYSTEMS

CABLE AMPACITY

Project: 8804
Document: E-850 Rev. 2
Page 31 of 38

UNIENERGY TECHNOLOGIES, LLC

Uni.System

Battery Short Circuit Calculation

ALTERNATE DOCUMENT NUMBER: SN2-ES-16

SN2-ER-02 rev0.7 - Hazard Analysis Report.docx

1energy SYSTEMS

Report No. 15179.02

Seismic Analysis-Qualification Report

Qualified to Level High ; 0.5 g ZPA of the RSS

500kW Uni.System
Equipment Designation

550kW, 0.283kV 3-Phase AC Output (Up to 34kV Connection Voltage)
kV or equipment rating

Report Prepared by: John Riley, Quantum Consulting Engineers

SOUND ANALYSIS
for
SNOHOMISH PUD #1
MODULAR ENERGY STORAGE ARCHITECTURE (MESA-2) PROJECT
SN2-ER-06
Everett Substation, Washington

S&C ELECTRIC COMPANY
Excellence Through Innovation

MESA-2 FLOW BATTERY INSTALLATION

SNOHOMISH COUNTY
1ENERGY SERVICES, LLC

GROUNDING STUDY

S&C PROJECT NUMBER: 8804
DOCUMENT NUMBER: E-820
REVISION: B

SANDIA NATIONAL LABORATORIES

Sandia Third Party Witness Test

UniEnergy Technologis 1 MW / 3.2 MWh
UniSystem

Benjamin Lewis Schenkman and Dan Borneo
5/14/2015

SNOHOMISH COUNTY PUD PUBLIC UTILITY DISTRICT NO. 1

HAZARDOUS MATERIALS MANAGEMENT PLAN (HMMP)
&
HAZARDOUS MATERIAL INVENTORY STATEMENT (HMIS)

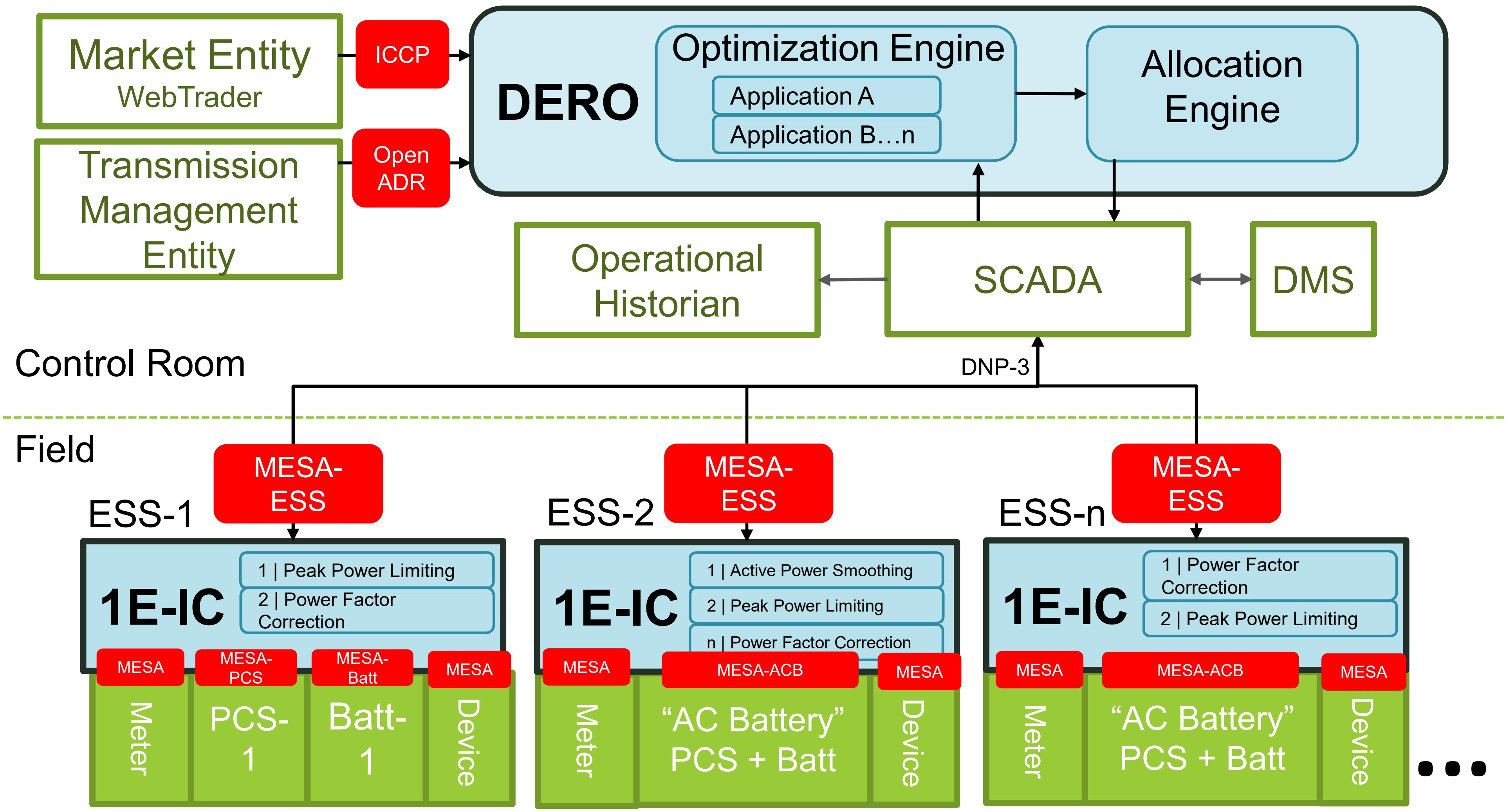
Snohomish County Public Utility District No. 1
Modular Energy Storage Architecture Project 2
Vanadium Redox Flow Battery Installation
Everett Substation
3402 Paine Ave.| Everett, WA

FINAL
6/15/2016

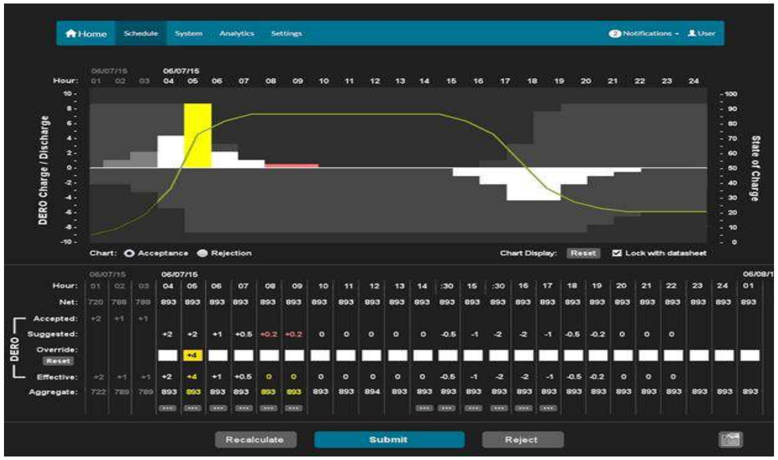
Broad Utility Engagement

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

MESA Enables Optimal Fleet Control Strategy



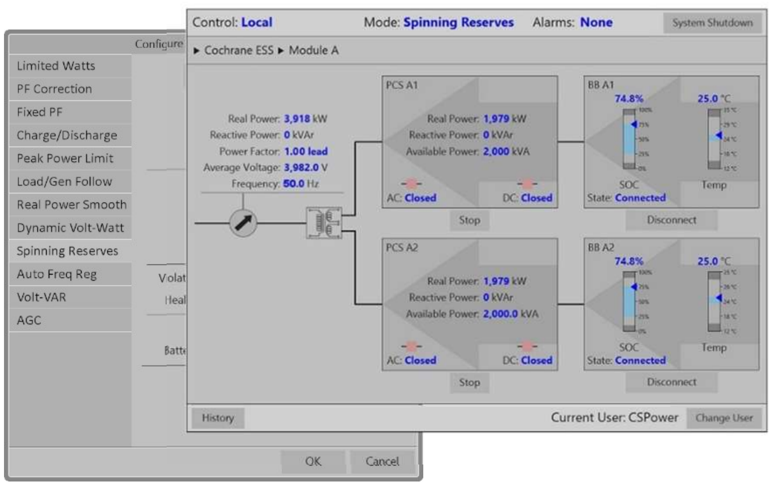
Coordinated, Hierarchical Control Platforms



Bulk system, centralized

Applications

- Market Participation
- Transmission Congestion Relief
- Unfavorable Market Avoidance
- Energy Imbalance Mitigation
- Frequency Response



Local circuit, autonomous

Operating Modes

- Peak Power Limit
- Load/Generation Following
- Power Factor Correction
- Real Power Smoothing
- Volt-VAR

DERO Applications

Energy Arbitrage: *Buy Low, Use, or Sell High*
Looks ahead 1 – 5 days; Calculates once a day

Transmission Constraints: *Avoid Energy Congestion*
Looks ahead 6 hrs – 5 days; Calculates every 6 hours

Best Market: *Avoid Unfavorable Purchases*
Looks ahead 1 – 5 hrs; Calculates at least once an hour

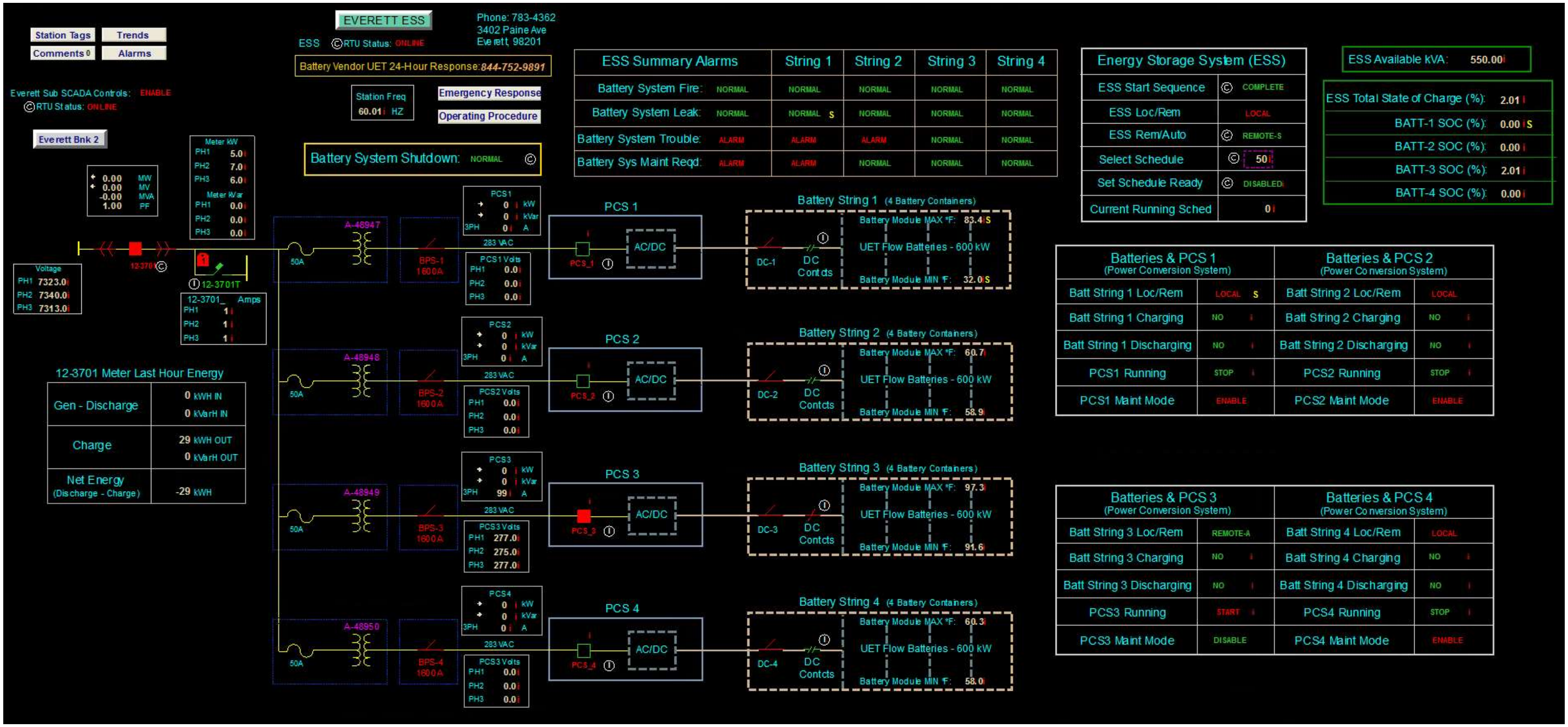
Energy Imbalance Mitigation: *Avoid forecast error penalties*
Looks ahead 20 – 90 mins; Calculates every 5 – 10 minutes.

Now → *Future*

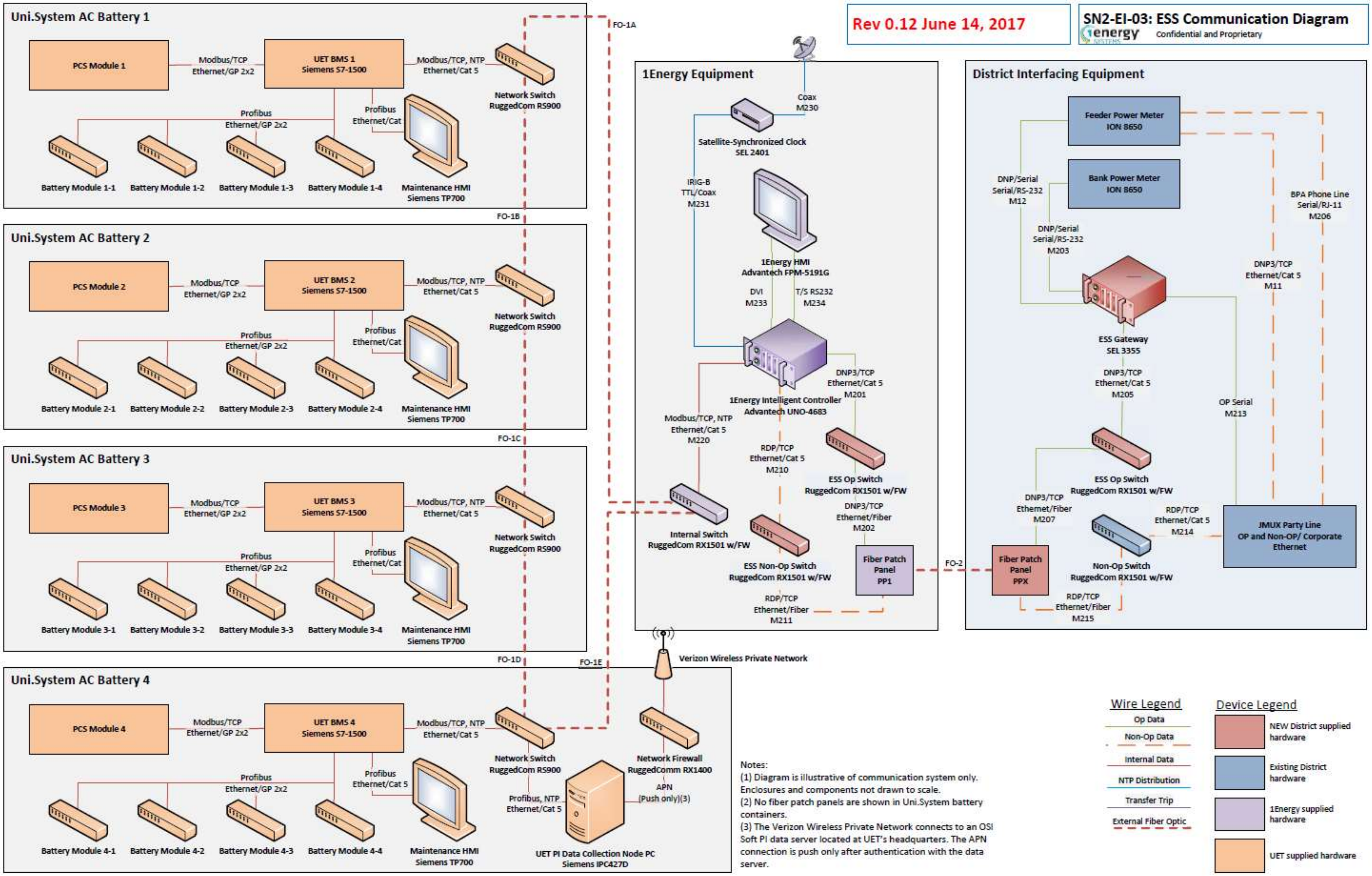
Ability to be Nimble ⟷ Ability to Plan Ahead

Blend to Maximize Value for Your Grid

SCADA Screen



Communication Diagram

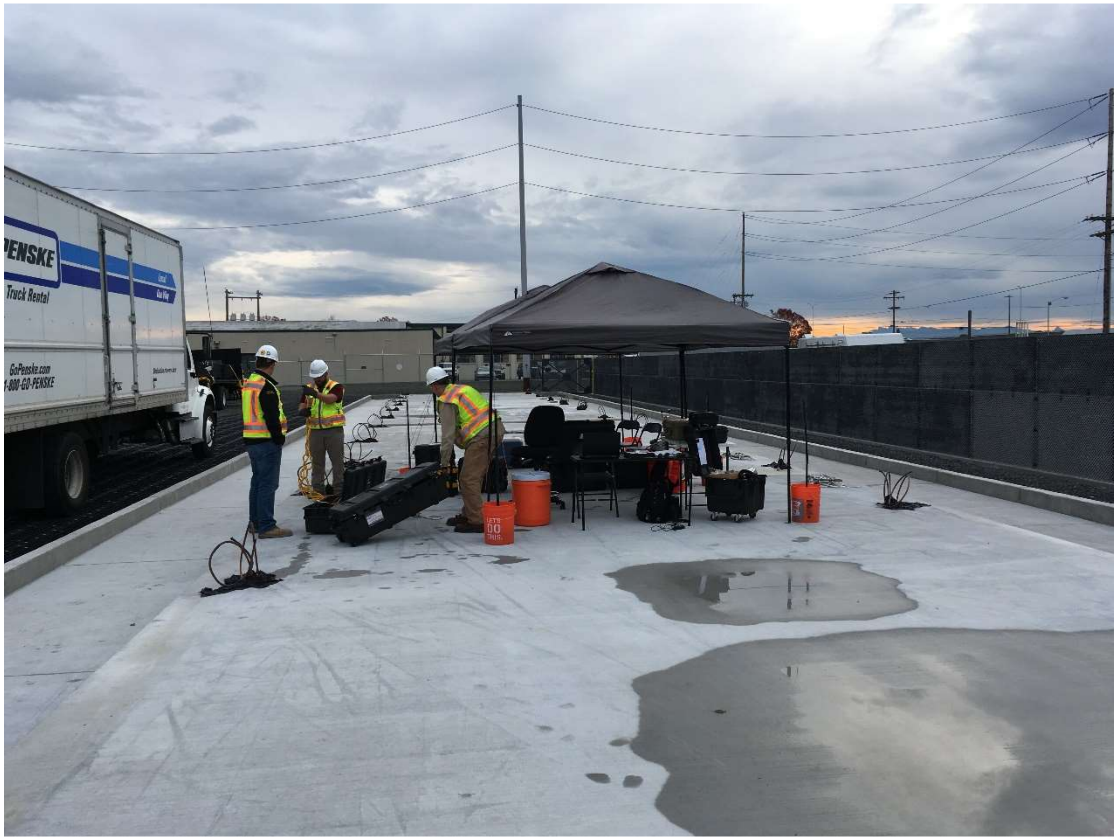


Construction Pictures

GeoTerra Construction Mat
Installation

Construction Pictures

UET's set-up



Construction Pictures

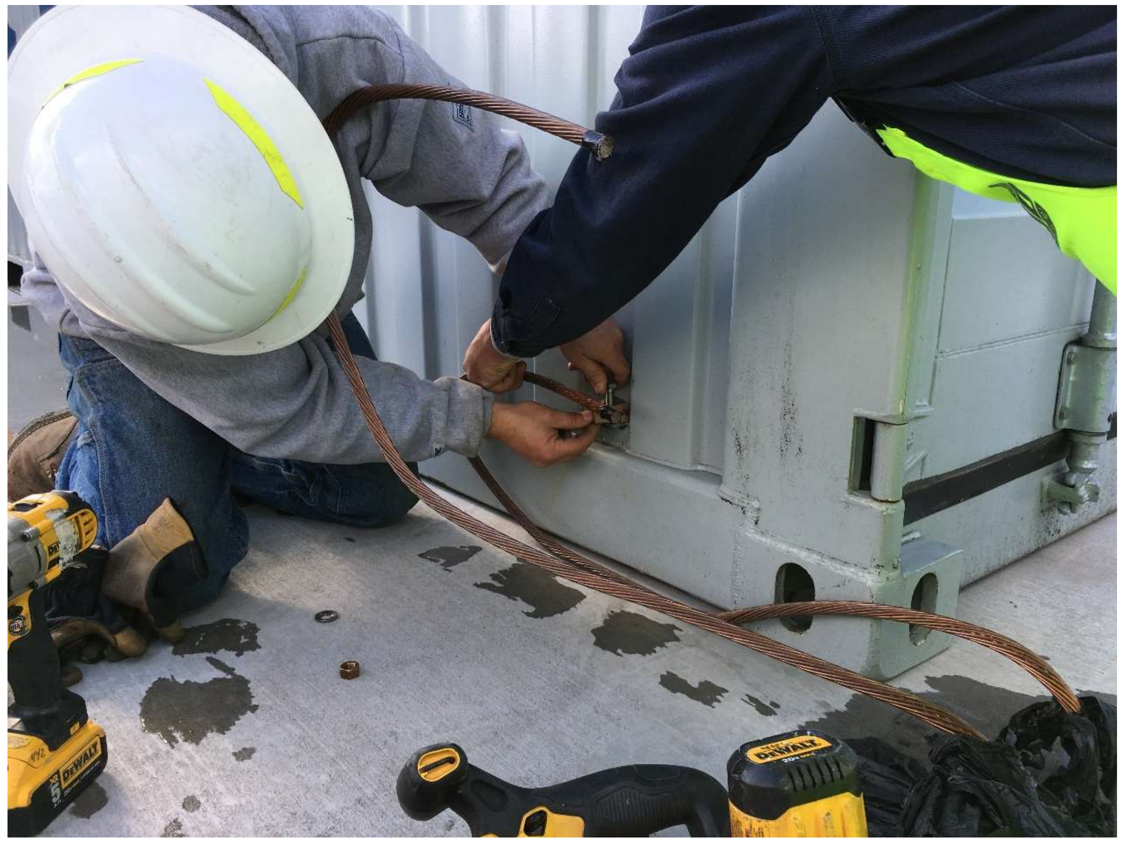
First Containers Arrived

Construction Pictures

PCS Container
Installation

Construction Pictures

Grounding
the Container



Construction Pictures

Battery Container Installation

Construction Pictures

Last
Container

Construction Pictures

Two Strings
North View

Construction Pictures

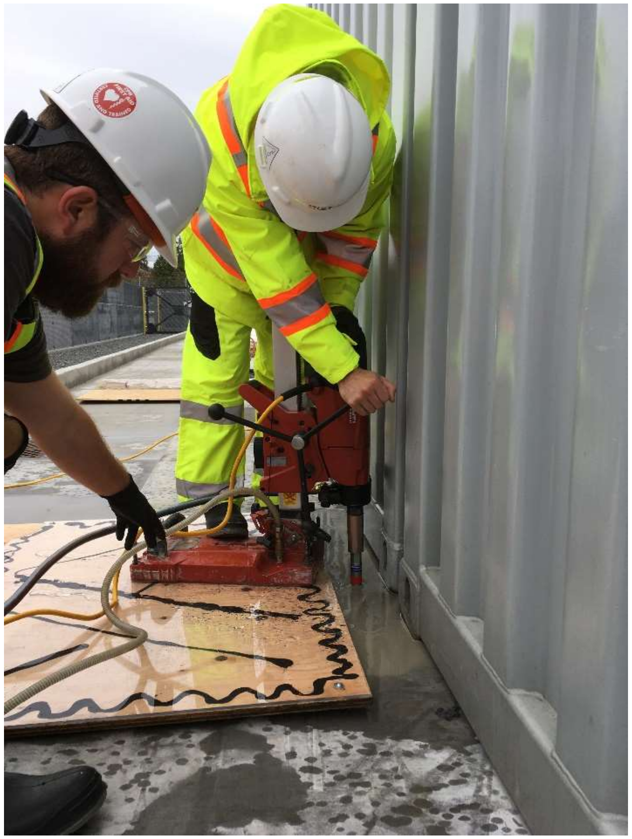
Two Strings
South View

Construction Pictures

Cooling Units
Being Installed

Construction Pictures

Drilling Holes for Anchor Installation

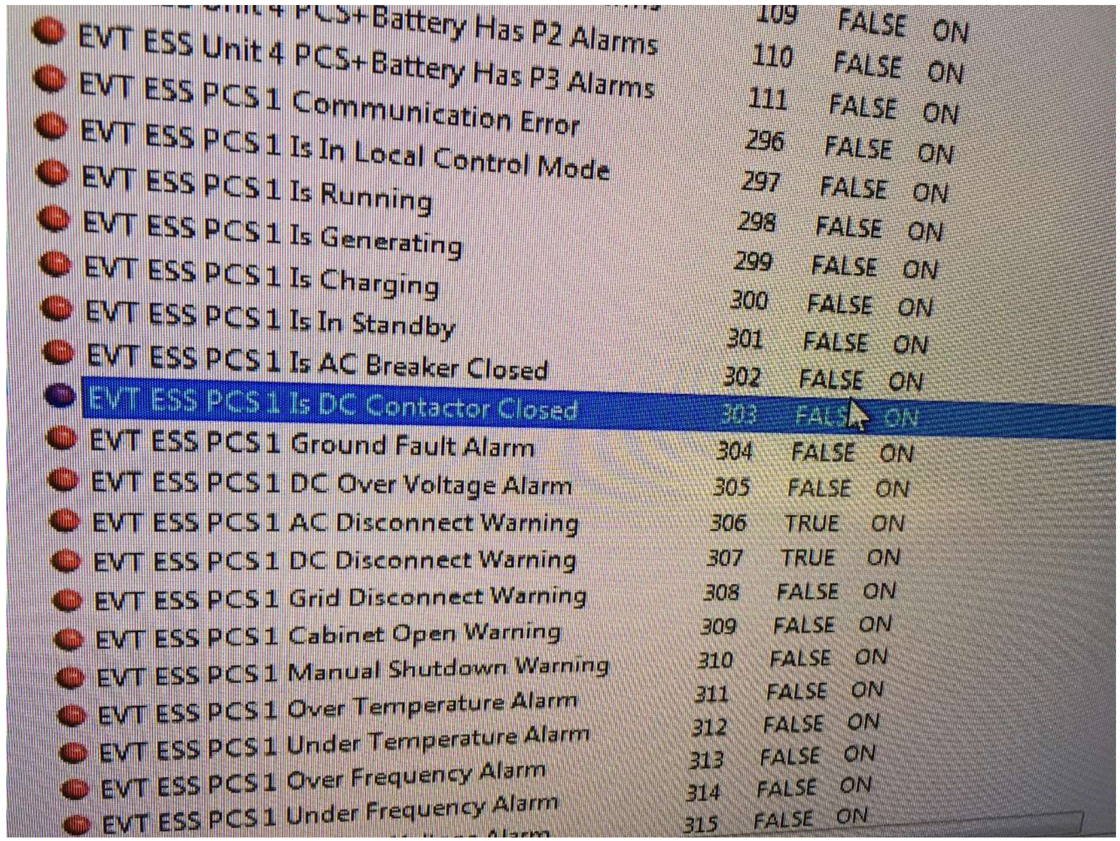


Construction Pictures

(7) Runs of
500 KCMIL Cables
being pulled

Construction Pictures

Fire and Leak Alarms being Tested via SCADA



Construction Pictures

Spill prevention
Berm being
Installed for
Storing
Electrolyte

Construction Pictures

Field Clearances were Issued and LOTO Applied

Construction Pictures

1 String
of Electrolyte
on Site and Ready
to be Filled

Construction Pictures

Getting Ready for Filling

Construction Pictures

Fill Process

Thank you

Arturas Floria afloria@snopud.com

Extra Slides

MESA 2 – Containment Pad

MESA 2 – Non-Conductive Fence

MESA 2 - Transformers