UniEnergy Technologies

UET Welcomes IEEE PES Seattle Chapter

IEEE PES Power & Energy Society™

May 2014

UniEnergy Technologies

Mission: Be a major global provider of bulk energy storage solutions through *innovation, quality and strategic partnerships*

We will accomplish this by commercializing break-through vanadium redox flow batteries with new generation high performance electrolytes, field-proven stacks, optimized control/power electronics, and refined "plug & play" containerization

Achievement: UET has successfully developed the world's first flow battery product fully integrated into a single shipping container for rapid and flexible grid deployment

UET's DNA and Strategic Partnerships

NEW ELECTROLYTE

- ✓ 2X power and energy density
- ✓ –40°C to +50°C
- ✓ Improved safety

Pacific Northwest NATIONAL LABORATORY

DOE

PRODUCT ENGINEERING AND MANUFACTURING

67,000ft^2 design, development & manufacturing facility in Seattle

FIELD EXPERIENCE

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

RONGKE POWER

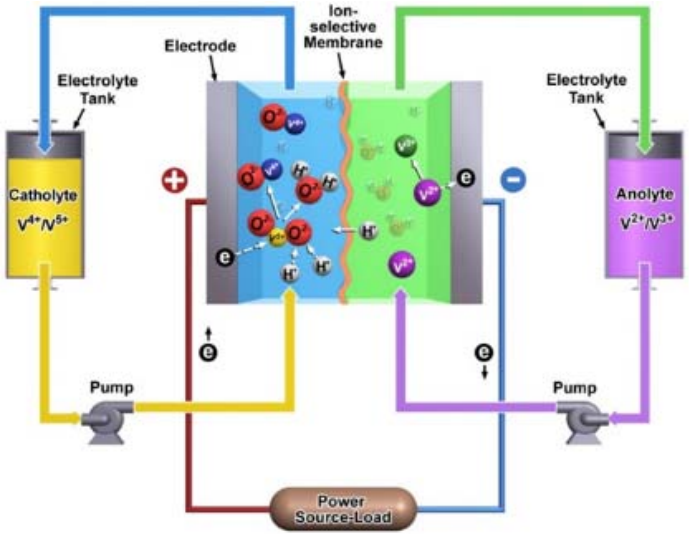
ELECTROLYTE PRODUCTION

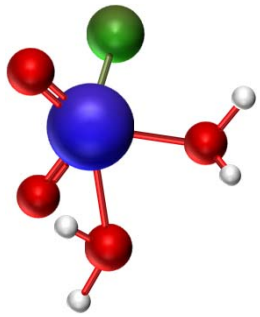
- ✓ 1,324,000 ft^2 production facilities
- ✓ Electrolyte production capacity > 1.5GWh/year
- ✓ ISO9001:2008 Certified

STACK PRODUCTION

- ✓ 108,000 ft^2 manufacturing facility
- ✓ 100MW production capacity
- ✓ ISO9000/14000, GB/T28001 Certified

Core Technology: Stable and Powerful Vanadium Chemistry





$VO_2Cl(H_2O)_2$

Cathode: $VO_2Cl + 2H^+ + e^- \leftrightarrow VO^{2+} + Cl^- + H_2O$

Anode: $V^{2+} - e^- \leftrightarrow V^{3+}$

Cell: $VO_2Cl + V^{2+} + 2H^+ \leftrightarrow VO^{2+} + V^{3+} + Cl^- + H_2O$

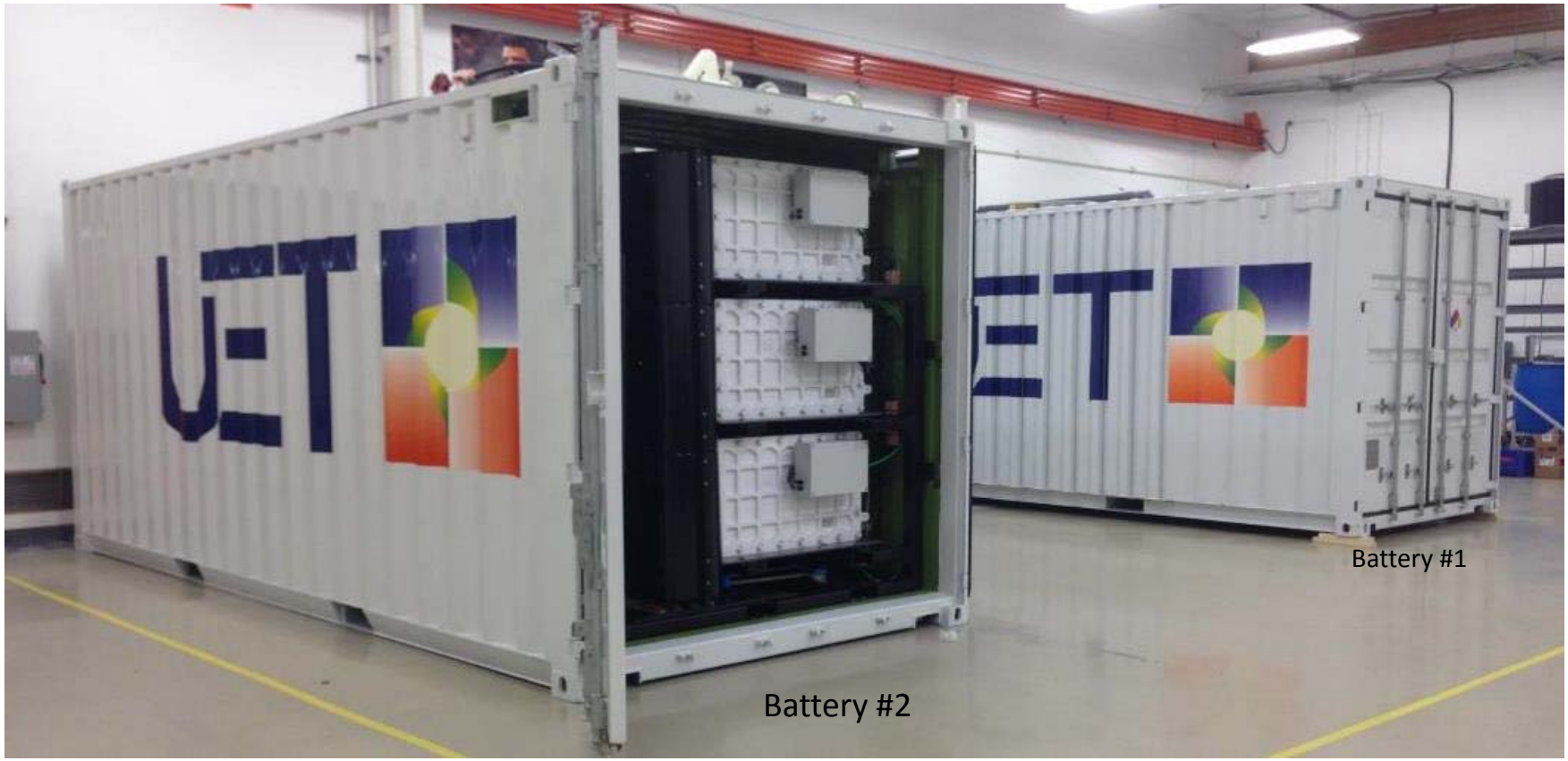
Pacific Northwest NATIONAL LABORATORY

New molecule designed with PNNL's super-computing and advanced analysis equipment

- Team of 20 scientists led by Dr. Gary Yang & Dr. Liyu Li who then founded UET in 2012
- Won the US Government' highest Award of Excellence in Technology Transfer to UET
- Extraordinary electrolyte stability
  - stable from -40 °C to +50°C
- 2X energy density improvement
  - → 5X footprint reduction
- Inherent Safety
  - Non flammable
  - No thermal runaway
  - Reduced chemical volume
  - Nonreactive with water

+ Containerization

2013 The first Uni.Systems™



April 2014 First field deployed Uni.System.AC™ adjacent to UET

4 Battery Containers
- Only 4 states of charge
- 12 stacks; 8 tanks; 8 pumps
- 600 – 1000V

Power Electronics Container
- PCS & Controls
- Communications
- 480V transformer

UET's Modular and Containerized Uni.System™

- Full integration of stacks, electrolytes, balance of plant, power electronics, controls, communications, cooling, and medium voltage transformer
- Compact, modular, and scalable 20' containers that meet ISO standards
- Proprietary flow architecture and chemistry
- 20 safety features including built-in secondary containment & hardware interlock loop
- Optimized array of sensors to warrant operational stability and reliability

Containerization yields a high quality, practical product

1. Modular, efficient production
2. Built-in secondary containment
3. Factory integration
4. System-level factory testing
5. Rated to Transport and Seismic codes
6. No onsite building required
7. More rapid permitting
8. “Plug and Play” deployment
9. Incremental deployment
10. Option for relocation or removal
    - » Enables lease financing as non-fixed assets

- ✓ Safe
- ✓ Reliable
- ✓ Flexible
- ✓ Affordable

2015 Uni.System.AC™: 500kW/4h; 600kW$_{peak}$; 2.2MWh$_{max}$

Uni.System.AC™

- ✓ Temperature Agnostic
  -40 °C to +50 °C
- ✓ SOC Agnostic
  100% capacity access
  no capacity fade
- ✓ Cycle Agnostic
  20-year design life
- ✓ Factory integration
  precision assembly & QC
- ✓ Parallel Architecture
  array sizes over 20MW
- ✓ Inherently Safe
  no thermal runaway
- ✓ Plug & Play
  rapid incremental deployment
- ✓ 97% Availability
  no stripping or equalizing
- ✓ 100% recyclable
  disposal contract included

2015 Uni.System.AC™ Performance Data

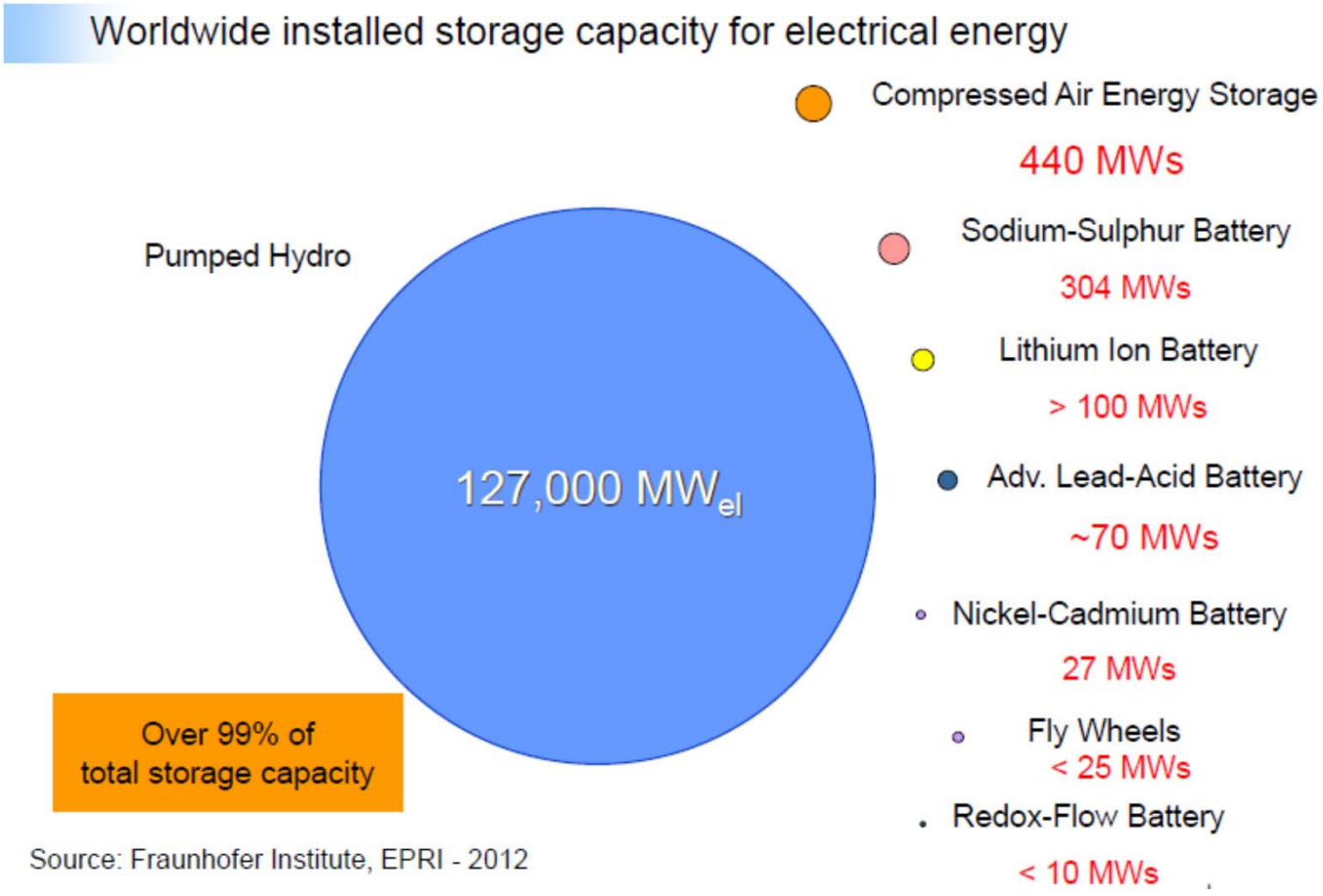
	2015 Uni.System.AC™			
Peak Power	700 kW_{AC}			
Maximum Energy	2.2 MWh_{AC}			
Discharge time	1 h	2 h	4 h	8 h
Power	700 kW_{AC}	600 kW_{AC}	500 kW_{AC}	275 kW_{AC}
AC Efficiency	65-70%			
Voltage Range	465-1000 V_{DC}			
Max. Current	1500 A_{DC}			
Response Time	<100 ms			
Footprint	820 ft^2			
Envelope	41'W x 20'D x 9.5'H			
Total Weight	170,000 kg			
Cycle and Design Life	Unlimited cycles over the 20 year life			
Ambient Temp.	-40°C to 50°C (-40°F to 122°F)			
Self Discharge	Max capacity loss: <2%			

Excellent Safety of the Uni.System™

- Inherent Safety with Core Technologies
  - » Benign operating temperature: slightly above ambient, operation limit to 50oC
  - » Minimal fire hazard: aqueous, fire retardant electrolytes act as a large heat sink
  - » No thermal run-away: non-reactive with water; no violent electrochemical and chemical reactions; and mixing fully charged electrolytes will raise the system temperature by <20°C
  - » Full system shut-down capability: turning off the pumps stops the chemical reactions within minutes
  - » Benign chemicals: no human health hazards under normal operation beyond corrosiveness of 10% acid solution (3-5 times less acidic than lead-acid batteries)
- Passive Safety by Design
  - » Multi-layer containment: thick-walled rotomolded tanks, coated container steel walls and welded floor, no penetration below electrolyte levels, tertiary containment optional in the field
  - » Electricity safety strictly adherent to codes
  - » Ambient pressure operation: with pressure relief valves, no connection between containers
- Active Safety Features
  - » Real time monitoring and automated response
  - » Fire suppression
  - » Hardware Interlock loop
- Operation Safety
  - » Onsite control, fault response, remote monitoring, chemical and spill handling codes, disposal contract

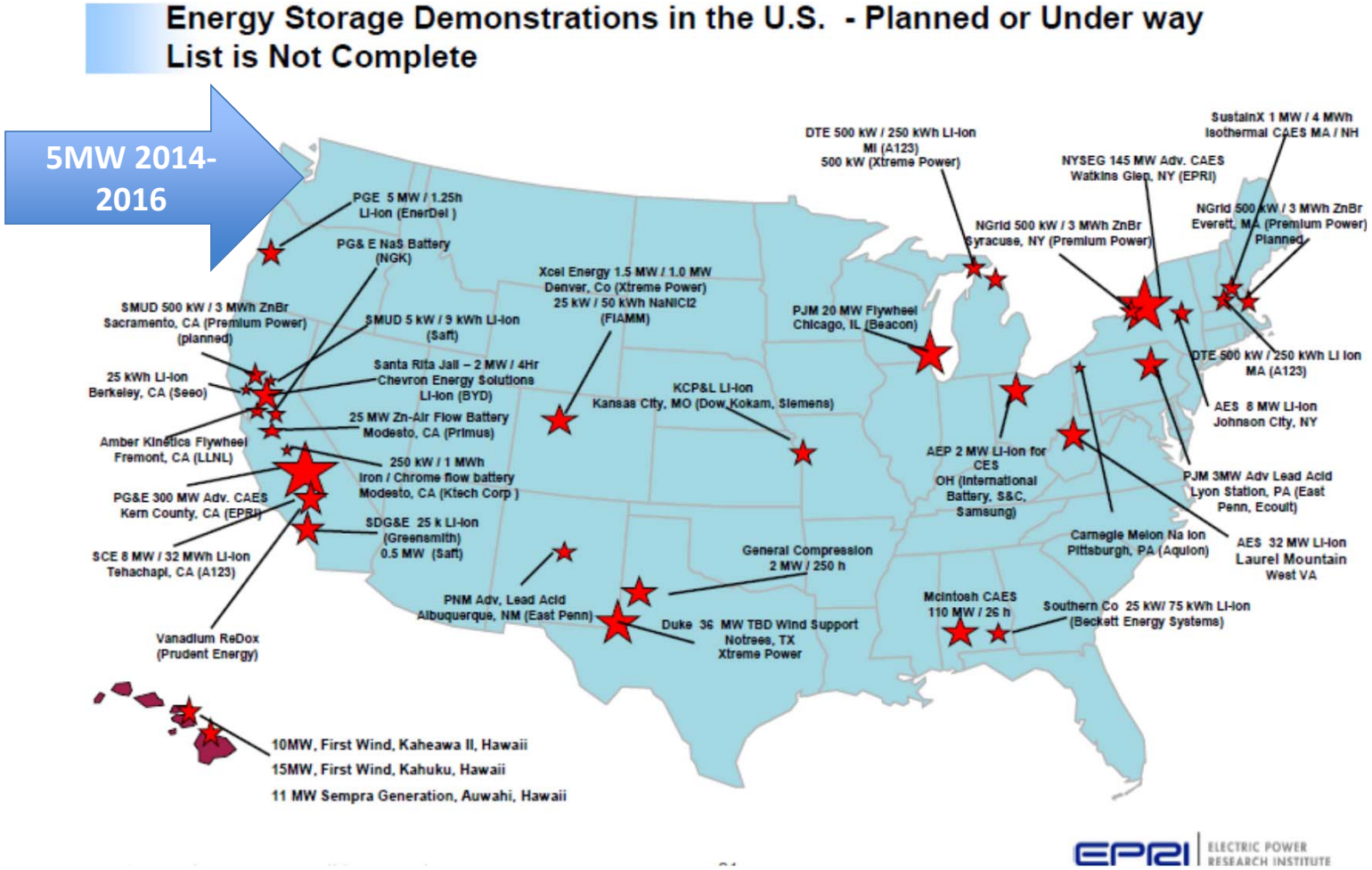
Energy Storage for Power Systems, The Big Picture

Total Global Grid Storage



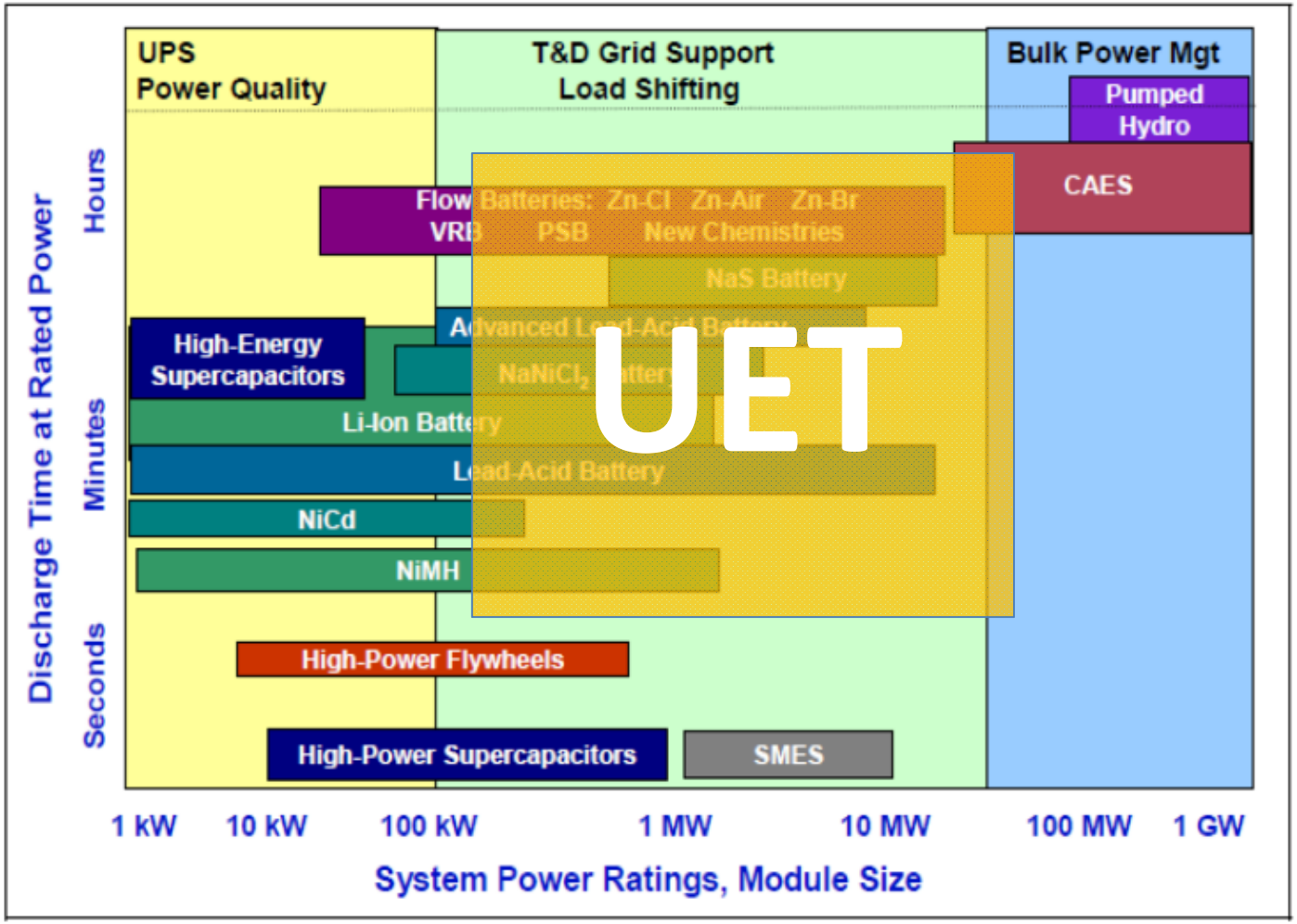
Source, EPRI

U.S. Grid Storage Deployments, Circa 2012



Source, EPRI

Storage Technologies Overview



Source, EPRI, modified by UET

Energy Storage for Power Systems, Applications

Grid Storage Use Cases (CA AB2514 Storage Procurement)

Rulemaking Use Cases, from OIR Phase 1

Market Revenue, plus Capacity Value

T&D Avoided Cost

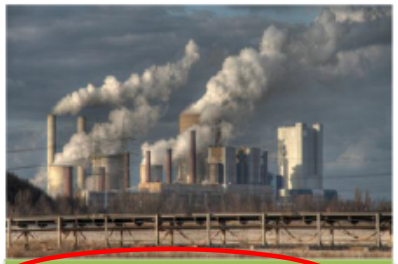
Bill Reduction, plus Incentives

		Priority	Use Case Prioritization	Primary Benefit	Conventional Technology Priority #1	Storage Technology Priority #1
Phase 1	T-Connected Bulk Storage	1	Peaker Plant	Capacity, Energy, A/S	CT	Battery
		2	Ancillary Services Only	A/S	CT	Flywheel
		3	Base Load Plant	Capacity, Energy	CCGT	Pumped Hydro
	Distribution Energy Storage	4	Distributed Peaker	Upgrade deferral & Market $	Circuit Upgrade & CT	Battery
		5	Substation-Sited Storage	Voltage Reg	Circuit Upgrade	Battery
		6	Community Energy Storage	Voltage Reg	Circuit Upgrade	Battery
Phase 2	Behind-the-Meter Energy Storage	7	Behind the Meter	Bill Mgt/ Avoid Cost, Market $	Circuit Upgrade & CT	Battery
		8	Behind the Meter Utility Controlled	Bill Mgt/ Avoid Cost, Market $, Grid Rel	Circuit Upgrade & CT	Battery
		9	Permanent Load Shifting	Bill Mgt/ Avoid Cost, Grid Rel	CT	Thermal

Source, KEMA

Comparison of 100MW Gas Turbine with 100MW Battery *

Energy storage can provide much greater benefits per MW as a flexible resource!



VS.

100 MW Gas Turbine	Energy Storage Benefits	100 MW Energy Storage
10 minute ramp	>600x the ramp rate	<1 second ramp
50 MW flexible range	>4x the flexible range	200 MW of flexible range
2768 useable hours/year(1)	>3x the operational hours	>8300 useable hours/year
6500 gallons per hour	Less water usage	Little to no water usage
Status quo GHG emissions	Lower GHG emissions	Reduces GHG emissions by up to 90%(2)
	Investment lowers costs	

output range 50 to 100MW

20-40% utilization

output range -100 to +100MW

95% availability

(1)Excluding start-up and shutdown time

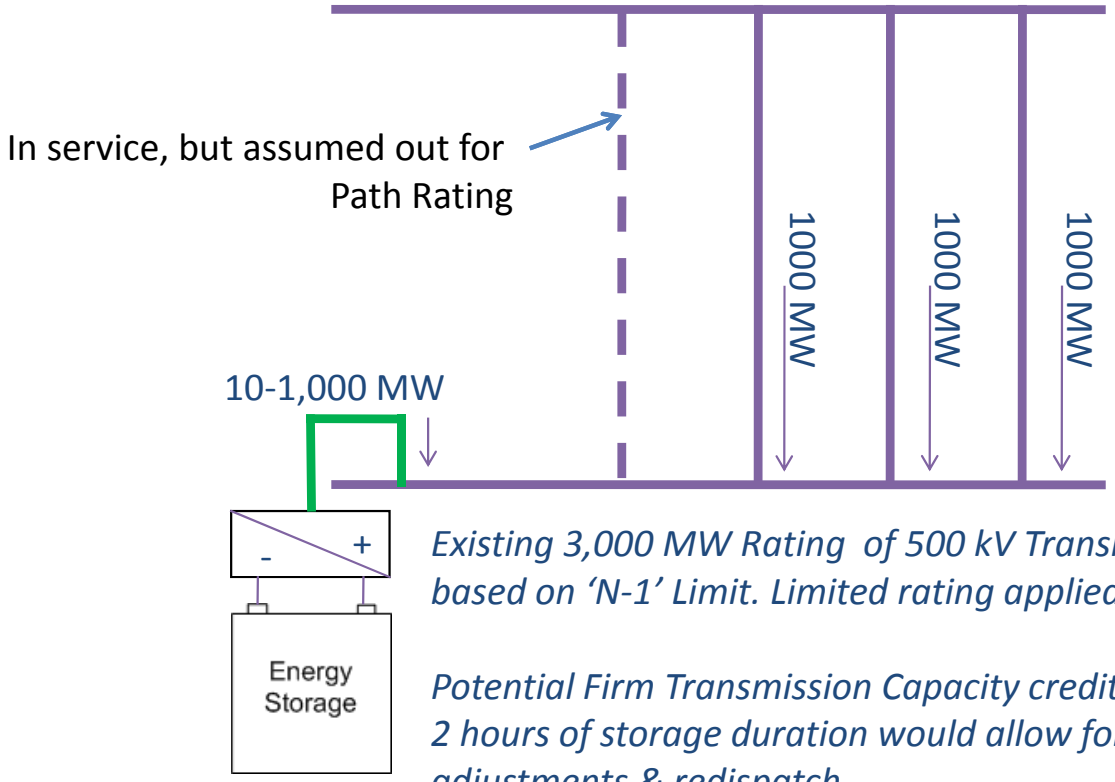
(2)http://www.energy.ca.gov/2011_energypolicy/documents/2011-02-15_workshop/comments/California_Energy_Storage_Alliance_03032011_TN-59863.pdf

12 ENERGY STORAGE 2013 NORTH AMERICA

* Summary slide from STRATEGEN at ESNA conference in September, 2013

Storage for Transmission

Benefits, Tradable capacity (FTC) credits, and better utilization of existing but constrained transmission capacity



Existing 3,000 MW Rating of 500 kV Transmission Path based on 'N-1' Limit. Limited rating applied 24 X 7 X 365.

Potential Firm Transmission Capacity credit for each MW of storage. 2 hours of storage duration would allow for post-outage grid adjustments & redispatch.

Storage for Distribution

Benefits, Delay financing cost of much larger substation transformer project, e.g. 5MW storage defers need for 20MVA+ XFMR bank increase. Secondary benefits include voltage support and substation asset life extension.

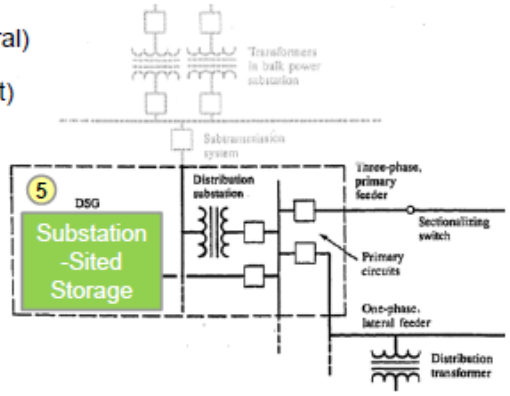
Substation Sited Storage

Application 5

- Distribution Peak Capacity Support (Deferral)
- Distribution Operation (Voltage/VAR Support)
- Loss Reduction
- Transformer Life Extension
- Market Services

Core Cases

- Battery Types:
  Li-ion, Advanced Lead
- Size: 0.5 MW, 1 MW, 2 MW
- Duration: 2 hour, 4 hour

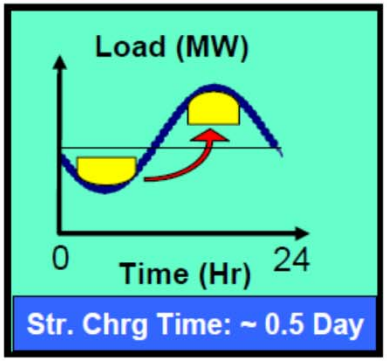


Legend
Original Definition
Added Consideration
To Be Completed

Source, KEMA

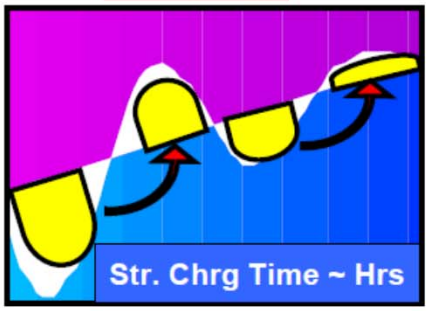
Energy Storage Efficiently Resolves Wind/Solar Power Fluctuations, Ramping and Load Management Issues

Load Leveling



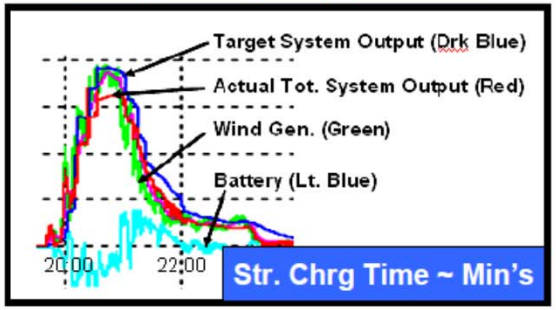
- CAES
- Pumped Hydro

Ramping:



- CAES
- Pumped Hydro
- Battery, Flow Type
- Note: For many utilities, ramping and reducing part load problems are high priority, especially due to power fluctuations from wind/solar plants

Frequency Regulation:



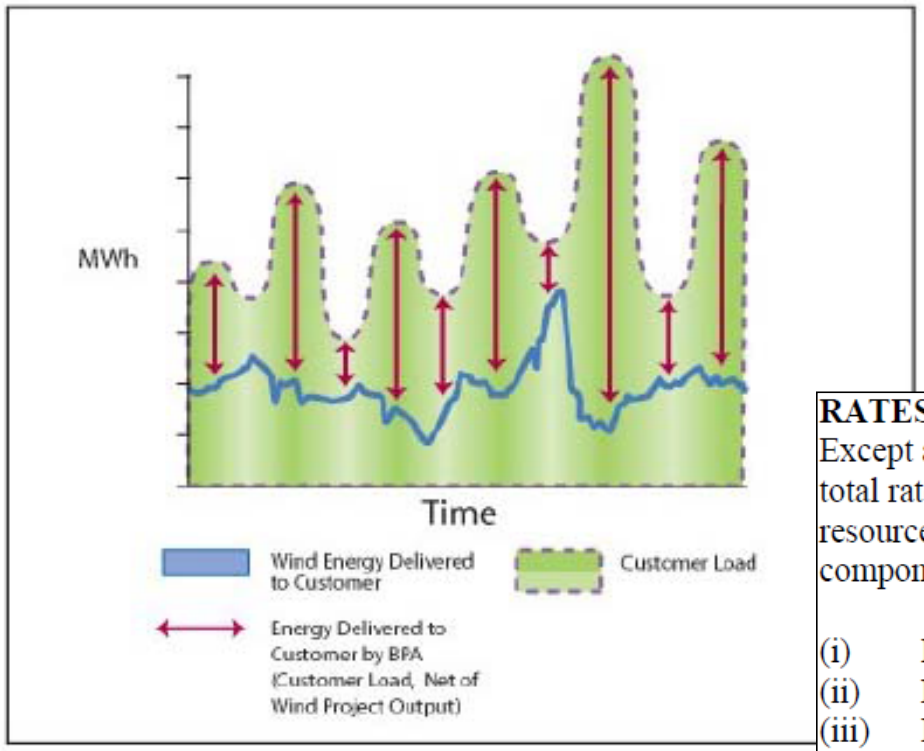
- Battery, Regular or Flow Type
- Super-Capacitor
- Flywheel
- Superconducting Magnetic Storage

Source: EPRI, Schainker

Source, EPRI

Renewables Integration, a PNW Perspective

Network Wind Integration Service



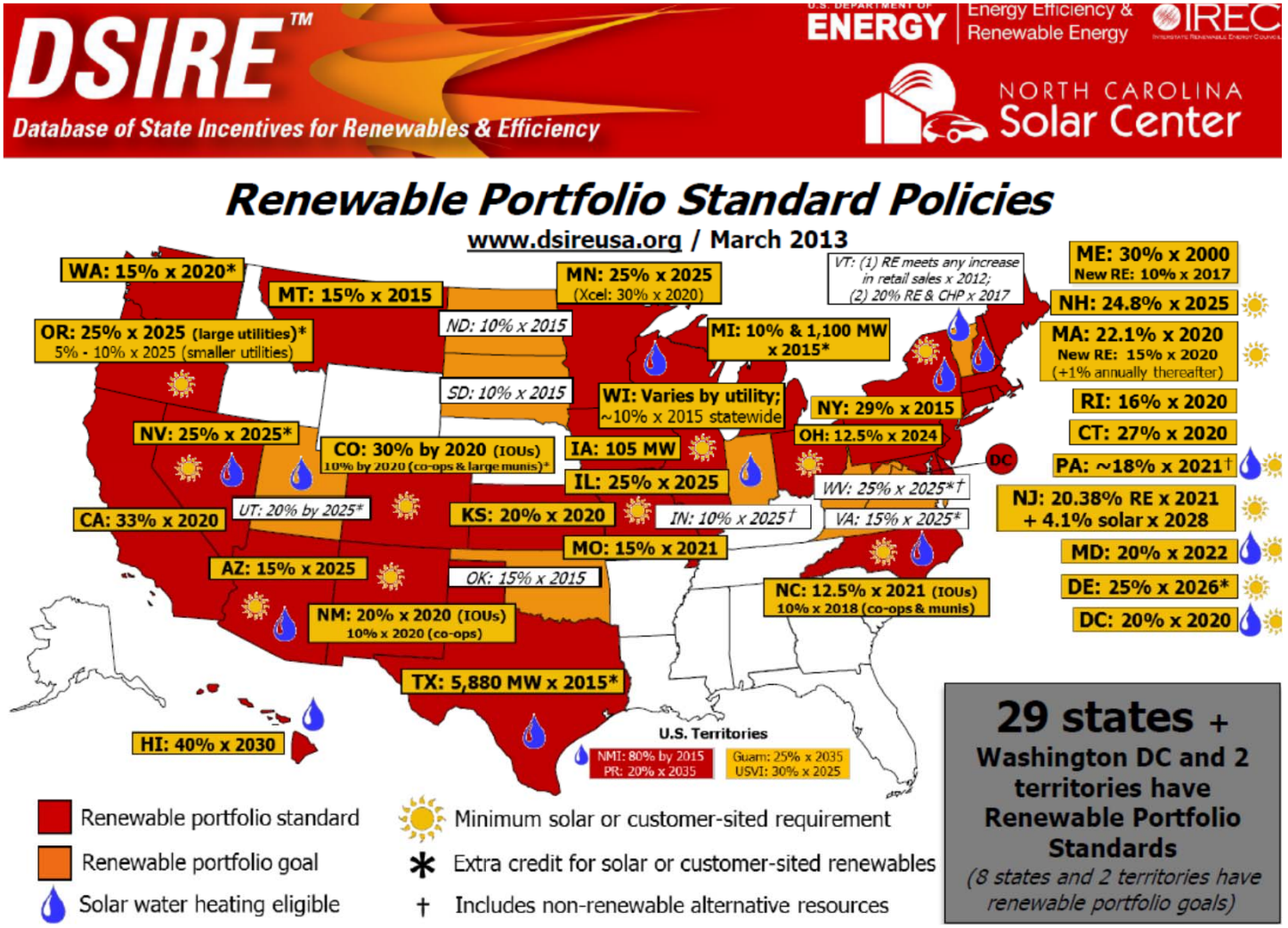
RATES

Except as provided in section 7, Formula Rate Adjustments, below, the total rate for Variable Energy Resource Balancing Service for wind resources shall not exceed $1.23 per kilowatt per month and each component of the rate shall not exceed the following:

(i)	Regulating Reserves	$0.08 per kilowatt per month
(ii)	Following Reserves	$0.37 per kilowatt per month
(iii)	Imbalance Reserves	$0.78 per kilowatt per month

Source, BPA

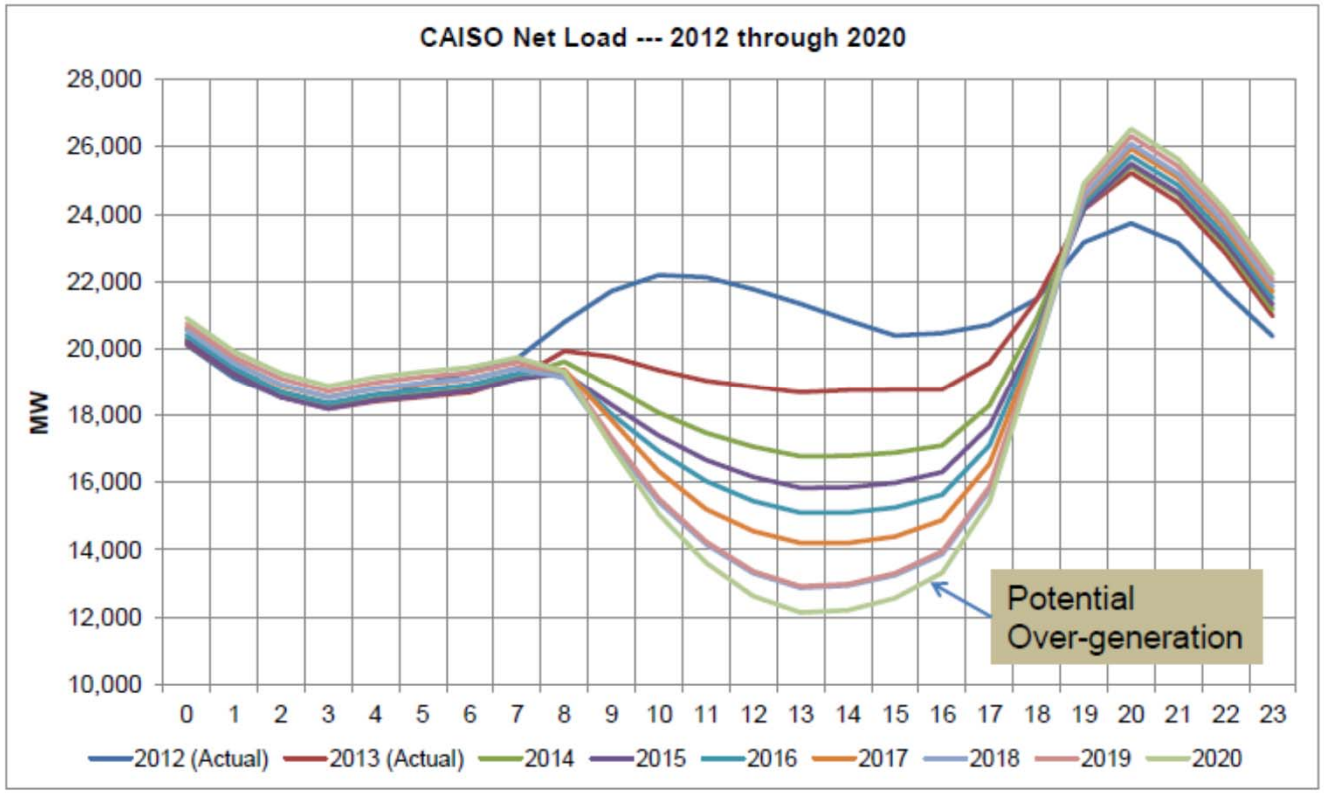
Renewables Integration, Major Driver



Source, DSIRE

Renewables Integration, Major Driver

Non-summer months --- Net load pattern changes significantly starting in 2014



Source, CAISO

Energy Storage for Power Systems, The Market

Grid Storage Market: Analyst firms project >>$100B energy storage market by 2020 with CAGR >30%

Lux Research	$114B by 2017
SK Holdings	$180B by 2018
Piper Jaffrey	$600B by 2020
Boston Consulting	$400B by 2020
Pike Research	14GW installed by 2022
IHS Report	40GW annually by 2022