



**MICROGRID
KNOWLEDGE**

CONFERENCE SERIES

Microgrid 2019
CONFERENCE



Long Duration Energy Storage – UCSD Microgrid

May 2019

A Long-Life Energy Asset – an infrastructure investment that has value for 20-30 years

- Minimal O&M
- No Degradation

Workhorse - Energy Storage that has the capacity for multiple value streams, every day

- Capacity = lifetime MWh and cycles
- Short duration ancillary services
- Daily bulk energy shifting: Renewables, Peak Demand, TOU Arbitrage
- Extended backup for critical loads – hours and days

ESS Installations



Stone Edge Farm

60 kWh
Microgrid/Renewables
Operational Q1 2015



DNV-GL

400 kWh Renewable Integration
Operational Q2 2017



NV Energy

400 kWh
Operational Q1 2019
Ships May 2019



US Army Corps

225 kWh Off-grid/Renewables
Operational Q2 2016



CleanSpark – Camp Pendleton

400 kWh DC Microgrid
Operational Q1 2019



Pacto Energy

400 kWh
Operational Q1 2018
Ships Q3 2019



UCSD Microgrid

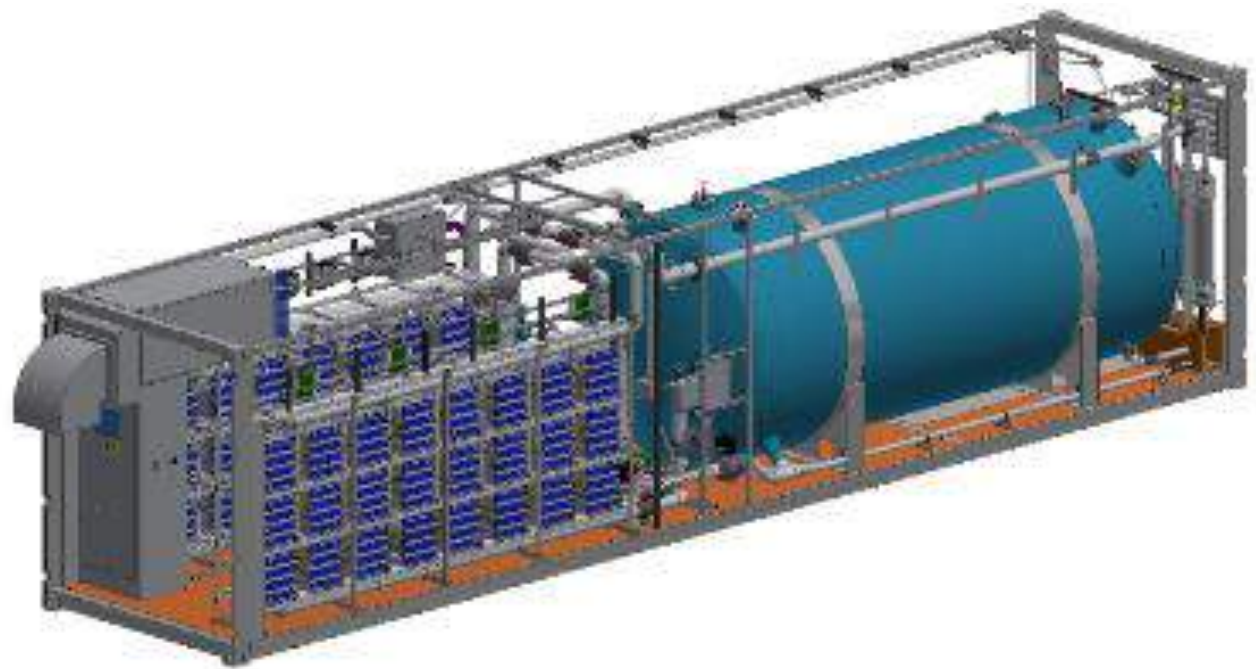
400 kWh Microgrid
Operational Q3 2017



BASF

400 kWh
Operational Q1 2018
Ships June 2019

8 MWh is currently in contracting with 2019 deliveries.
2019 deliveries scheduled for North America, Australia, Germany, South America



Low-Cost Abundant Electrolyte Materials



Iron

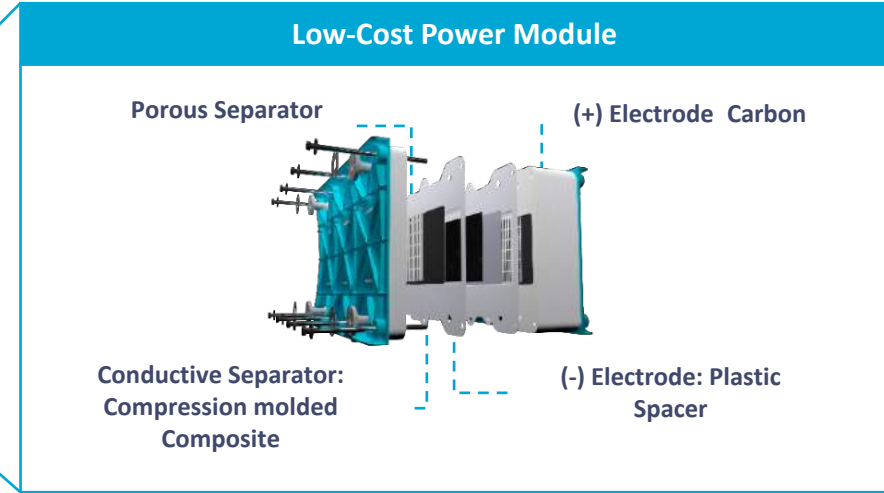
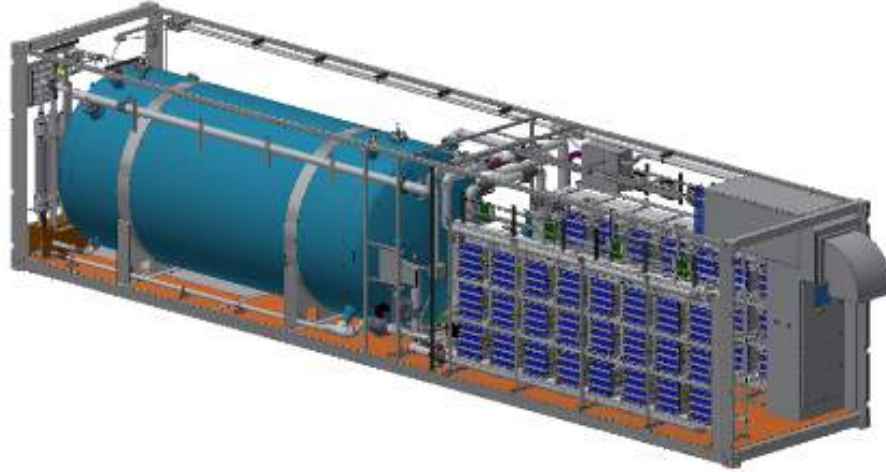


Salt

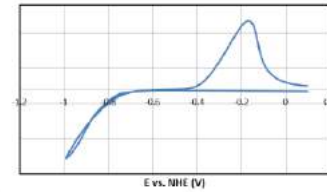


Features

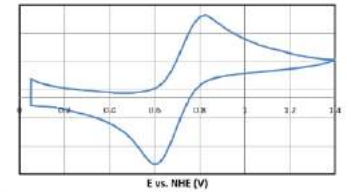
- pH similar to soda and wine, no toxic materials
- Inherently safe, no fire or explosion risk
- Food-grade iron
- Environmentally friendly, 100% recyclable
- Benign chemistry enables standard, off-the-shelf BOP components for system; no specialty plumbing, pumps or equipment.



- The Standard for Long Duration**
- Capable of 20,000 cycles and 20+ years with no degradation
 - Voltage range eliminates carbon electrode corrosion
 - No exotic materials or catalysts required



(-) Reaction
 $Fe^{2+} + 2e^- \leftrightarrow Fe^0$
 $E^0 = -0.44V$

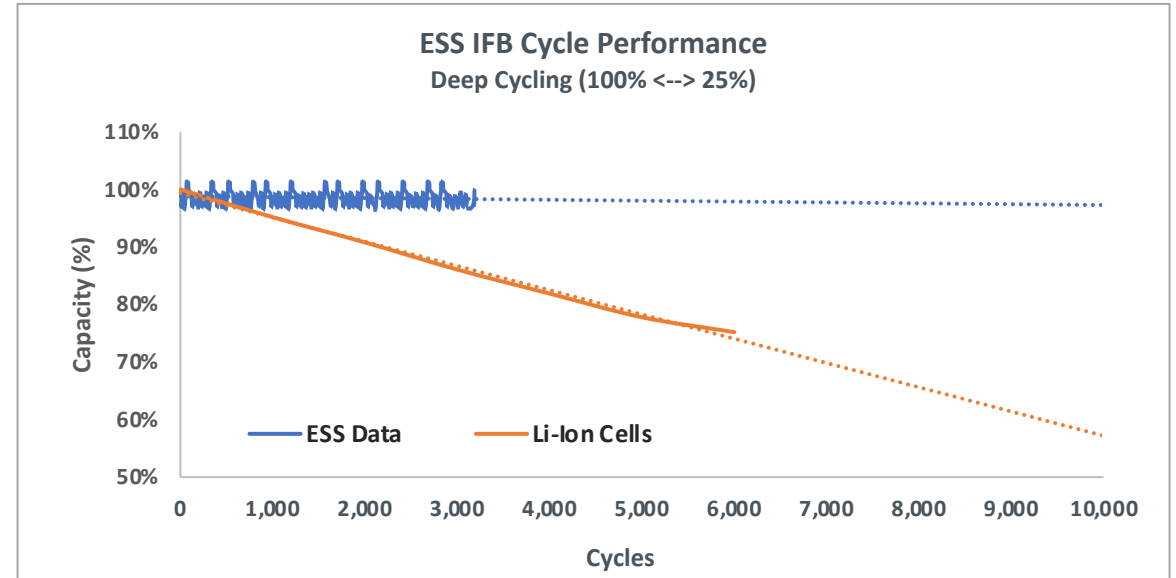
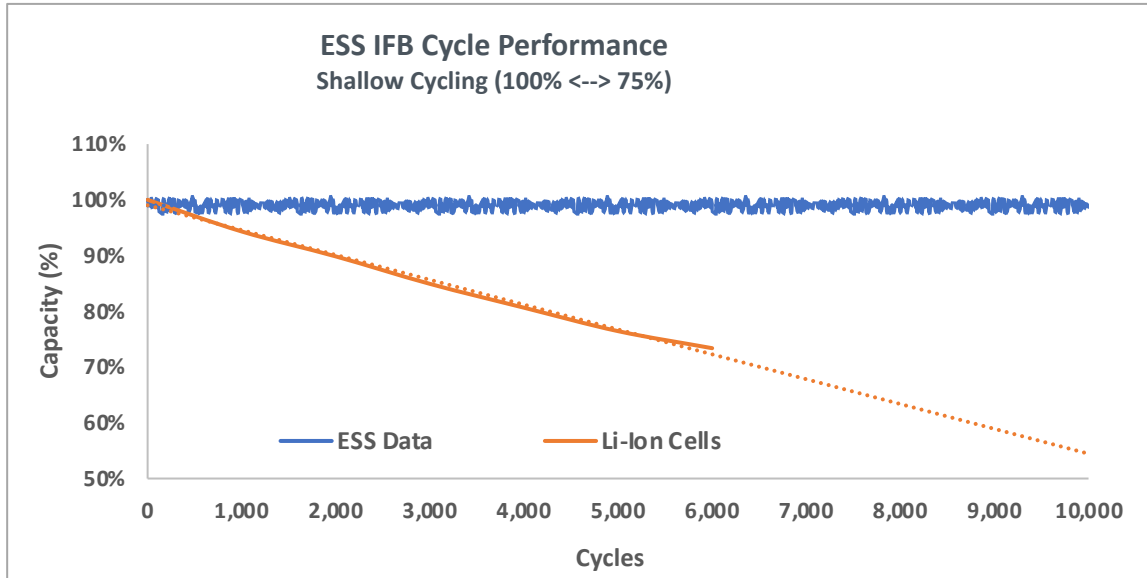


(+) Reaction
 $Fe^{2+} - e^- \leftrightarrow Fe^{3+}$
 $E^0 = 0.77V$

Separator

Iron Flow Battery – Cycling Capability

40+ years simulated operation of electrolyte and power module



Multi-cycle test results conducted under ARPA-E program

Workhorse Battery: No degradation in performance regardless of duty cycle

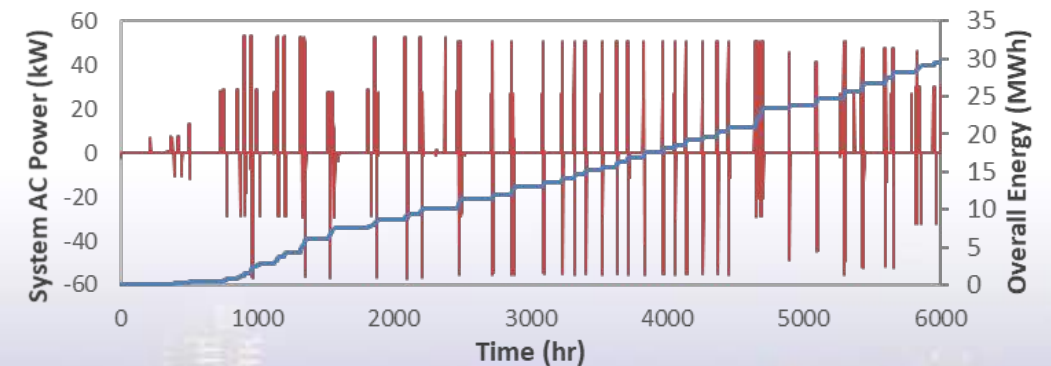
Long Duration Energy Storage Testing

UCSD Microgrid

400 kWh, Microgrid-connected
Operational Q3 2017

Testing Multiple Use Cases under DOE Program:

- Bulk shifting of PV
- Demand Charge Management
- TOU Arbitrage
- Utility Demand Response
- Frequency Regulation



- **Minimal permitting requirements**
 - No fire risk or explosion risks
 - No hazmat risks
 - No chemical safety risks
- **Can be quickly deployed and commissioned**
 - Minimal siting requirements
 - No HVAC required (or redundant systems)
 - No fire suppression
 - Engineered for seismic zones
- **No hidden liabilities or cost**
 - No specialized training or licensing
 - No specialized incident response requirements
 - No annual compliance requirements



Current Macro Market Characteristics:

- The energy storage space is **dominated by short duration, lithium-Ion batteries.**
- Grid Operators, Utilities, industrial & Commercial customers know how to **evaluate the characteristics** of these batteries.
- **Longer Duration Storage** is quickly becoming a Requirement
- **Longer duration “Flow Batteries” have characteristics that are not normally evaluated and their benefits are often overlooked.**

Microgrid Parameters for Technology Agnostic Decisions:

- Unlimited cycling (compared with single cycle/day lithium-ion)
- Zero Capacity Fade regardless of the number of cycles/day or lifetime;
- Extended operating temperatures (25-125 degrees F)
- Zero Capacity Fade during “idle conditions”
- Lowest Levelized Cost of Service (LCOS) with multiple cycles/day
- Ability to provide 4, 6, 8, or 10 hours storage duration on a single cycle
- No Hazardous Chemicals; No Hazardous Chemical Plan or Disposal Plan required; No shipping restrictions
- No Fire Risk (battery is a “fire extinguisher”); Substantially Reduced Risks of Operating in Substations or in fire hazard areas.
- Virtually No Permitting Risks
- No precious metals or hard to source materials and no associated price or supply disruption risk
- End-of-life disposal, recycling

Design and Installation:

- The use cases need to be well defined, leave room for future flexibility
- Size for lifetime capacity or power, warranty
- EH&S needs to be involved early
- Transportation, installation, commissioning according to mfr. Recommendations

Operation:

- Control system interface: Proven ahead of installation. Sunspec protocol over MODBUS communications.
- Microgrid equipment compatibility: inverters, voltage spikes, grid faults and noise
- 24/7 monitoring of energy storage assets key to availability



UCSD Microgrid Tour Thursday, May 16



Thank you.

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