

Energy Storage—Are We There Yet?

Utah Governor's Energy Development Summit

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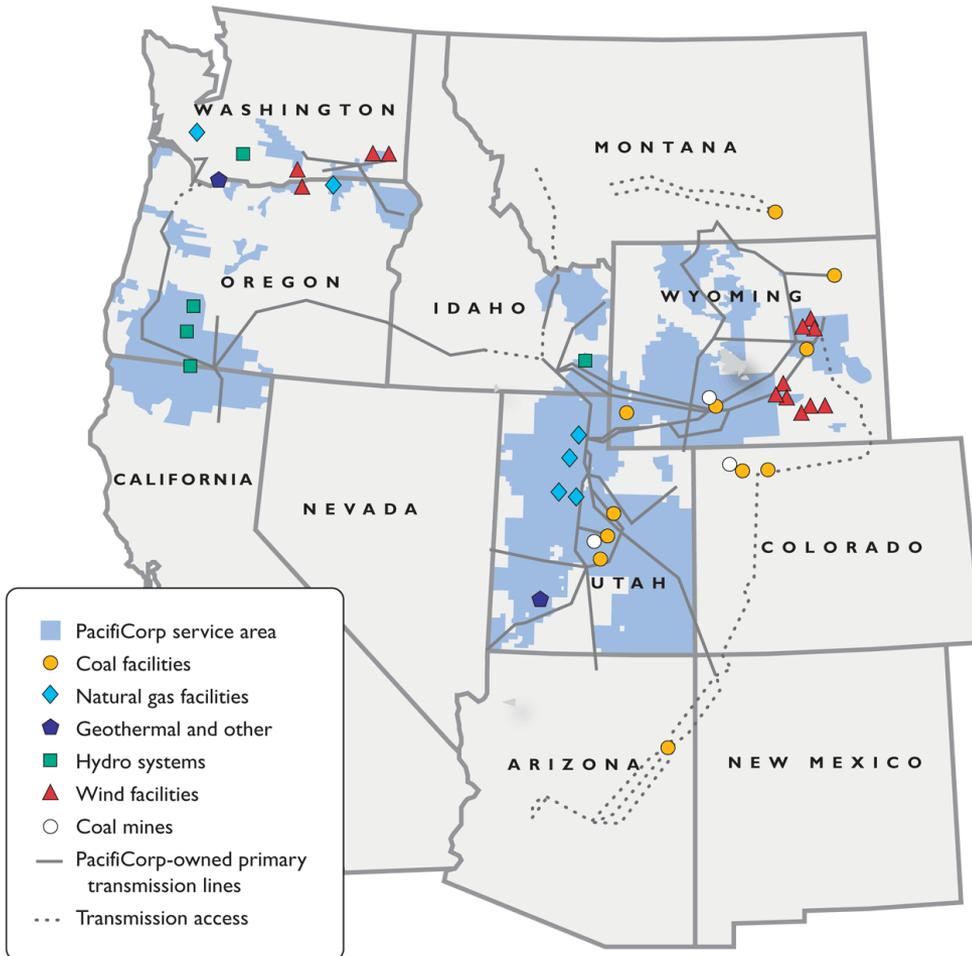


Let's turn the answers on.

What We'll Cover Today

- Who are Rocky Mountain Power and PacifiCorp?
- How are Electric Utilities Changing?
- Utility Energy Storage Basics, “Apps” and Technologies
- Rocky Mountain Power’s Experience With Energy Storage
- Are We There Yet?

Rocky Mountain Power in Utah 2014



822,875 customers

2,022 employees

Distribution lines:
21,366 miles

2013 state property taxes:
\$67.9 million

Net book value:
\$6.6 billion

PacifiCorp is a Berkshire Hathaway Energy Company

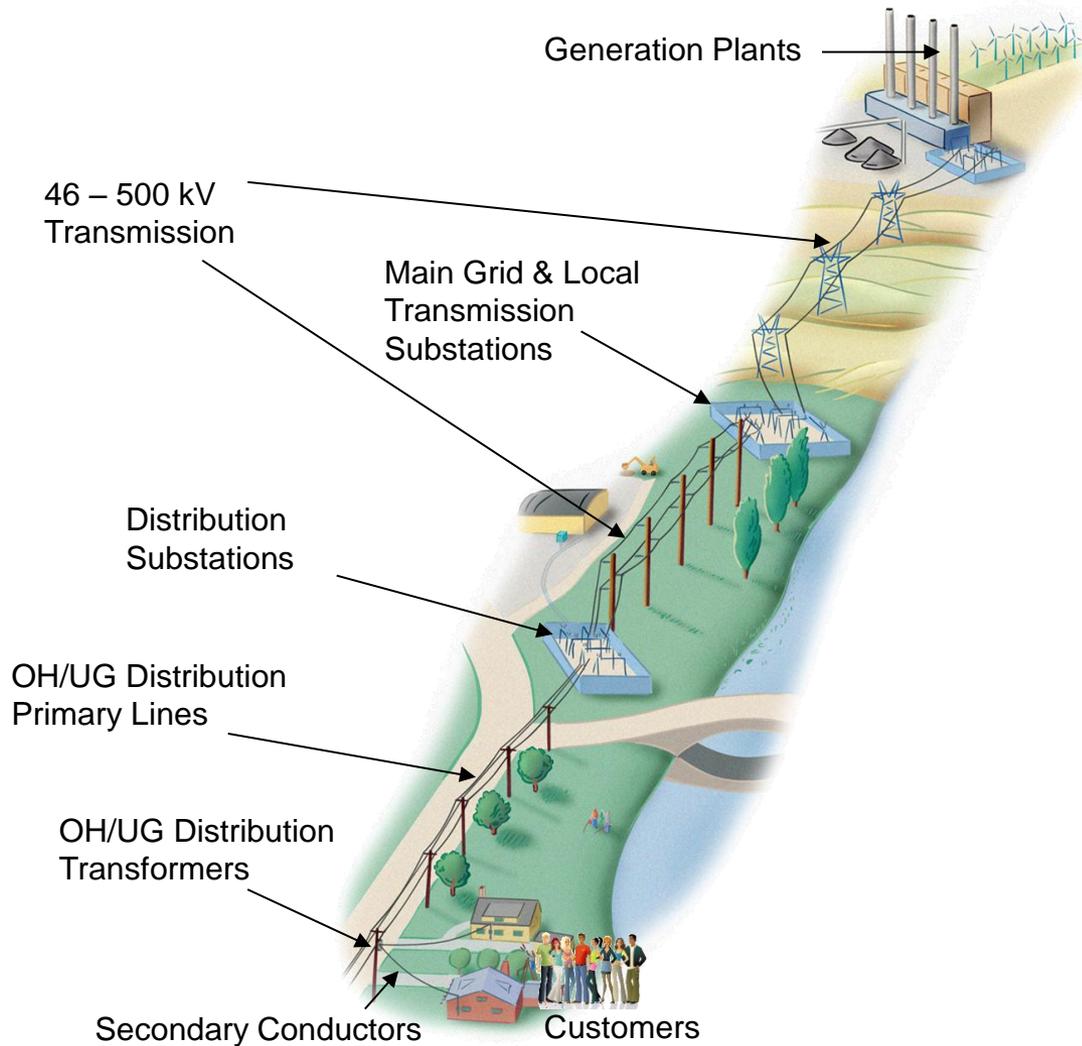
- By the end of 2014 Berkshire Hathaway Energy will own or receive
 - 8% of wind capacity in U.S.
 - 20% of solar capacity in U.S.
- Berkshire Hathaway Energy includes utility in the U.K. with active energy storage initiative
- Also includes 4 MW battery project in Texas with AEP
- Seeks balanced outcome of core principles



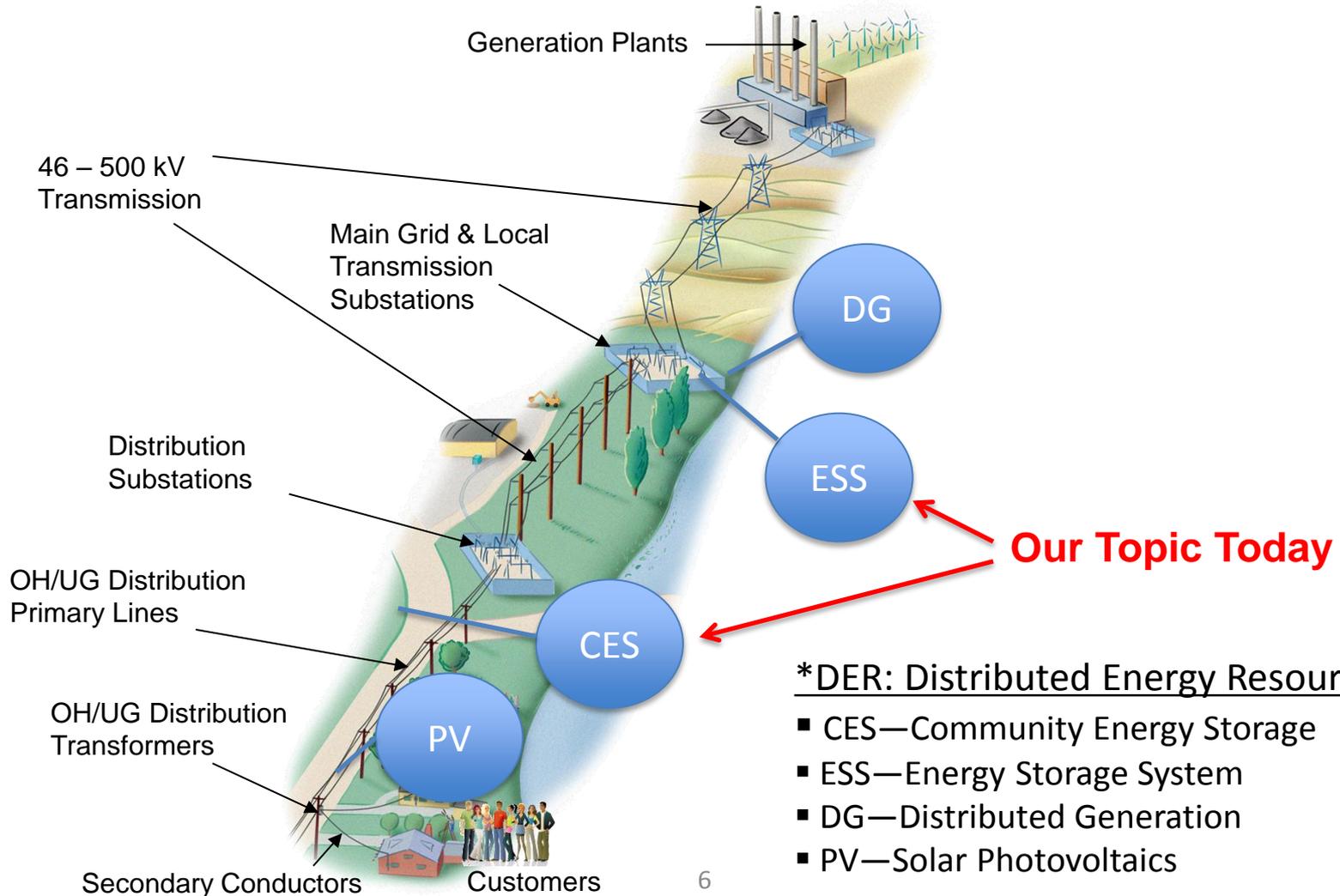
Core Principles

- Customer Service
- Operational Excellence
- Employee Commitment
- Regulatory Integrity
- Environmental Respect
- Financial Strength

The Power System of Yesteryear

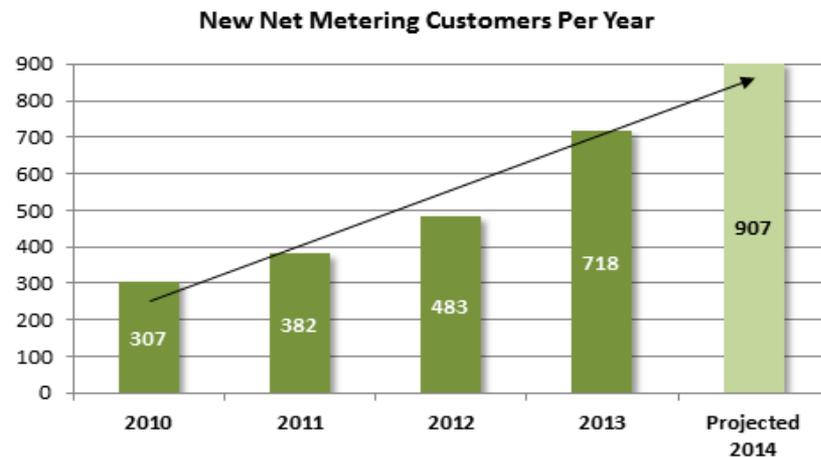


The Power System of the Future with DER*

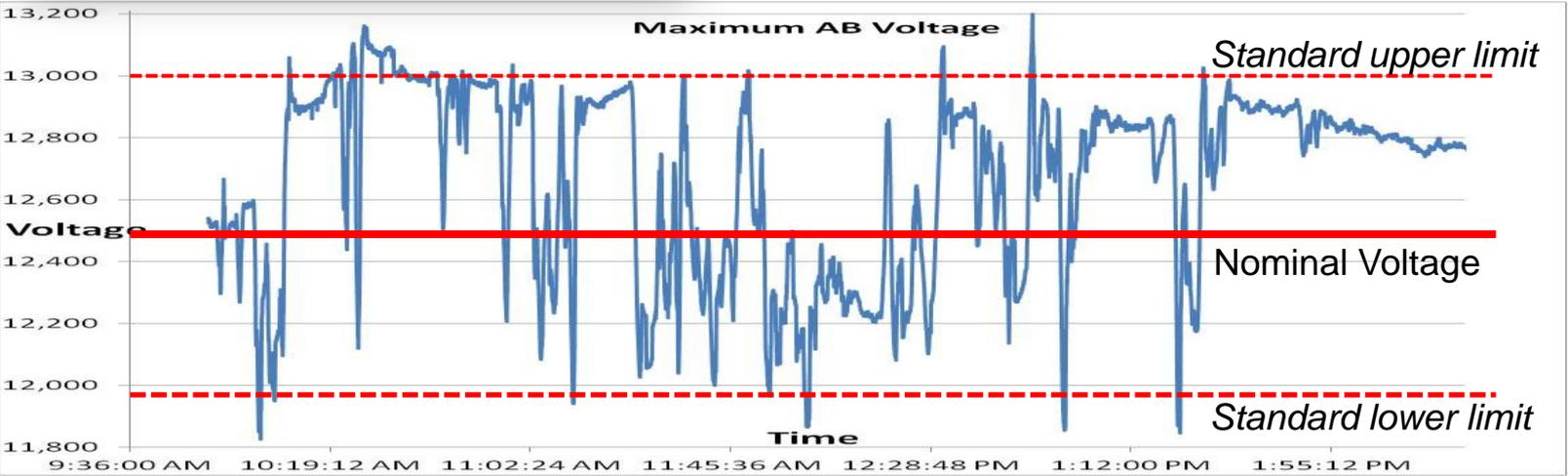
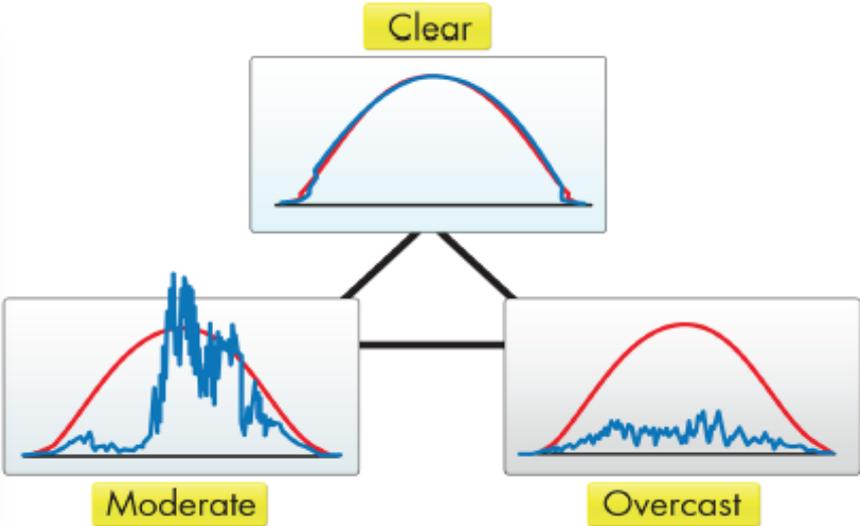


Growth in Customer Generation

- More than 2,200 net metering customers in Utah, with 14.6 megawatts of generating capacity.
- More RMP customers are generating part of their own electricity, primarily with solar panels (96%).
- Net metering measures the difference between the energy a customer consumes from the utility and the energy generated and sent to the utility.

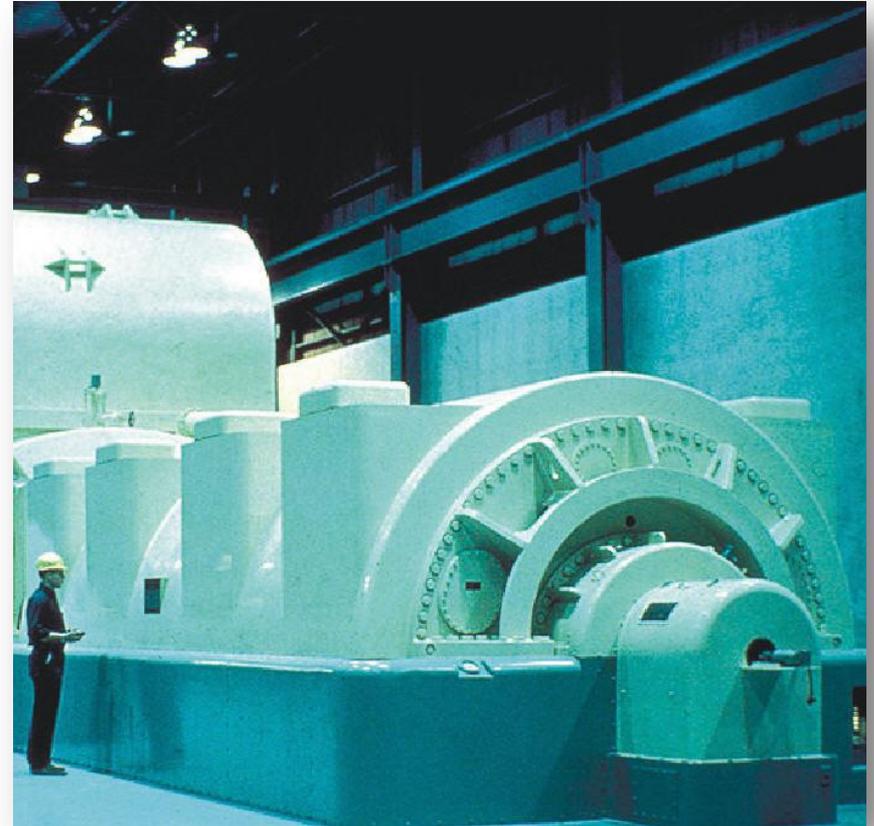


Renewables Integration: Intermittency Issue



Utility Energy Storage Basics

- Electric utilities are unique—historically electricity is not “warehoused” AFTER its production, it’s been too costly.
- Traditional hydroelectric and fossil generation needs are forecast and matched to load minute by minute.
- Historically the storage has been in two places:
 - the collective “rotating mass” of the interconnected power system
 - The hydro reservoirs and coal piles of the power plants
- Different applications are now driving electricity storage.



Potential Utility Storage “Apps”

(from 19 possible applications in the Sandia Labs Report, February 2010)

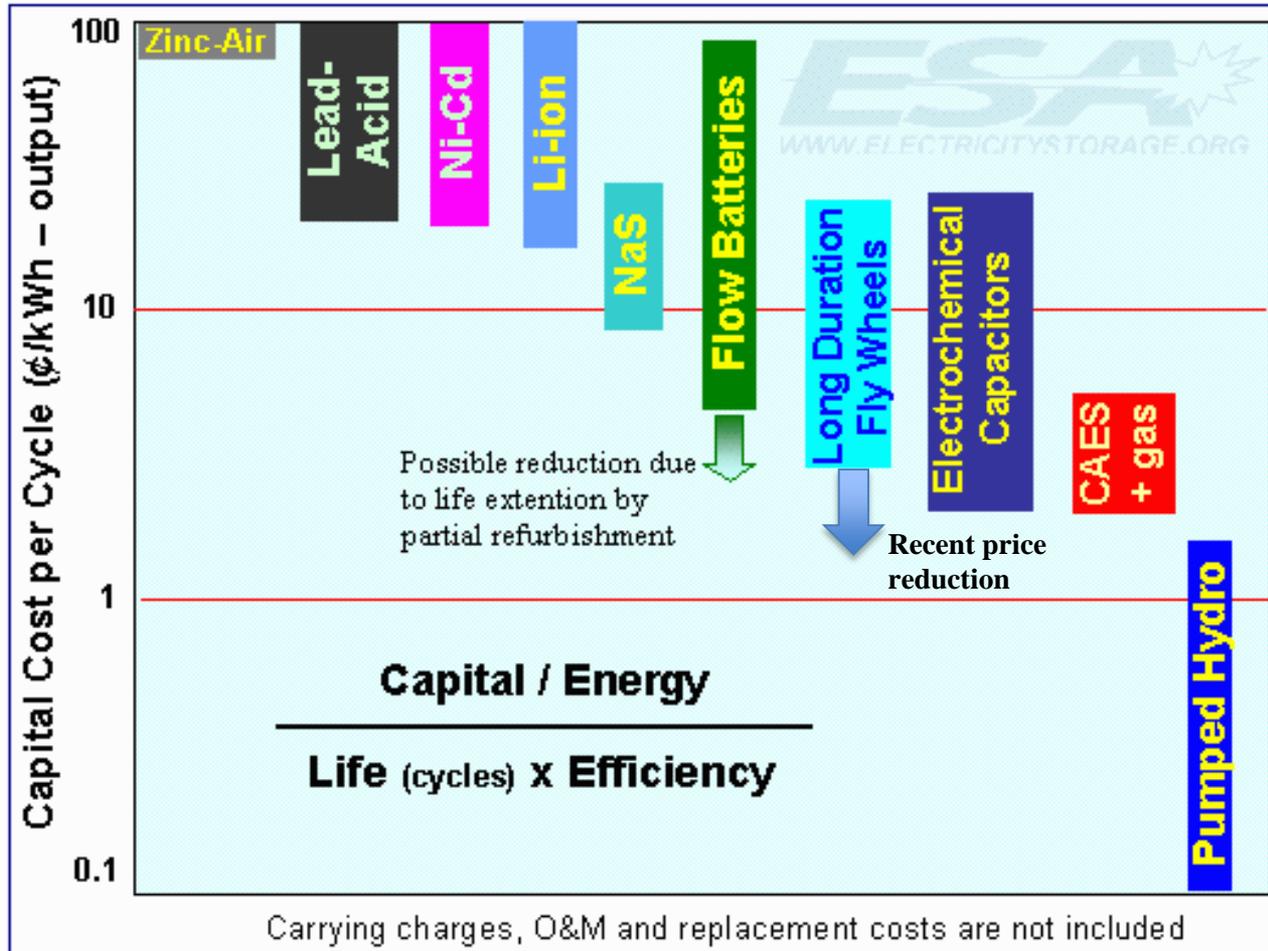
- **Large-scale Energy**

- Energy time shift
(“energy arbitrage”)
- **Renewables integration**
(long-term—hours/days)
- Demand response
- Supply reserve
- Investment deferral
- Transmission congestion relief

- **Smaller-scale Energy**

- **Frequency regulation**
(Energy balancing)
- Steady-state V support
- **Renewables integration**
(short-term—minutes)
- Sag ride-through
- Outage ride-through
- Resiliency (emergencies)

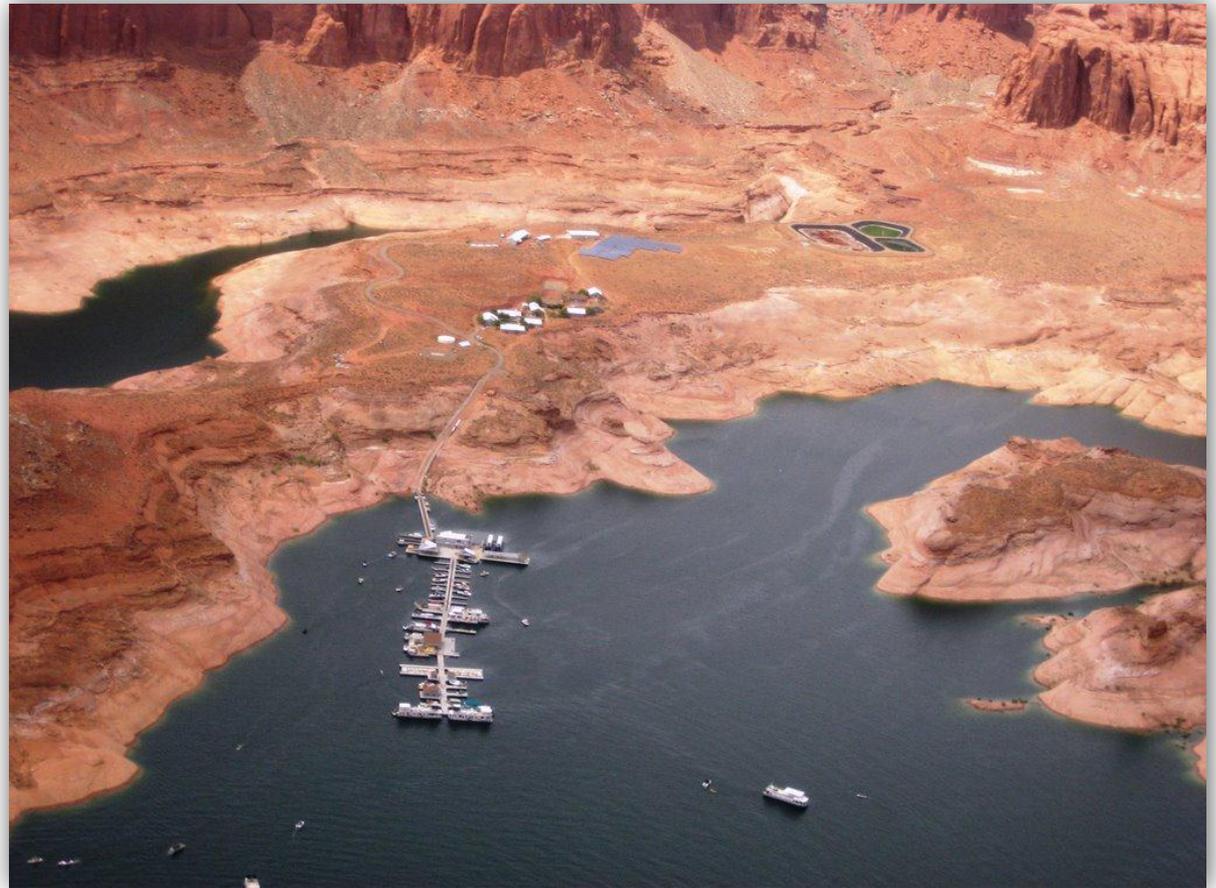
Per Cycle Energy Storage Costs



First Experience with Renewable Generation

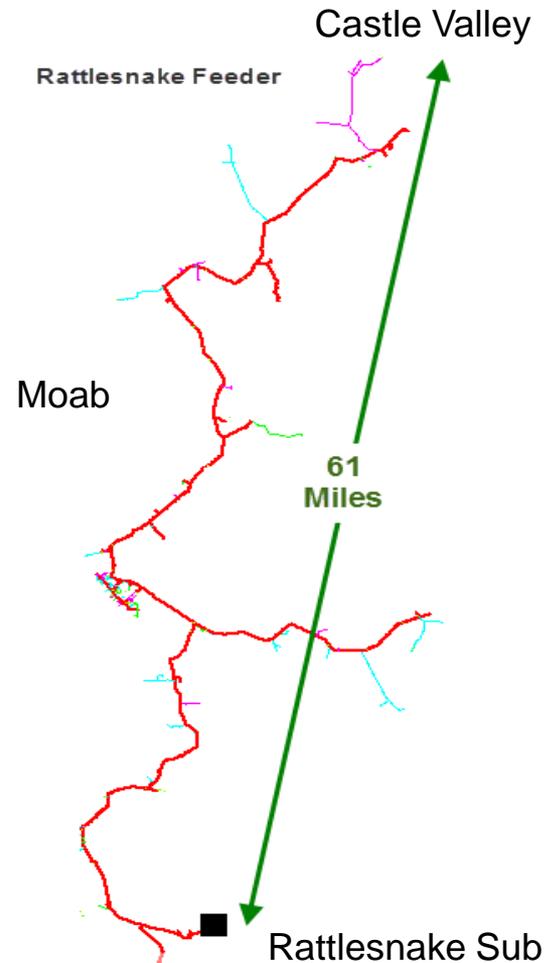
Dangling Rope Marina on Lake Powell

- Installed in 1993
- Cooperation and learning for
 - Utah Energy Office
 - National Park Service
 - Sandia Labs
 - PacifiCorp
- Hybrid System
 - Solar PV-115 kW
 - Lead-Acid Batteries
 - Energy efficiency
 - Natural gas generator
- Off grid system—a “microgrid”



PacifiCorp's First Energy Storage Pilot

- Started in 2001
- 85 mile Rattlesnake feeder at 25 kV, north of Moab, Utah
- Surrounded by National Parks and sensitive environments
- Permitting difficult
- New load requests denied in Castle Valley; reliability issues
- Load was higher in daytime during summer—HVAC
- Classic day/night storage case



Castle Valley Vanadium Redox Flow Battery

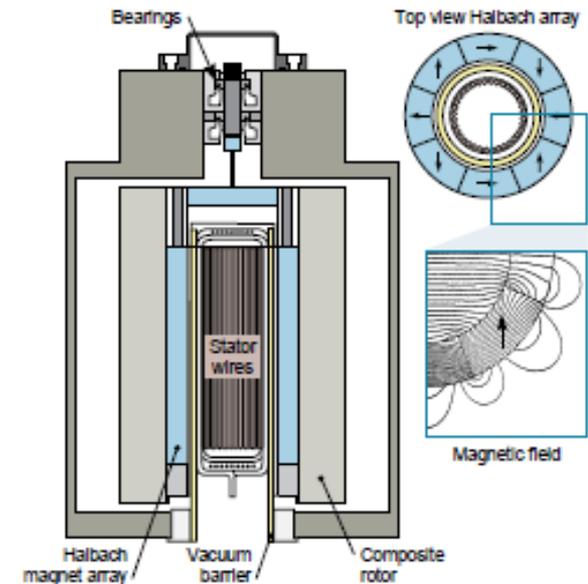
- Several technologies compared
- Projected CAPEX \$525/kWh
- Project started in 2002
- 250 kW, 2.0 MWh design
- “Early adopter” issues
 - Reliability of system
 - High parasitic load
 - Remote site/high tech issues
 - Supplier business issues
- Actual CAPEX \$925/kWh by 2006-2007
- Environmental concerns on cleanup



The Electromechanical Battery

An Attempt to Drive Down Clean Storage Costs

- EMB Energy worked with Lawrence Livermore National Labs
- Innovative fresh ideas
- Promising science and engineering
- PacifiCorp followed R&D 2010-2012 and had a demo site selected
- EMB lost its venture capital funding at end of 2012
- Project cancelled, but technical merits still seen as attractive



Note: early concept design shown here is publicly available; no confidential designs disclosed.

Commercial Flywheel technology

Beacon Power has the highest energy flywheel in commercial operation

- ~7' tall, 3' in diameter
- 2,500 pound rotor mass
- Spins up to 16,000 rpm
- Max power rating 190 kW, 30 kWh/charge
- Lifetime throughput is over 4,375 MWh
- Capable of charging or discharging at full rated power without restriction
- Beacon flywheel technology is protected by over 60 patents



Are We There Yet?

Looking for a compelling utility-scale project in this fast-moving area

- Perhaps a liquid metal battery when fully commercial, or flywheel hybrid
- Must provide safe, reliable, and affordable power to customers
- Meets balanced outcomes:
 - Price is right
 - Serves customers better than alternative technologies
 - Minimal impact on the environment
 - Regulatory approval and recovery of investment

