THE ONLY MEGAWATT-SCALE

CONTAINERIZED FLOW BATTERY

TOPICS

1. THE UET DIFFERENCE
2. UET DEPLOYMENTS (including Avista and SnoPUD)
3. UET COMPANY SUMMARY
4. APPENDIX

THE UET DIFFERENCE:
Only Megawatt-Scale, Containerized Flow Battery

1MW/4MWh

Harbour Pointe Distribution Circuit

Mukilteo, WA (near Seattle)

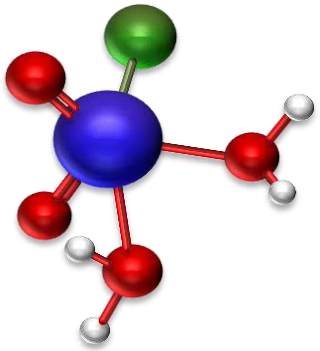
UET's advanced vanadium flow batteries

operating at MW-scale since April 2014 on SnoPUD's grid

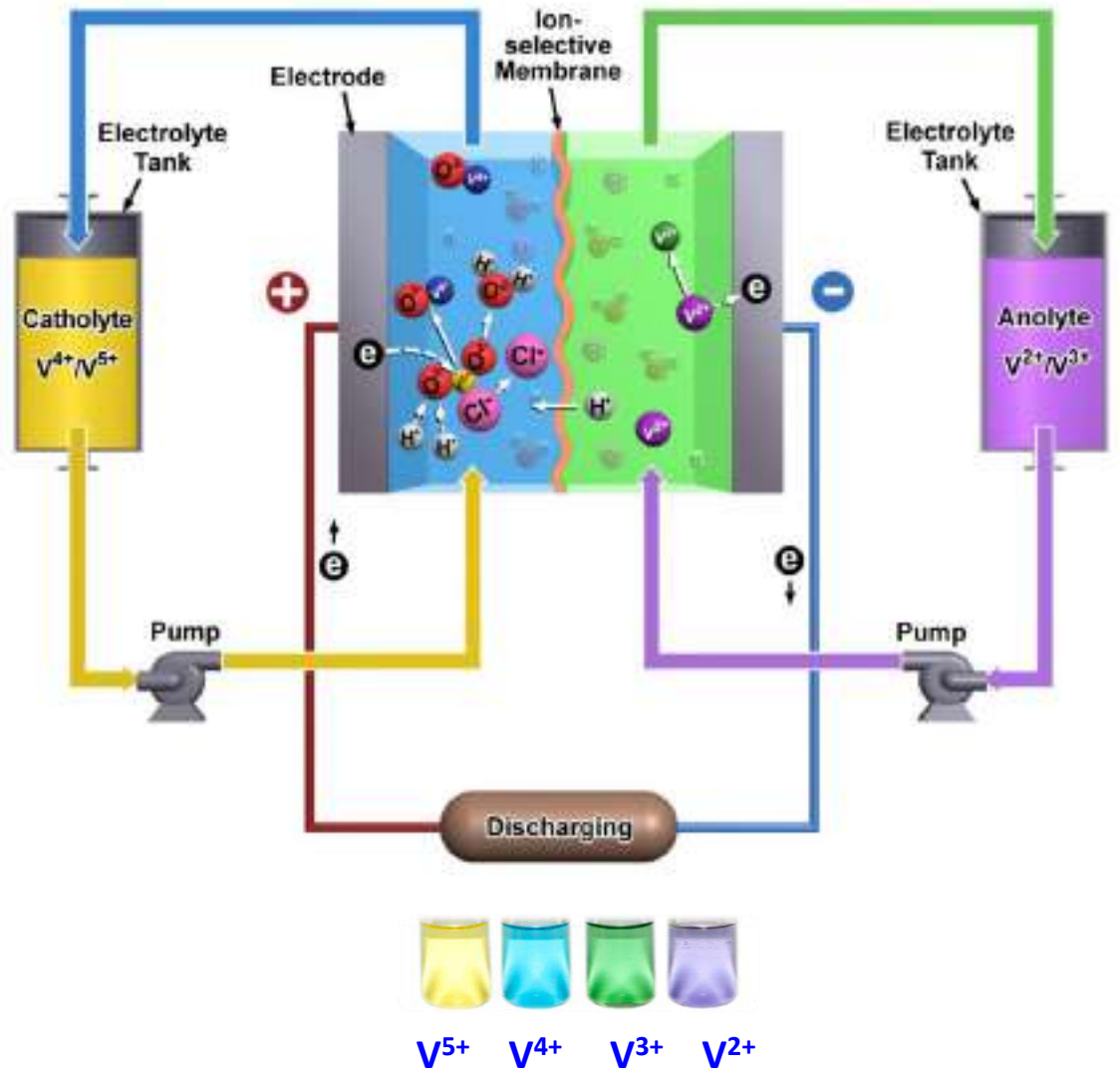
Advanced Vanadium Flow Battery

U.S. DEPARTMENT OF ENERGY
Office of Electricity

Pacific Northwest NATIONAL LABORATORY



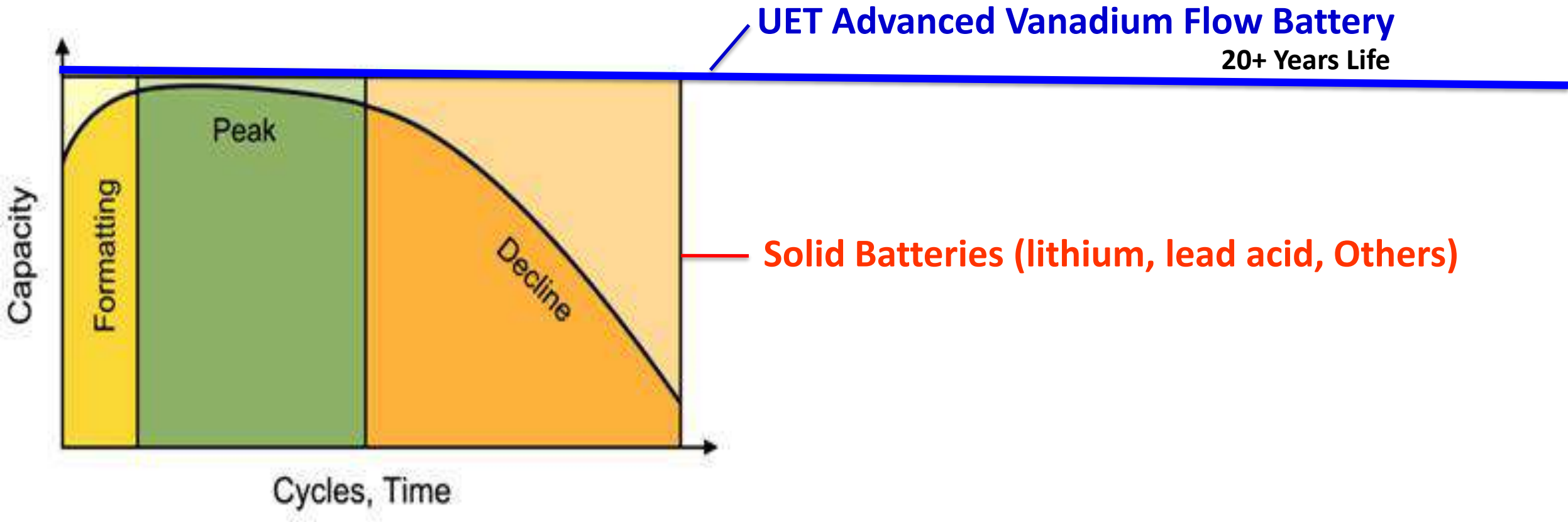
$VO_2Cl(H_2O)_2$



- New molecule developed at PNNL
- Improved & commercialized at UET
- No limits on:
  - number of cycles
  - using 100% of stored energy
- No degradation for 20 years +
- Non-flammable

No Degradation Unlike Solid Batteries

such as lithium and lead acid



UET Power and Energy Ratings Do Not Degrade

Non-Flammable Unlike Solid Batteries

such as lithium and lead acid

UET Advanced Vanadium Flow Battery

Solid Battery Example: Lithium cobalt oxide

*** Hazardous Materials Identification System (HMIS) ratings**

UET Systems Have Zero Flammability

UET is Safest Grid-Scale Battery Available

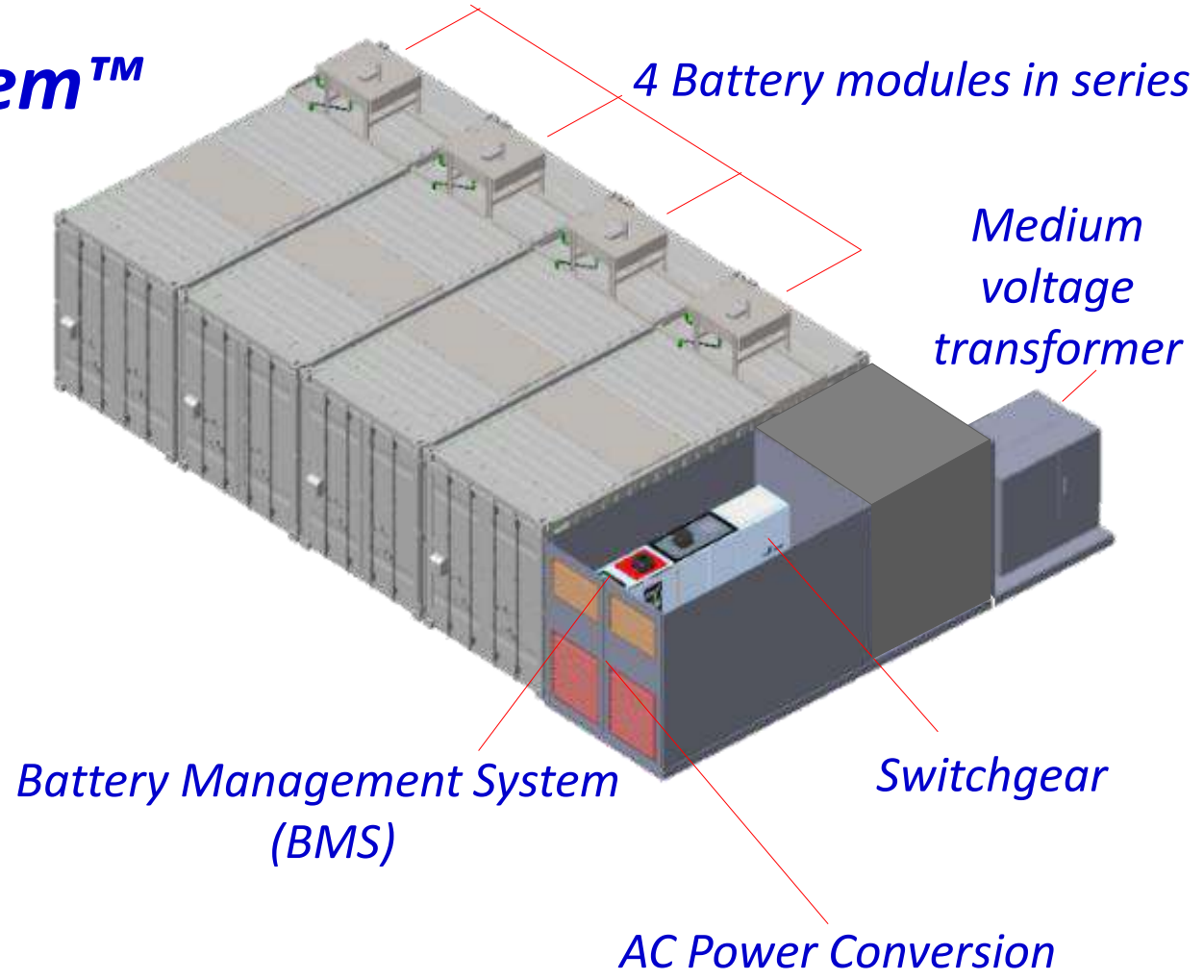
- **Inherent Safety Features**
  - ✓ No thermal run away or explosion
  - ✓ Minimal fire hazard
  - ✓ Benign operating temperature
  - ✓ Full system shutdown capability
  - ✓ Benign chemistry
- **Passive Safety Features**
  - ✓ Primary containment
  - ✓ Secondary containment
  - ✓ Electrical safety
  - ✓ Ambient pressure operation

- **Active Safety Features**
  - ✓ Real-time status monitoring and automated response
  - ✓ Hardware interlock loop
  - ✓ Fire suppression (customer option)
- **Operational Safety**
  - ✓ Onsite control
  - ✓ Fault response
  - ✓ Remote monitoring
  - ✓ Proven operational safety
  - ✓ Reuse and recycling
  - ✓ Chemical handling procedures
  - ✓ Spill handling procedures

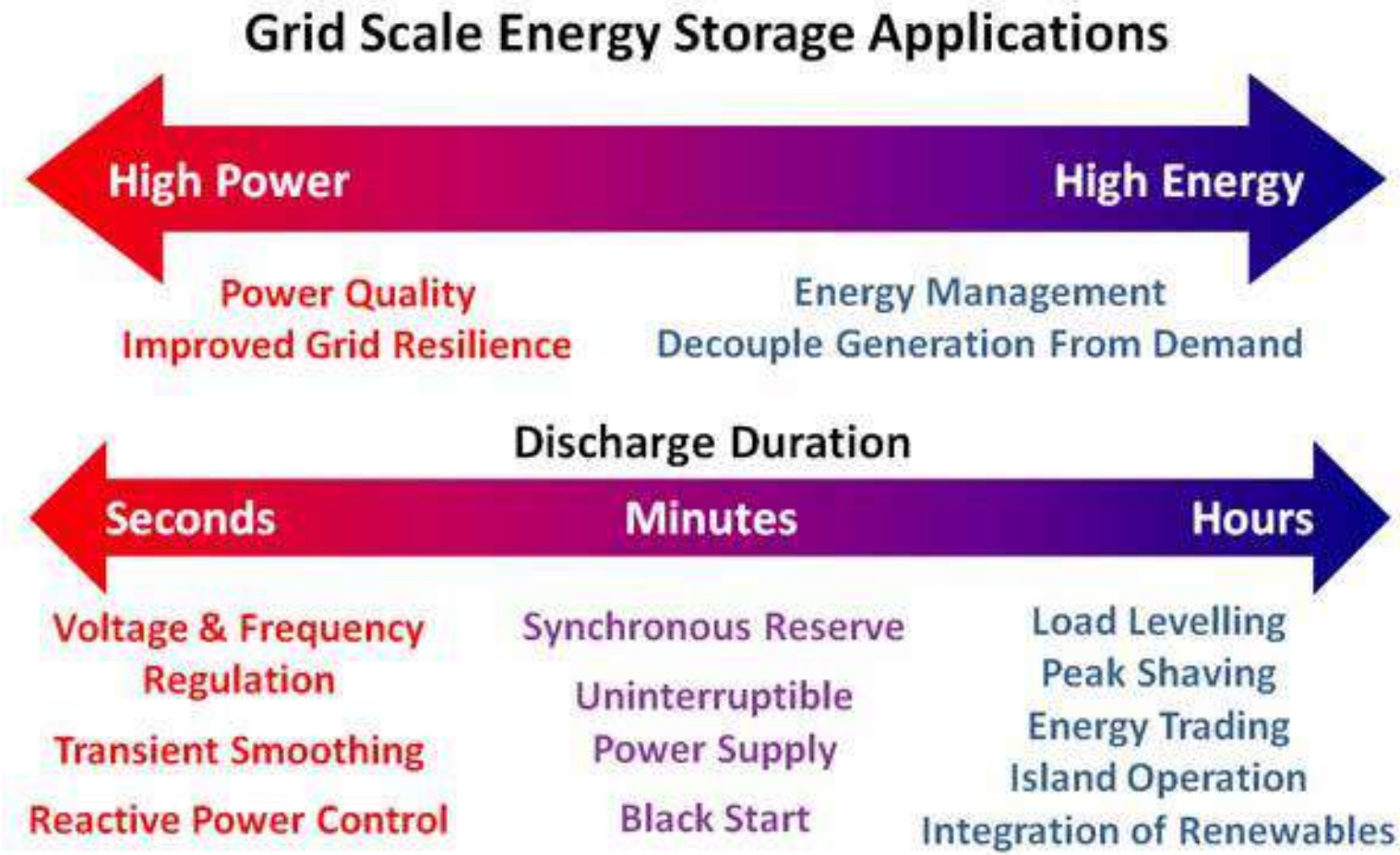
First-of-its-Kind Containerization

- Fully containerized –
  no liquid between containers &
  built-in secondary containment
- AC conversion & passive cooling –
  factory integrated & tested
- Modular system
- Readily transportable
- More rapid permitting
- “Plug and Play” deployment

Uni.System™



Full Range of Power & Energy Applications



UET's Systems Provide All of the Above

UET DEPLOYMENTS

UET Deployment Schedule Through Q4 2016

- *9.45 MW / 38 MWh in total*

1) Harbour Pointe Energy Storage Project (near Seattle, WA) May 2014 COD
   - 500kW/2MWh Uni.System™, demonstrating fully commercialized system with >300MWh discharged to Snohomish PUD grid and providing voltage support to distribution circuit

2) Bosch/BWP Braderup-Tinningstedt Citizens Wind Park (Braderup, Germany) Sept 2014 COD
   - 250kW/1MWh, exceeding performance requirements (tested over 1.25MWh) and buffering intermittency of wind generation, shifting energy, and providing park power & voltage support

3) Avista Energy Storage Project (Pullman, WA) June 2015 COD
   - 1MW/4MWh Uni.System, the largest capacity containerized flow battery in the world, grid-connected supporting distribution circuit and also customer-side islanding, black start, and seamless switching protecting Schweitzer Engineering Lab electronics manufacturing

4) Terna Energy Storage Project (Italy) Q3 2016 COD
   - 500kW/2MWh Uni.System™, part of 35MW procurement providing solar integration, voltage support, and other utility applications

(continued)

UET Deployment Schedule Through Q4 2016

- *9.45 MW / 38 MWh in total*

(continued)

5) Snohomish PUD Energy Storage Project (Everett, WA) Q3 2016 COD

- 2MW/8MWh Uni.System at Everett Substation, providing balancing of wind procured as part of fossil-free policy in conjunction with hydro, supporting distribution circuit, and preparing for growth of rooftop solar & EV charging

6) Mission Produce (Oxnard, CA) Q4 2016 COD

- 500kW/2MWh Uni.System at packing & ripening center, providing peak-shaving, energy savings, and back-up power without diesel generators, integrating 1MW solar array

7) City of New York Department of Citywide Administrative Services (NY, NY) Q4 2016 COD

- 100kW/500kWh ReFlex™ system at Bronx hospital, providing peak-shaving, energy savings, and back-up power

8) Energy Power Board (EPB) of Chattanooga (TN) Q4 2016 COD

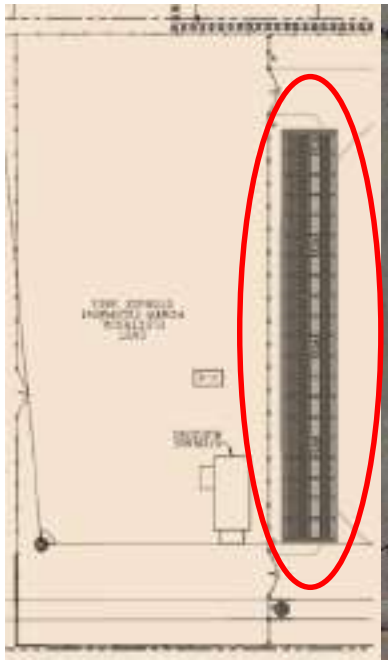
- 100kW/500kWh ReFlex™ system, part of US DOE Grid Modernization program (GMLC) program, including operational and control optimization and value analysis

9) More coming ….

Utility Installation: AVISTA Project in Pullman, WA

- 800kW/4h; 1MW$_p$; 4MWh$_p$ Uni.System™
- Grid-tied & customer-side @ Schweitzer Engineering Labs
- Commissioned April 2015
- Use cases:
  - Grid-tied
    - Energy shifting
    - Grid reliability
    - Improved distribution system efficiency
    - Enhanced voltage control
  - Customer-side
    - Islanding
    - Black start
    - Seamless switching
- Project partners
  - AVISTA
  - UET
  - WA State Dept. of Commerce
  - PNNL

Utility Installation: Snohomish PUD Project in Everett, WA

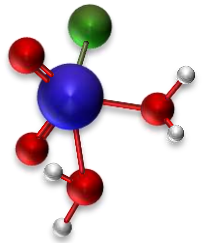


- 2MW / 8.0MWh Uni.System™
- Everett Substation
- Deploying Q4 2016
- Use Cases
  - Energy shifting
  - Improved distribution system
  - Enhanced voltage control
  - Optimized utilization of energy storage
- Project Partners
  - SnoPUD
  - UET
  - 1Energy
  - WA State Dept. of Commerce
  - PNNL

UET COMPANY SUMMARY

NEW ELECTROLYTE

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



PRODUCT ENGINEERING, MANUFACTURING & SERVICE

60,000ft² facility in Seattle

FIELD EXPERIENCE

- ✓ **≈60MWh** of UET and Rongke Projects
- ✓ German subsidiary VANADIS POWER

INNOVATION + PARTNERSHIPS + QUALITY

ELECTROLYTE PRODUCTION

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

$300MM INVESTED IN PORTFOLIO

STACK PRODUCTION

- ✓ 108,000 ft² manufacturing facility
- ✓ Ramping to **300MW** annual production capacity
- ✓ ISO9000/14000, GB/T28001 Certified

APPENDIX

Uni.System™ Specifications

	2016 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
Cycle and Design Life	Unlimited cycles over 20 year life
Available State-of-Charge	100%
Frequency Reg. Efficiency	$75\%_{AC}$
Peak Shaving Efficiency	$70\%_{AC}$
Response Time	<100 ms
Voltage Range	465-1000 V_{DC}
Max. Current	1500 A_{DC}
Footprint	820 ft^2 (41'W x 20'D x 9.5'H)[a]
Ambient Temp.	-40°C to 50°C (-40°F to 122°F)
Total Weight	170,000 kg
Self Discharge	Max energy loss <2%[b]

[a]Five 20' standard size containers: four battery plus one power container;
[b]Self-discharge limited to only the residual volume of electrolyte left in stacks; no discharge of energy remaining in electrolyte tanks over time.

500kW system

Re.Flex™ Specifications

	2016 ReFlex™ (AC)
Nominal Rating	100 kW_{AC} /5 hours
Peak Power	120 kW_{AC} (5 secs)
Maximum Energy	500 kWh_{AC}
Cycle and Design Life	Unlimited cycles over 20 year life
Available State-of-Charge	100%
Frequency Reg. Efficiency	$75\%_{AC}$
Peak Shaving Efficiency	$70\%_{AC}$
Response Time	<100 ms
Voltage Range	400_{AC} -10% to $480V_{AC}$ + 10%
Footprint	160 ft^2 (8'W x 20'D x 9.5'H)[a]
Ambient Temp.	-40°C to 50°C (-40°F to 122°F)
Total Weight	40,000 kg
Self Discharge	Capped at <2%[b]

[a]A 20' standard size container;
[b]Self-discharge limited to only the residual volume of electrolyte left in stacks; no discharge of energy remaining in electrolyte tanks over time.

100 kW system

100MWh Battery: UET vs. Tesla

	Tesla	UET
Footprint	2 acres	½ acre
Solar heat load	8MW	2MW
Operating temp	23°C	45°C
Substation prep	$2.5MM	$800k
# of SOC's (states of charge)	>16MM	200

<u>UET</u> capacity: 100% SOC access for 20y

- Unlimited, no-fade cycles over 20 years
- Nonflammable; nonreactive; fire retardant
- -40°C to 50°C e'lyte temp
- Requires controlling only 2 SOCs per MWh

<u>TESLA</u> capacity: assuming 50% SOC access for 5y cycle life

- *Tesla limits SOC access to ~50% for heavy cycling, increasing the required installed capacity*
- *Risk of combustion, propagation and thermal runaway requires ample aisle space and eliminates stacking*
- *Lower capacity <0°C and accelerated degradation >35°C*
- *166,000 cells per MWh must be monitored and also controlled for temperature, voltage & current*

http://www.teslamotors.com/sites/default/files/images/presskit/teslaenergy_utility1.jpg?617

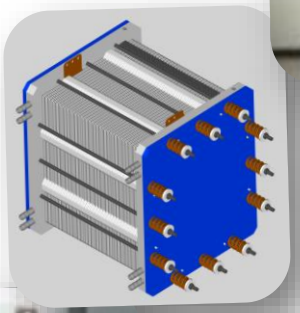
Proven, High-Performance Stacks

15 years R&D, 10 years field experience, 100's deployed

25kW Stack in 2012

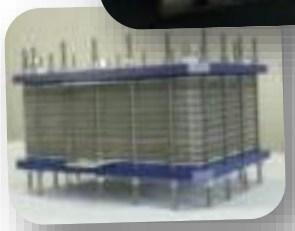
22kW Stack in 2011

10kW Stack in 2010



5kW Stack in 2008

2kW Stack in 2008



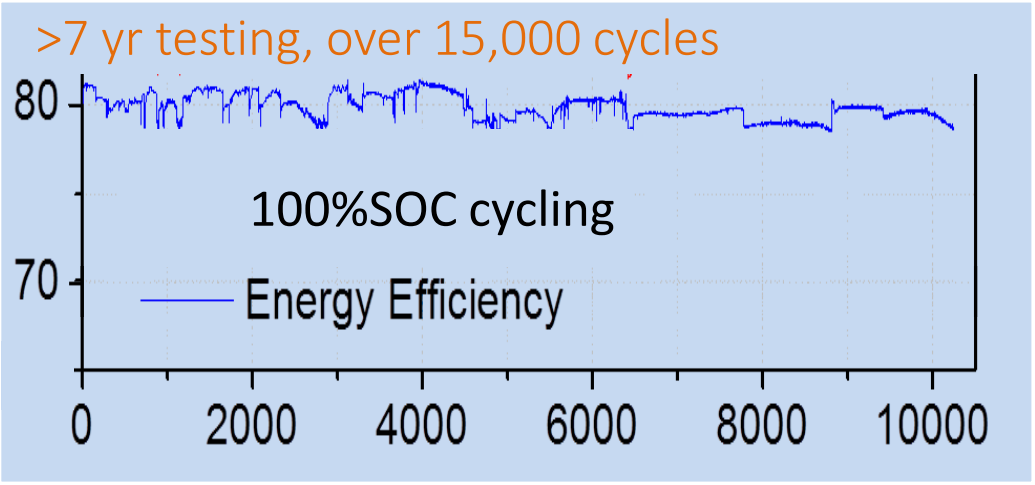
1kW Stack in 2006

RONGKE POWER

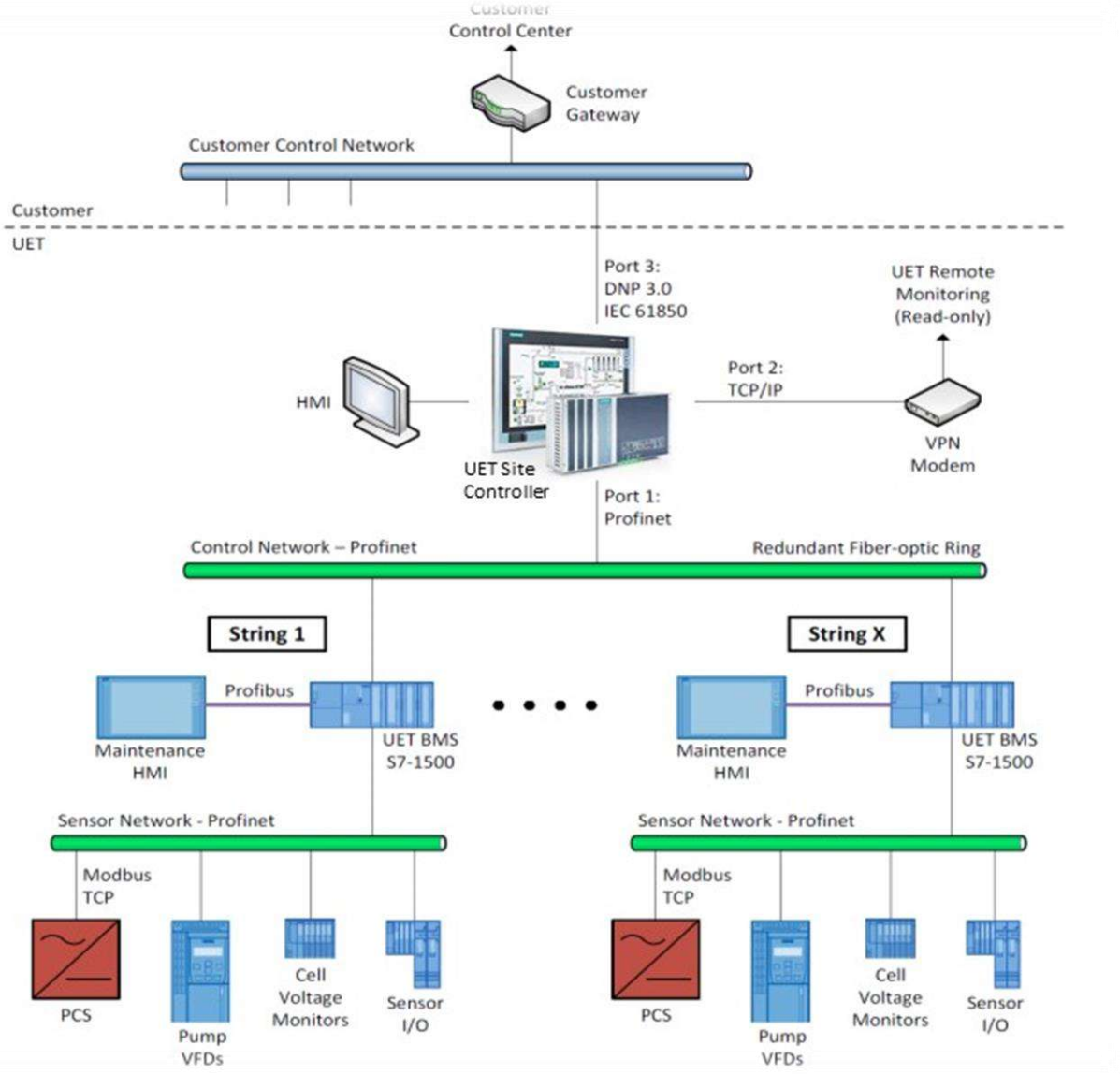
31.5 kW Stack in 2014

- ✓ Mature, powerful stack
- ✓ ISO9000/14000, GB/T28001 Certified
- ✓ Individual cell voltage data
- ✓ 108,000 ft^2 facility
- ✓ 100MW annual stack capacity, scale up to 300MW in 2017

>7 yr testing, over 15,000 cycles



Robust Control System Architecture



SIEMENS

Siemens Components

- Each string is controlled by a single Siemens PLC
- String consists of four batteries, the PCS, minimal cooling and 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

Value-Added Services

- Applications Engineering and Analysis
  - Storage asset configuration (and +PV)
  - Single and multiple use-case benefit analysis
  - Pre-engineered site configurations
- Deployment
  - Logistics and site engineering assistance
  - System installation and commissioning
- Maintenance
  - Scheduled maintenance
  - Performance reporting
  - Performance warranty management
- Monitoring and Operating Analysis
  - OSI PI - Industry standard data historian
  - Real-time monitoring and notifications
  - Custom analysis and reporting such as asset utilization and use-case economic analyses