



UET

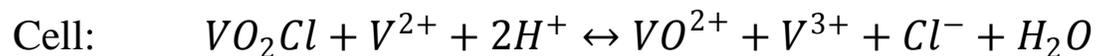
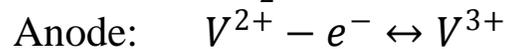
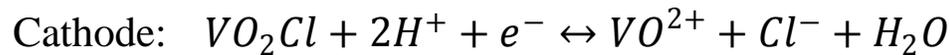
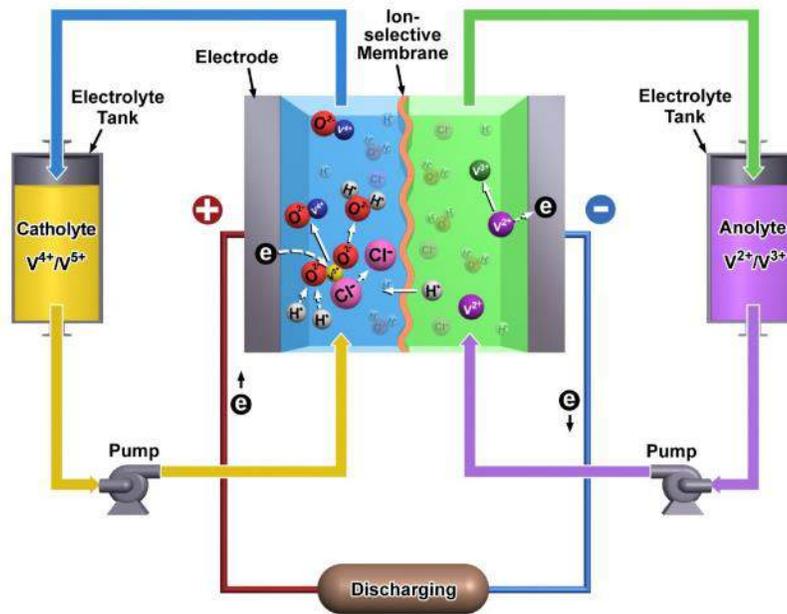
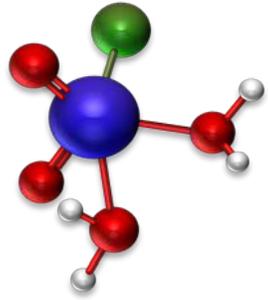
UniEnergy
Technologies

Developing MW-scale Chloride-containing All Vanadium Redox Flow Battery System

September 23, 2015 @ EESAT 2015 Portland OR

Liyu Li,
CTO & Co-founder

UET Next Gen Vanadium RFB Chemistry



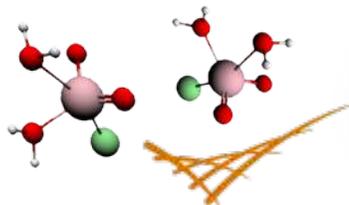
Developed at PNNL and licensed world-wide, encompassing:

- ❑ \$30M program over 6 years of RD&D, optimization and stack/system validation
- ❑ Won the US Government's highest Award of Excellence in Technology Transfer to UET
- ❑ Extraordinary electrolyte stability, stable from $-40^{\circ}C$ to $+50^{\circ}C$
- ❑ 2X energy density improvement
→ 5X product footprint reduction
- ❑ Improved reliability and performance and deployment flexibility through containerization and power electronics

Partnership: UET's Sister Companies

NEW ELECTROLYTE

- ✓ 2X energy density
- ✓ -40°C to +50°C
- ✓ Improved reliability



Pacific Northwest
NATIONAL LABORATORY



DOE

PRODUCT ENGINEERING AND INTEGRATION

R&D, marketing, and product service



FIELD EXPERIENCE

- ✓ 5MW/10MWh wind firming installation
- ✓ Numerous MW-class microgrid sites



 **RONGKE POWER**



BNM
BOLONG NEW MATERIALS

ELECTROLYTE PRODUCTION

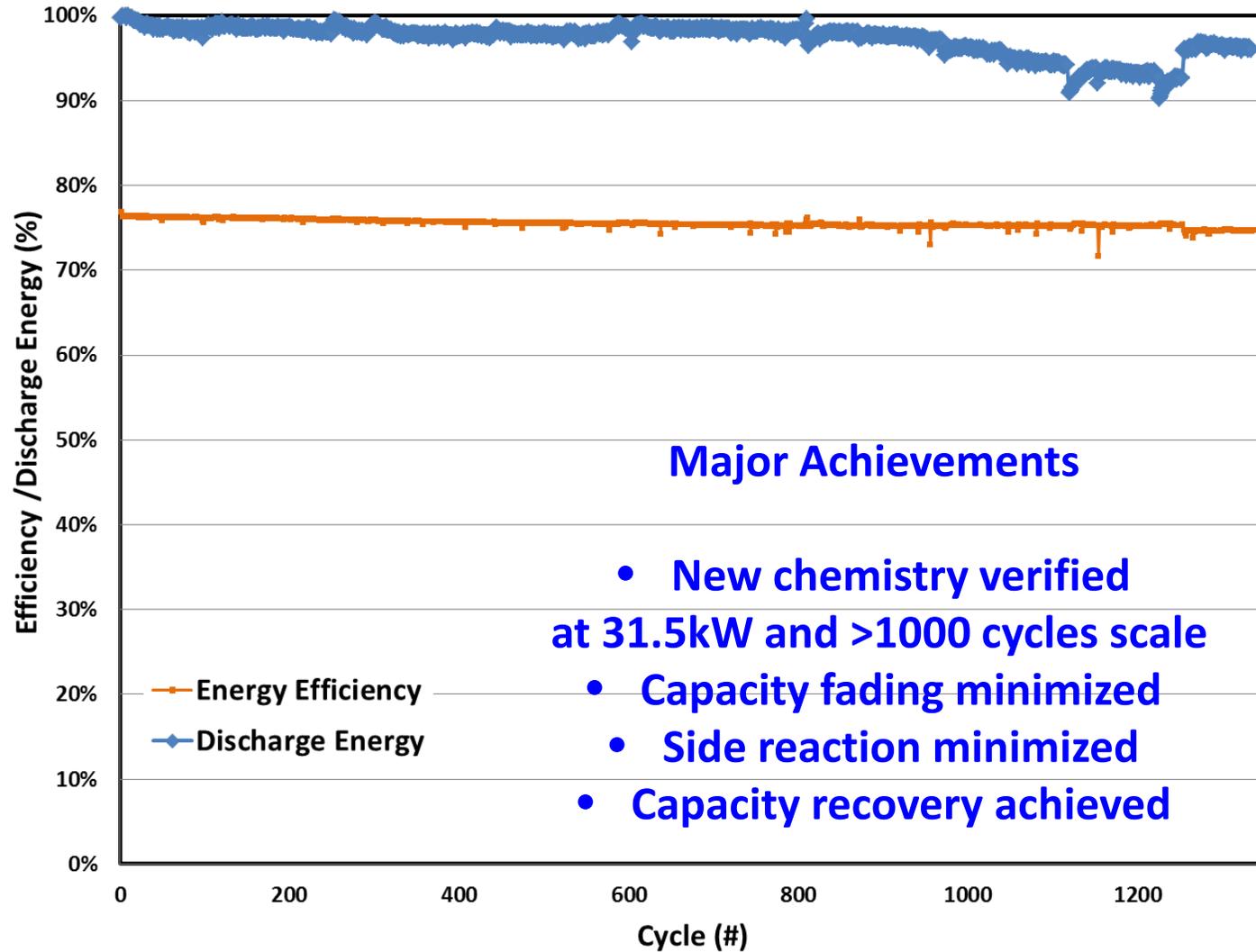
- ✓ 1,324,000 ft² production facilities
- ✓ Electrolyte production capacity > 1.5GWh/year
- ✓ ISO9001:2008 Certified

STACK PRODUCTION

- ✓ 108,000 ft² manufacturing facility
- ✓ 100MW production capacity
- ✓ ISO9000/14000, GB/T28001 Certified



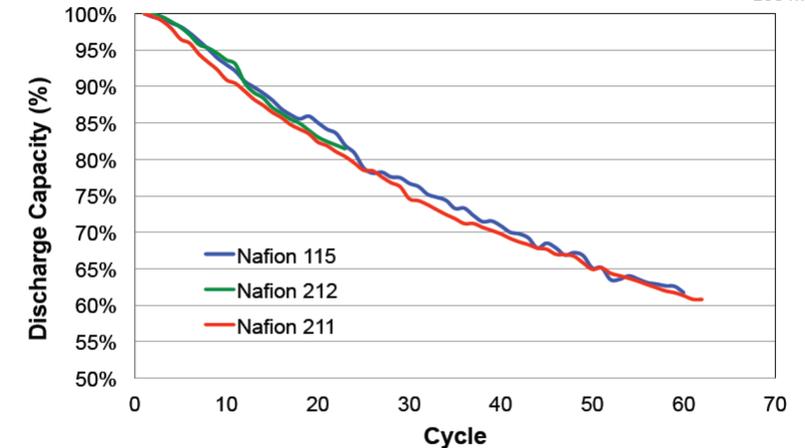
2012: Stable single full size stack performance with advanced electrolyte



Capacity fade of 3-cell stack with Nafion® 115, 212, and 211 membrane

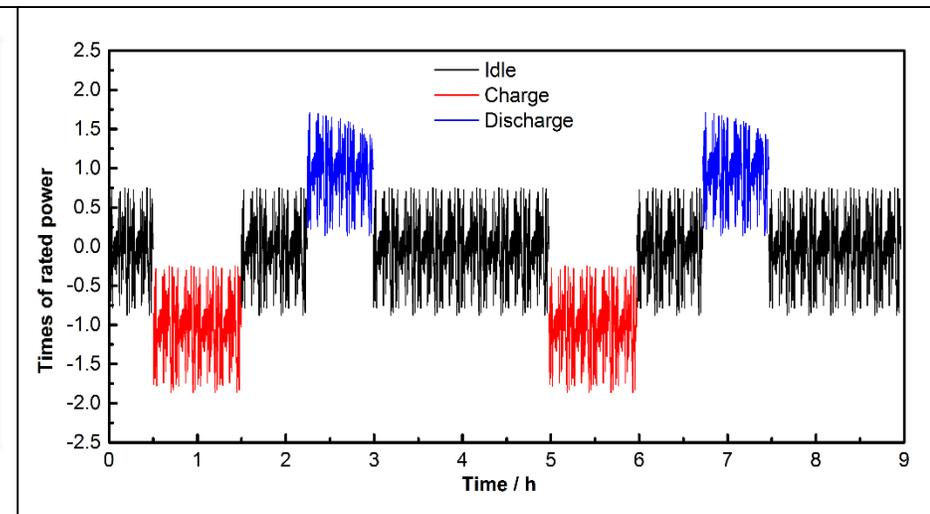
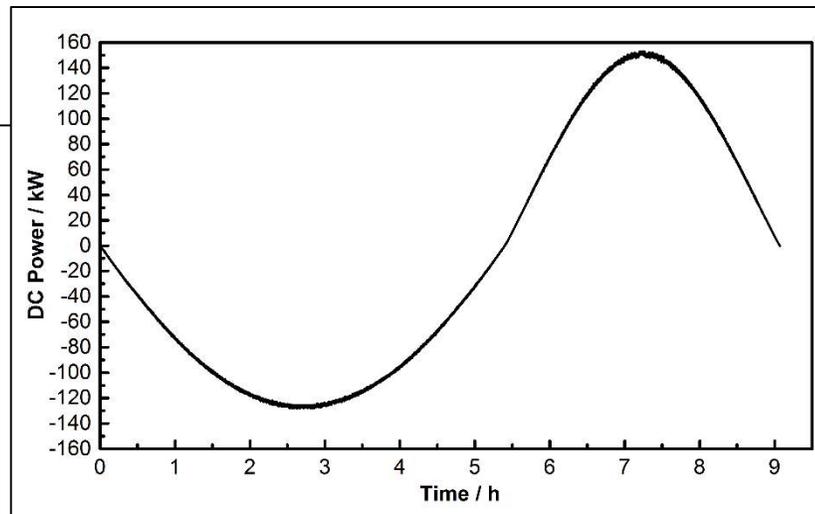
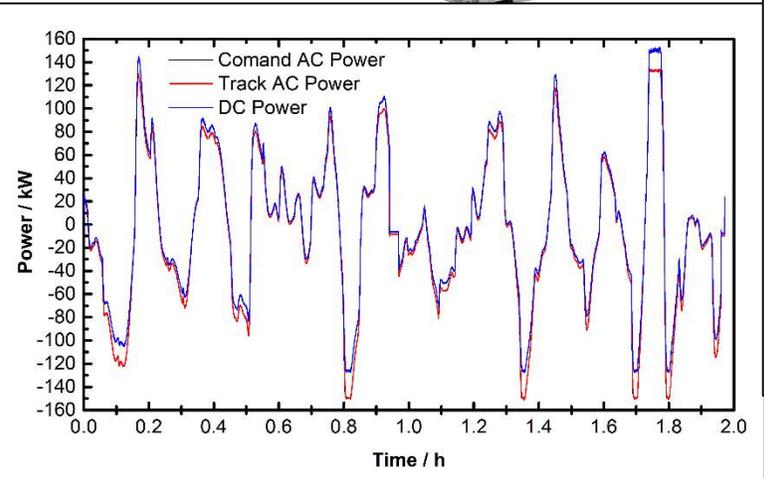
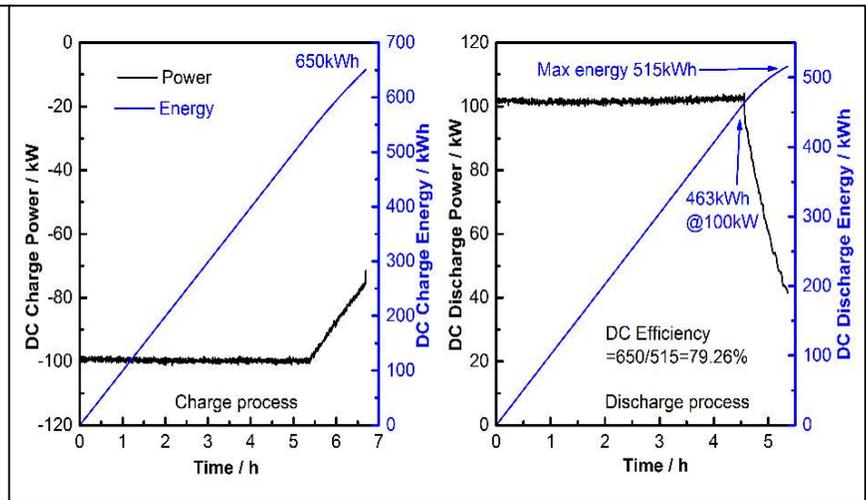
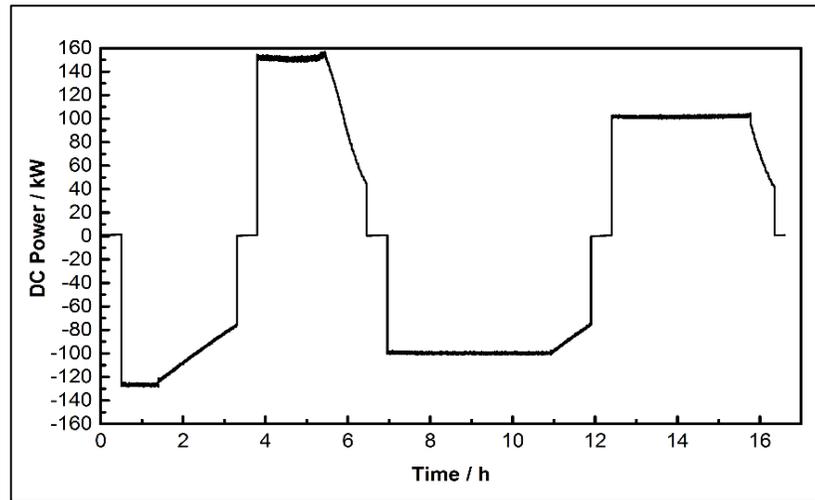
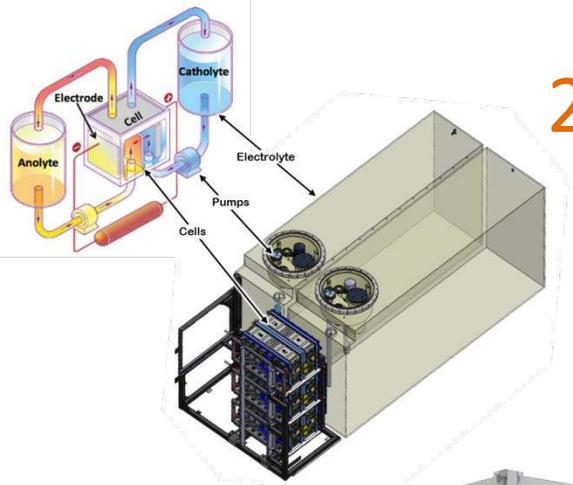
- 3 cell stack
- 780 cm² active area/cell
- 10-90% SOC
- 160 mA/cm²

Capacity Fade



➤ No significant difference capacity fade as a function of thickness

2013: 100kW/400kWh Uni.System™ DC Battery



2014: 400 kW/1.6 MWh Uni.System™ AC Battery



- ❑ Factory integration
precision assembly & QC
- ❑ Excellent safety
non-flammable, aqueous electrolytes; built-in secondary containment; no thermal runaway
- ❑ Temperature agnostic
-40 °C to +50 °C
- ❑ SOC agnostic
full capacity access
- ❑ Plug & Play
rapid, low cost deployment
- ❑ Excellent Availability
- ❑ 20-year design life
unlimited cycles
- ❑ 100% recyclable
disposal contract included

- ❑ Peak Power: 600 kW_{AC}
- ❑ Max Energy: 2.2 MWh_{AC}
- ❑ AC Round Trip Efficiency: 65-70%
- ❑ Self-Discharge Rate: <2%
- ❑ DC Voltage Range: 500 V – 1,000 V
- ❑ AC Voltage Output: Medium Voltage 12.47 kV
- ❑ System Response Time: <100 ms
- ❑ System Footprint: 76 m² (820 ft²)

Uni.System™ Validation Project: 3rd Party Validation

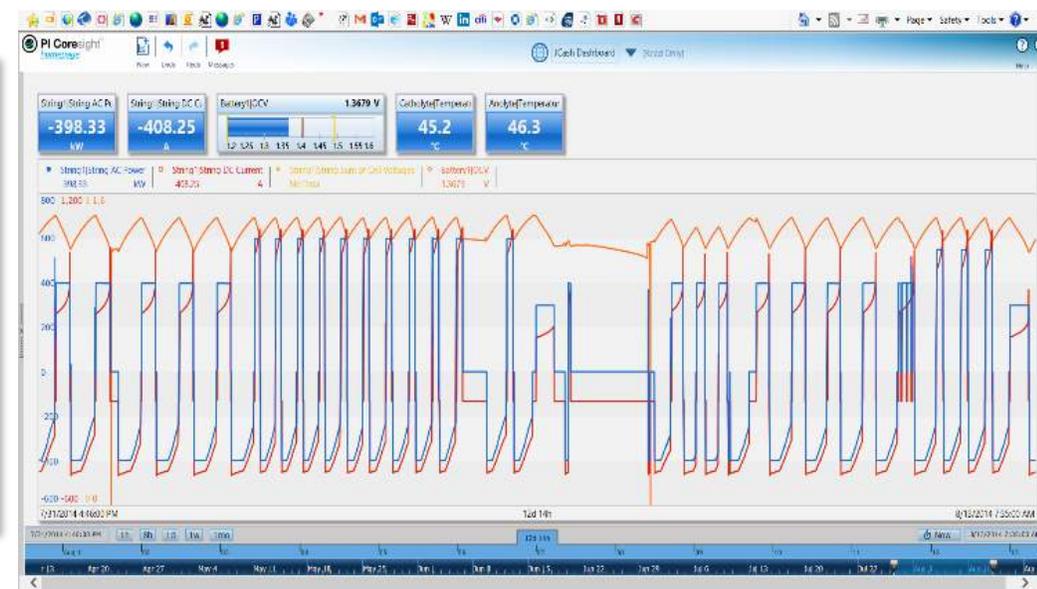
- ❑ 400kW/4hr
- ❑ Uni.System™ design
- ❑ Adjacent to UET Facility
- ❑ >200 MWhr dispatched
- ❑ 3rd Party Testing
 - » Independent consultant
 - » DOE Sandia National Labs



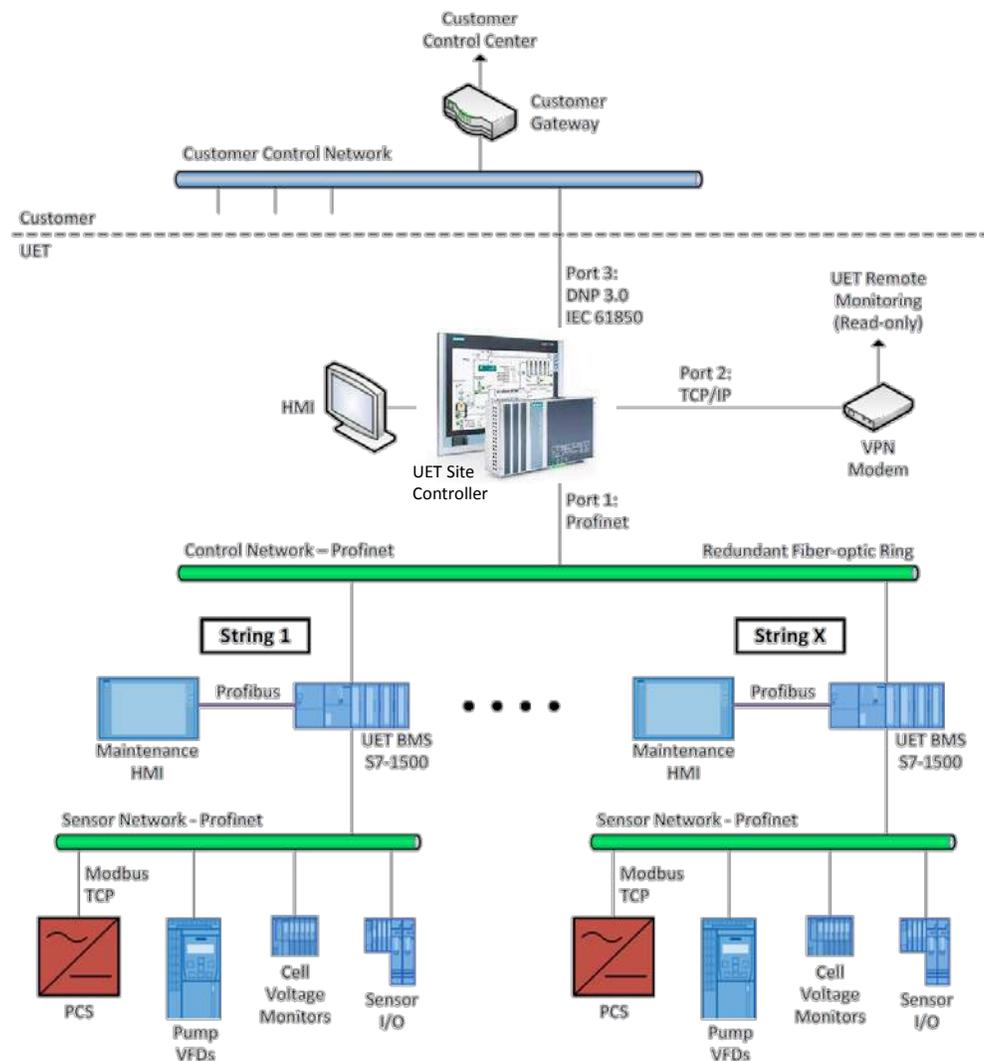
**An Assessment of the Uni.System™
Current State of Development and Testing**

COMMISSIONED BY
LiEnergy Technologies
Mukilteo, Washington

PREPARED BY
Garth P. Corey, Consultant
Energy Storage Systems Engineer
Albuquerque, NM



Robust Control System Architecture

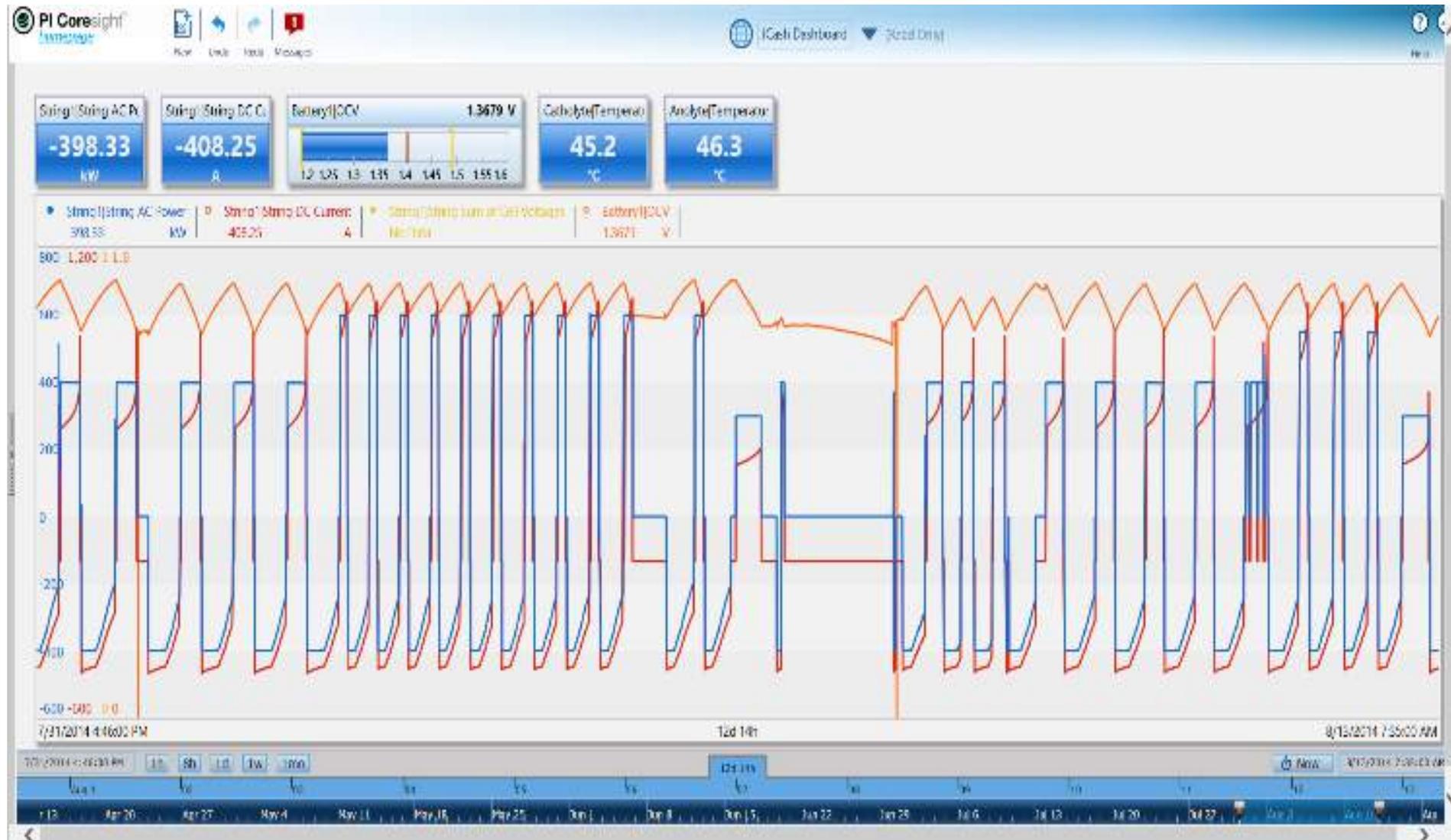


SIEMENS

Siemens Components

- ❑ Each string is controlled by a single Siemens PLC
- ❑ String consists of four batteries, the PCS, cooling system, communications
- ❑ The PLC is master of the PCS
- ❑ The site controller controls up to 100 strings using Siemens' new WinCC OA on an industrial PC

Data collection and Analysis with OSI Pi Coresight™



2015: 1MW-AVISTA Project in Pullman, WA



- 800kW/4h; 1MW_p; 4MWh_p Uni.System™
- T&D substation, Schweitzer Engineering Labs
- Deploy December 2014
- Use cases:
 - » Grid-tied and islanding operation
 - » Avista smart grid enhancement
 - Energy shifting
 - Grid reliability
 - Improved distribution system efficiency
 - Enhanced voltage control
 - Optimized utilization of energy storage
- Project partners
 - » AVISTA
 - » UET
 - » WA State Dept. of Commerce
 - » PNNL

Sales, Field & Software Services

Uni.System™ Sales including Financial Services



Distribution



Microgrids



Commercial



Renewables



Transmission



Military

Field Services



Transport



Site Prep



Install

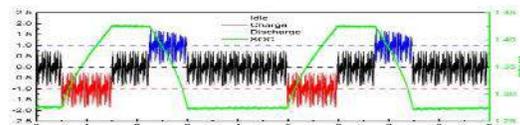


Monitor

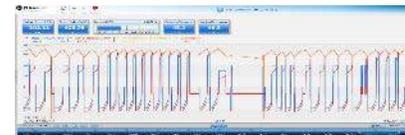


Maintain

Software Services with Annual Subscription



Economic Intelligence Engine



Dispatch Performance Optimization



Enhanced Functionality

2014

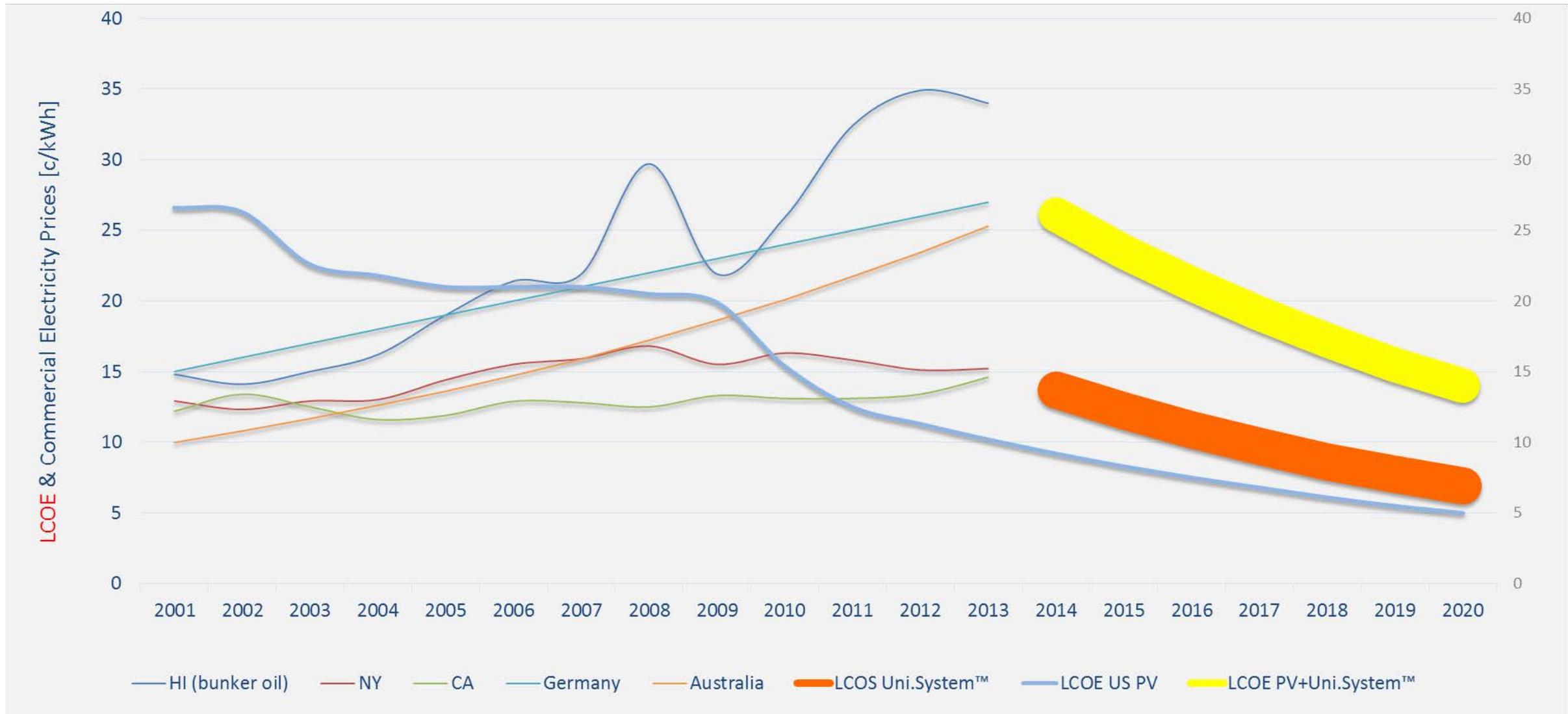
2015

2016

2017

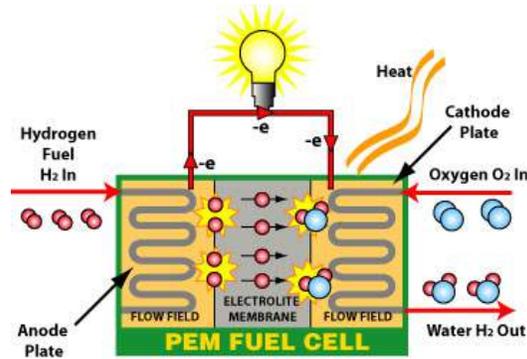
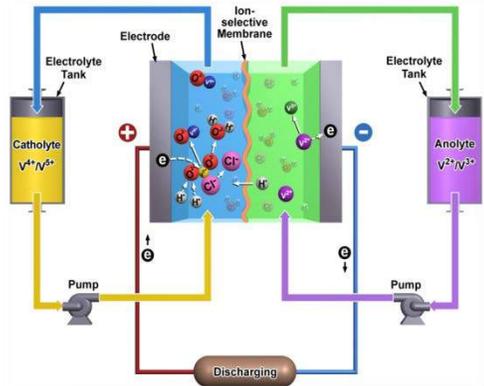
2018

We are at a turning point where a renewable electricity solution is *already* cheaper than the grid in many sectors



UET's Uni.System Cost Reduction Approaches

Innovation



Flow battery has similar working mechanism and structure to fuel cells. However, its current power density is 10 times lower (100 mW/cm^2 vs $>1000 \text{ mW/cm}^2$).

13 s seeing dramatic improvements in this area.

Partnership

Redox Cost Model

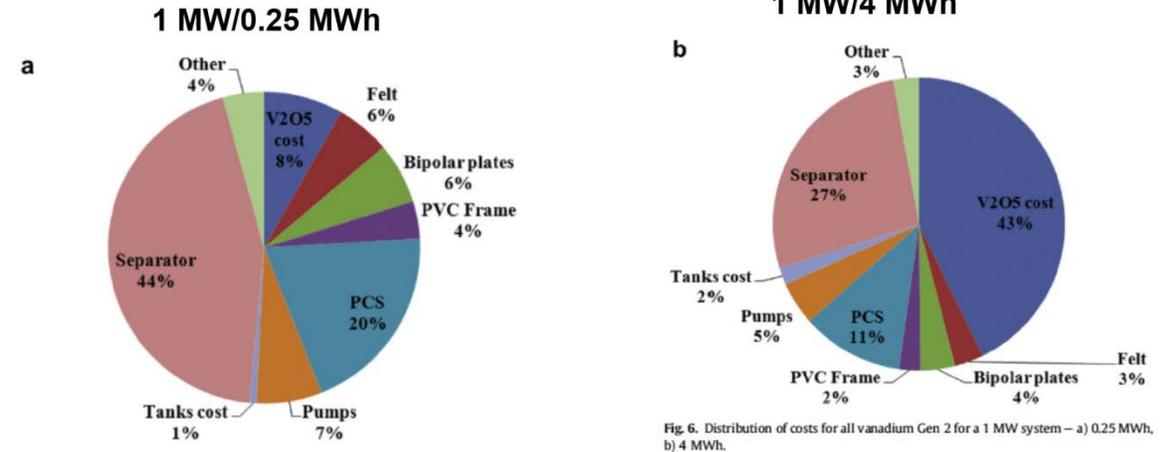


Fig. 6. Distribution of costs for all vanadium Gen 2 for a 1 MW system – a) 0.25 MWh, b) 4 MWh.

Viswanathan VV (PNNL), et al. Journal of Power Sources 247:1040-1051.

- Electrolyte has unlimited life, is not consumed during operation, and can be readily reused. It is also the largest cost of >4 hr battery systems.
- We can therefore separate power and energy costs in the business model.
- Partnership with financial institutes, vanadium suppliers, green bond issuers, et al. to enable electrolyte leasing business model to largely reduce system capital cost.

2015 Uni.System™ Performance

2015 Uni. System. AC™	
Peak Power	600 kW _{AC} over 2 hours
Nominal Rating	500 kW _{AC} over 4 hours
Maximum Energy	2.2 MWh _{AC} over 8 hours
Peak Shaving Efficiency	70% _{AC}
Frequency Regulation Efficiency	75% _{AC}
Voltage Tolerance	400V _{AC} -10% to 480V _{AC} +10%
Frequency Tolerance	45 Hz to 65 Hz
Response Time	<100 ms
Footprint	820 ft ²
Envelop	41'W x 20'D x 9.5'H
Total Weight	170,000 kg
Cycle and Design Life	Unlimited cycles over 20 year life
Ambient Temperature	-40°C to 50°C (-40°F to 122°F)
Self Discharge	Capped at <2%