Hawai'i's 100% Renewable Future

NELHA Energy Storage Conference

David Tomlinson
Sr. Director of Project Development
425/463-6741
David.Tomlinson@Uetechnologies.com

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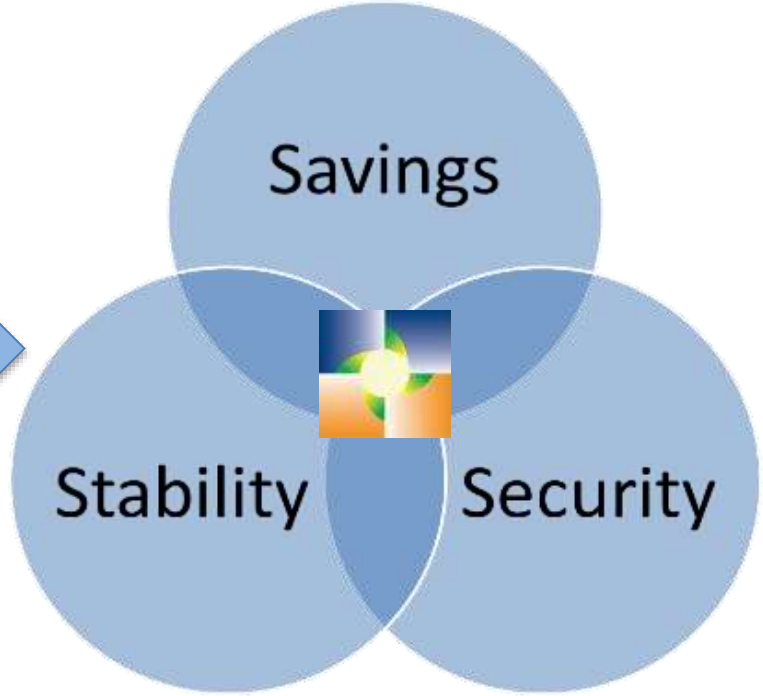
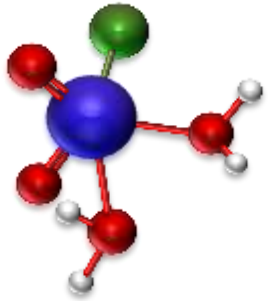
UniEnergy Technologies:
Solving Hawai'i's Energy Needs

- ✓ Renewable Integration
- ✓ Flexible, Dispatchable Generation
- ✓ Grid Stability
- ✓ T&D Deferral
- ✓ Load Shifting

UET Value

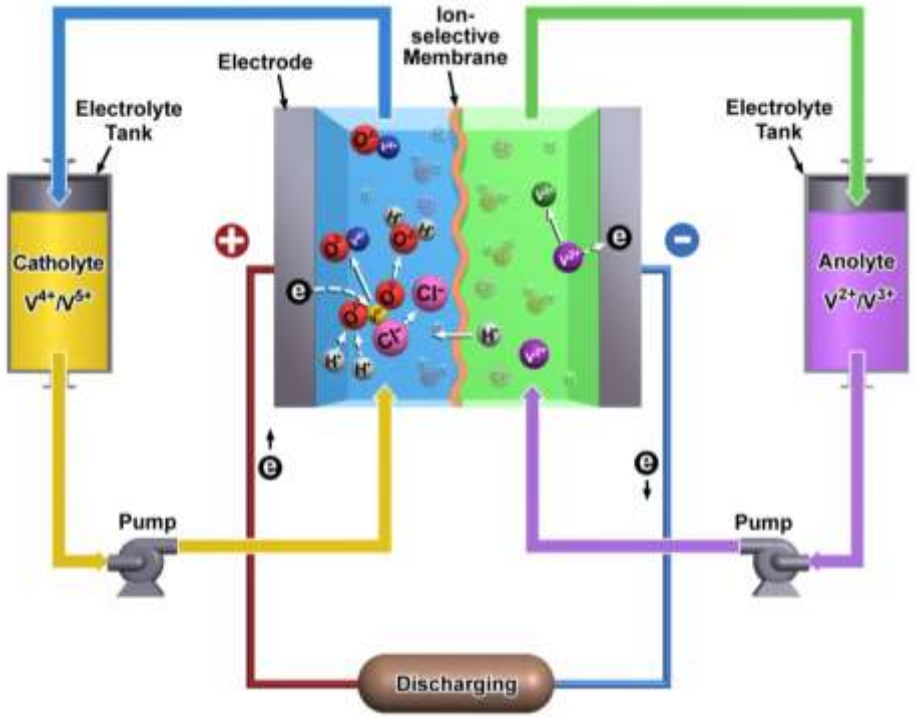


Breakthrough Chemistry: PNNL & UET Innovation



$VO_2Cl(H_2O)_2$

V^{5+} V^{4+} V^{3+} V^{2+}



U.S. DEPARTMENT OF ENERGY

Pacific Northwest NATIONAL LABORATORY

Developed at and licensed from PNNL
Improved and commercialized at UET

- $30M DOE & PNNL investment, 20 scientists & 5 years R&D with full stack/system validation
- Won the US Government's highest Award of Excellence in Technology Transfer to UET
- Unlimited cycle life, no capacity degradation, 100% of state of charge (SOC) available for use, power& energy decoupled, safe
- Extraordinary electrolyte stability, from -40°C to +50°C
- 2X energy density improvement

  → 5X product footprint reduction

UniEnergy Technologies:

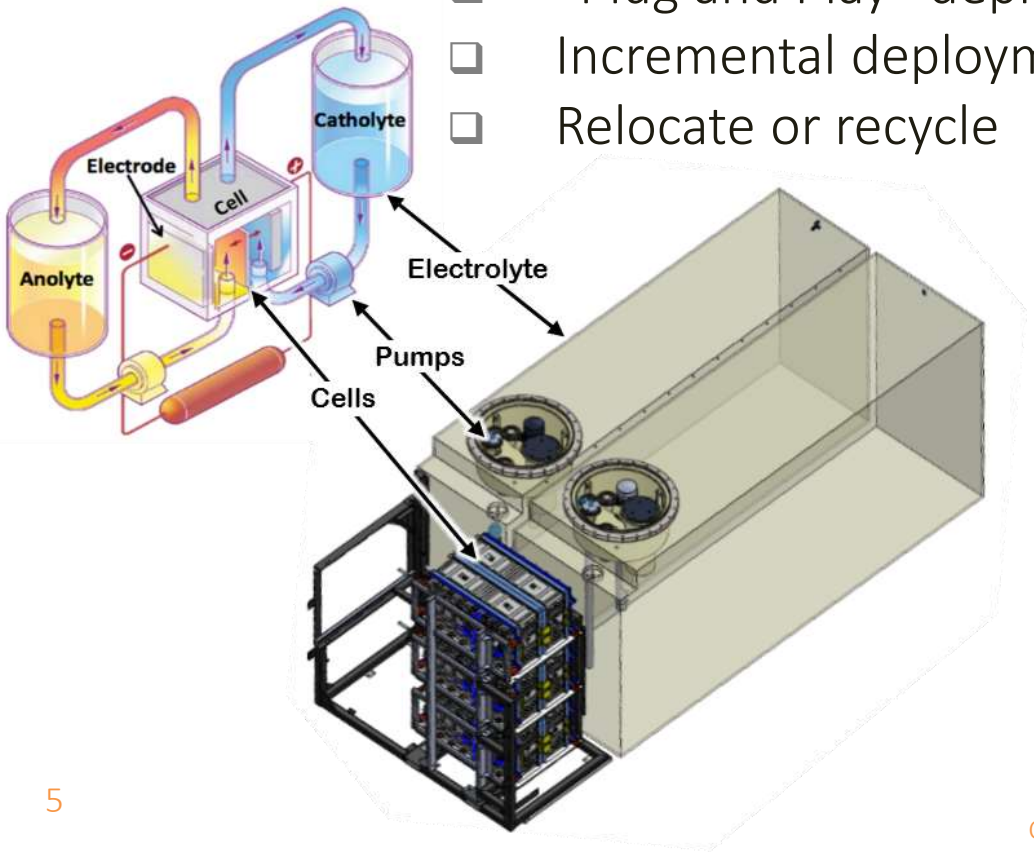
Leading Flow Battery Solution

HQ, ENGINEERING AND MANUFACTURING

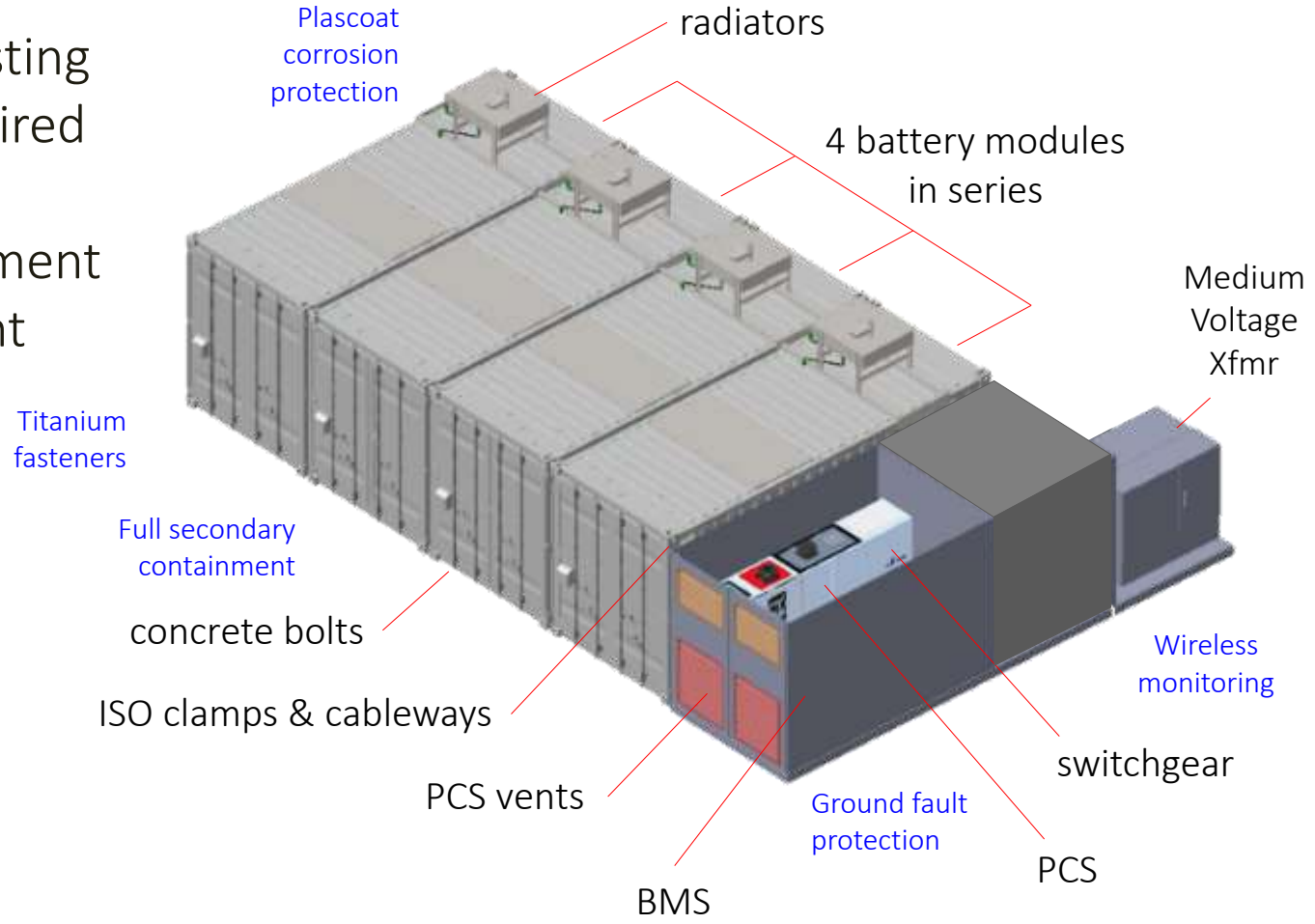
60,000ft^2 facility in Seattle, Washington

Uni.System™ - Integrated, Efficient, Modular Design

- Modular, efficient production
- Full factory integration
- System-level factory testing
- No onsite building required
- More rapid permitting
- “Plug and Play” deployment
- Incremental deployment
- Relocate or recycle



Uni.System™ Configuration 500kW/2MWh



ReFlex™ Specifications

	2016 ReFlex™ (AC)
Nominal Rating	100 kW_{AC} /5 hours
Peak Power	120 kW_{AC}
Maximum Energy	500 kWh_{AC}
Cycle and Design Life	Unlimited cycles over 20 year life
Available State-of-Charge	100%
Efficiency $_{\text{frequency regulation}}$	75%$_{AC}$
Efficiency $_{\text{peak shaving}}$	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 systems

UET Solution Key Features

- **Versatile**
  - Full range of power (kW) and energy (kWh) applications: **all-in-one**
  - From short- to long-duration including simultaneously, e.g. ramping and frequency regulation: **at same time**
  - No state-of-charge (SOC) or duty cycle limitations,
  - operational between -40°C to +50°C
- **Durable**
  - 20+ year system life, unlimited cycles (proven over >15,000 cycles, 0-100% SOC)
  - Top-of-class, field-proven components, including battery stacks, power electronics, and controls
- **Intrinsically Safe**
  - Aqueous electrolyte is safe – moderate pH, zero reactivity and flammability
  - Non-flammable
- **Low Cost**
  - Lowest levelized cost
    - CapEx+OpEx+O&M/GWh over life
  - 100% capacity access over life time
    - Captures multiple value streams

UniEnergy Technologies:

World Leader in Energy Storage Density

Sumitomo 1MW/5MWh

UET 1MW/4MWh

Conventional Vanadium	Uni.System™	*Key benefits*
12Wh/l e'lyte	24-30Wh/l e'lyte	*2X e'lyte density enables internal tanks*
5MWh on 10,000ft^2	4MWh on 2,500ft^2	*~1/5th footprint (single layer) & stackable*
85°F to 32°F (ambient)	122°F to -40°F (ambient)	*Wide thermal tolerance without damage*

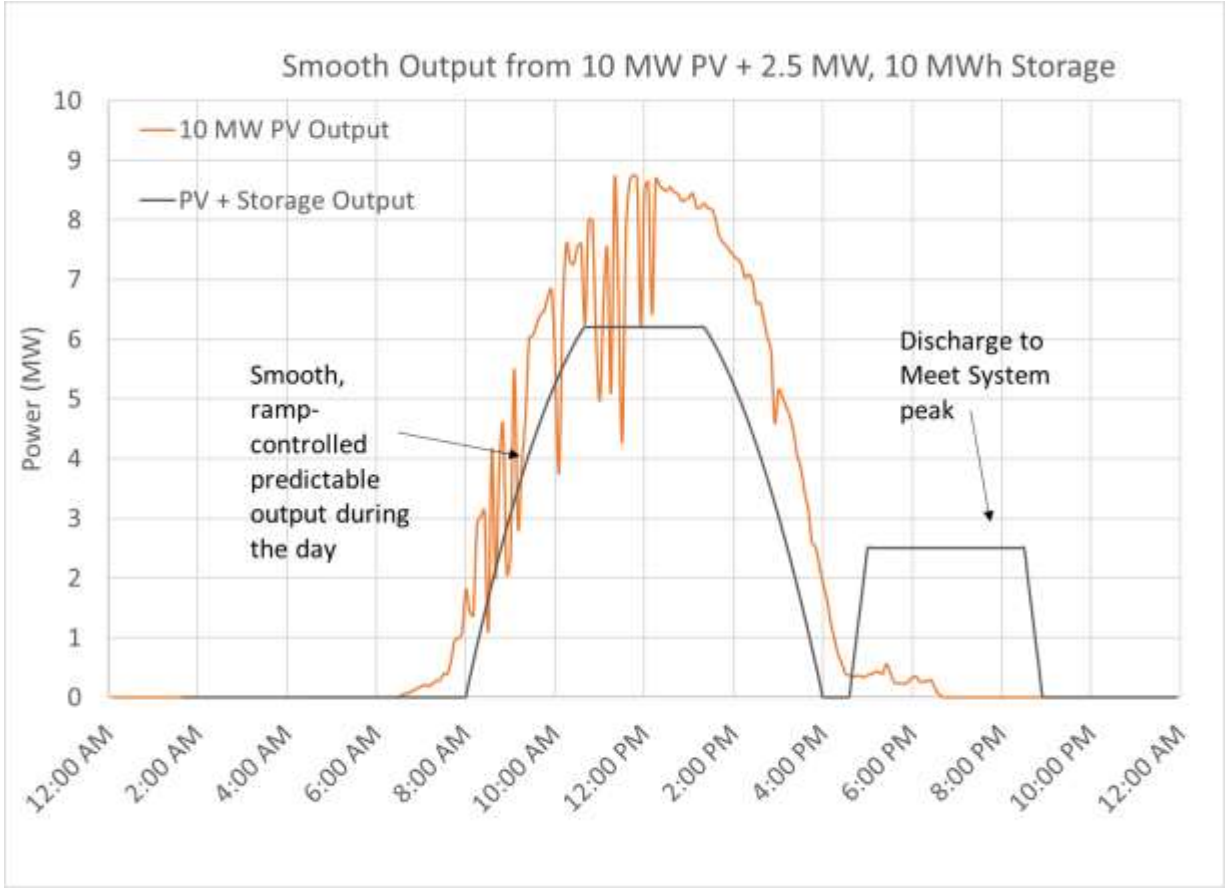
UniEnergy Technologies:
Out-Performs Lithium

Lithium	Uni.System™	*Key benefits*
4MWh on 7,000ft^2	4MWh on 2,500ft^2	*2-3X footprint reduction & stackable*
Needs to be internally cooled to <75°F, requiring chillers	122°F to -40°F ambient, w/ only radiators	*Thermal tolerance = <cooling and >efficiency* ***even in standby***
Required separation of flammable active materials	No separation required	*No thermal runaway or self ignition*
Limited cycles, 70-80% usable energy range Degrading power, energy, efficiency	Unlimited cycles, 100% usable energy range, ZERO degradation	*Unlimited SOC flexibility 100% capacity (power & energy) guarantee*

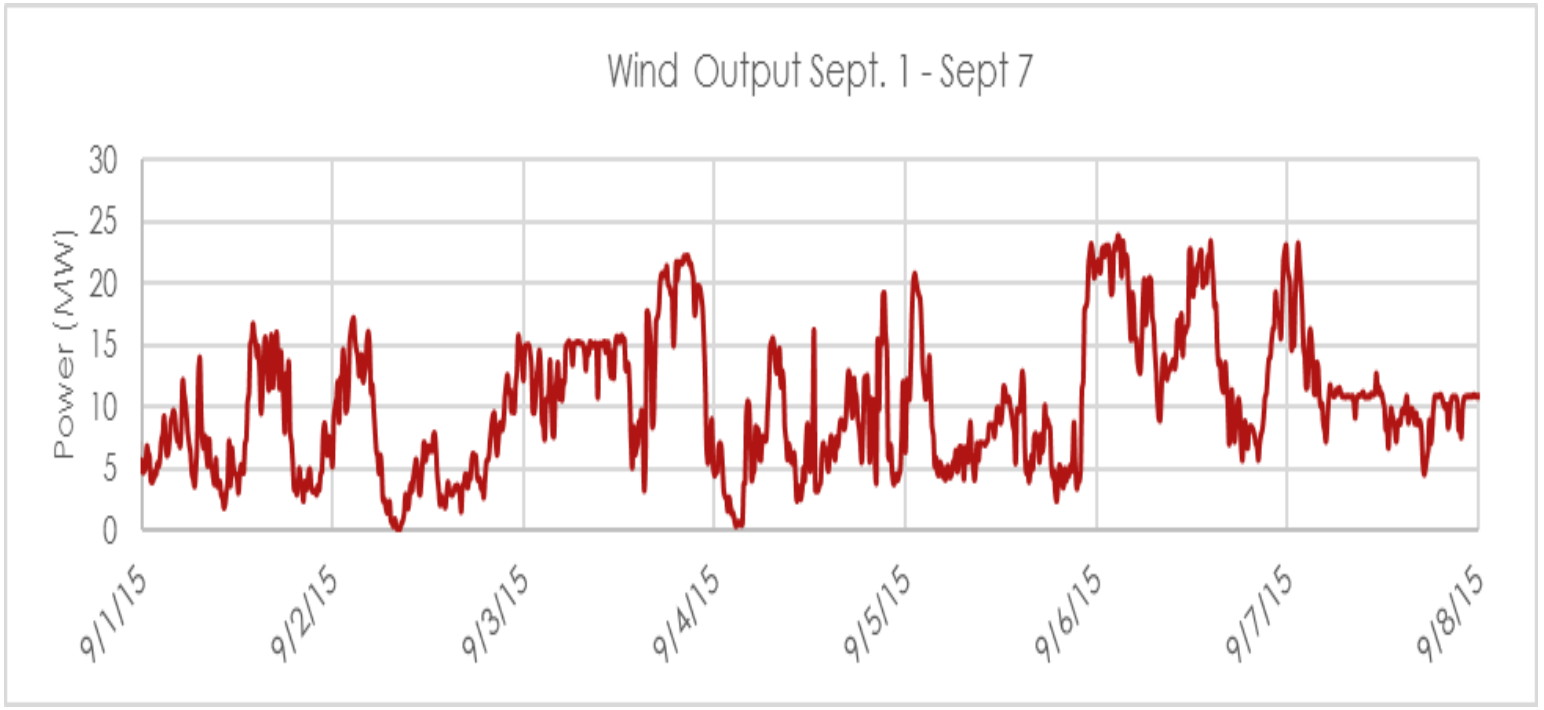
Energy Storage +Solar

Storage is used to control solar to a predictable & dispatchable output

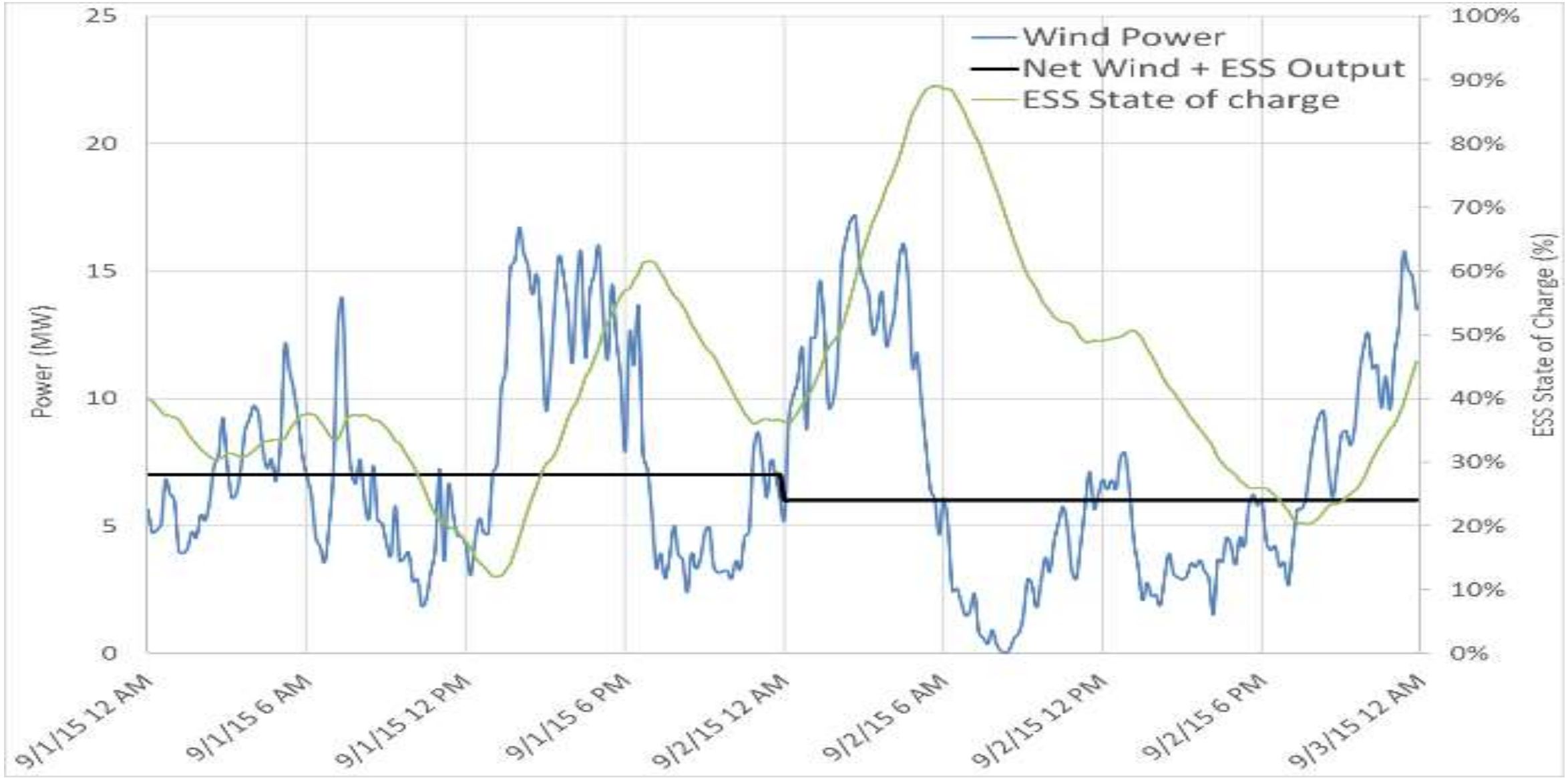
- Smoothing
  - » Improves renewable energy consistency & quality
- Flexible, Dispatchable, Controllable
  - » Balances system loads with generation
  - » Enables time-shift of energy to evening or morning hours
- Ramp Control
  - » Manages solar ramp rates
- Peak Shaving
  - » Limits peak solar output to improve grid stability



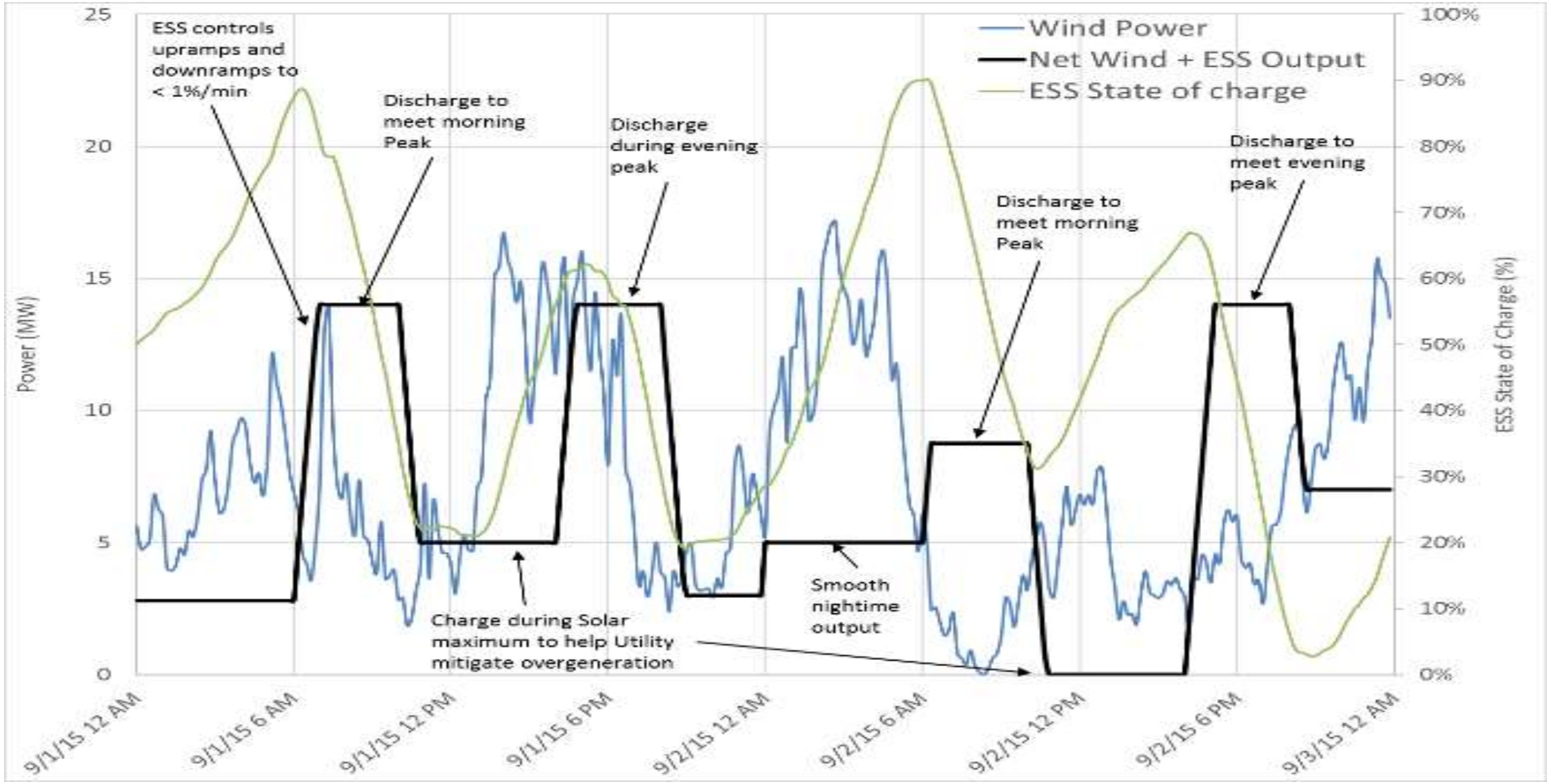
Energy Storage + Wind



Energy Storage + Wind = Baseload



Energy Storage + Wind = Load Following



Utility-Controlled and -Maintained Distribution Circuit Energy Storage Solutions

- Supports significant additional PV at residential and commercial locations
- Maintains/improves system power quality and resiliency
- Allows utility control and dispatch
- Economies of scale and maintenance programs
- Cost-effective energy storage solution as compared to individual, residential storage

HELCO-NELHA Gateway Center
Utility-Controlled Distribution Circuit Pilot Program

- Partnership Includes:
  - » Hawaii Electric Company
  - » Natural Energy Laboratory of Hawaii
  - » UniEnergy Technologies
  - » With support from Department of Energy, Sandia National Lab
- Demonstration of Utility-Controlled, Distribution Circuit Integrated Energy Storage
- Project Schedule:
  - » Final Design – Q4 2016
  - » Installation and Commercial Operation – Q1 2017

Energy Storage for Hawai'i's 100% Renewable Future

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Uni.System™
1MW/4MWh