Enhancing Renewable Systems with Electricity Storage

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Storage Enhancements Possible

- Storage can decrease the intermittency of wind and solar
- Storage could provide “faster” response for frequency regulation
- Storage can provide dynamic VAR support
- Improve grid reliability performance

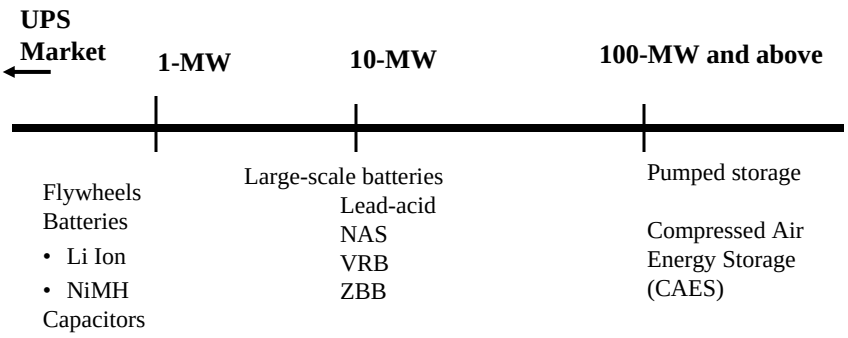
Storage in the Grid

- Pumped hydro has provided long term bulk storage in the grid
  - USA…… >2%
  - Europe……..10%
  - Japan……15%

Newer types of storage

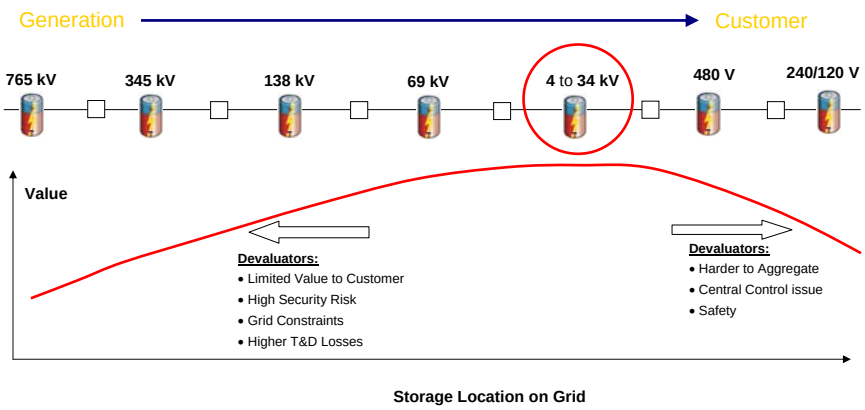
- Compressed Air Energy Storage (CAES) is gaining acceptance for mid-range applications
- Distributed storage emerging
  - Sodium Sulfur (NAS) battery
  - Flow batteries
- Flywheel energy being applied for fast acting ancillary services

Electricity Storage Technology Spectrum



Source: PacifiCorp

Storage Location in the Grid



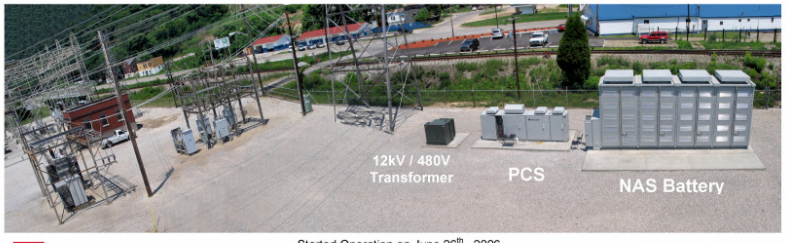
Distributed Storage Examples

- T&D growth deferment
- Dispatchable wind energy
- Ancillary services – frequency regulation

Storage Project Overview

Substation growth deferment using storage

1.2 MW, 7.2 MWh Distributed Energy Storage System in Chemical Station, North Charleston

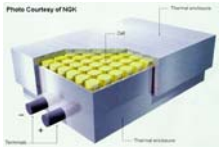


AEP APPALACHIAN POWER
A unit of American Electric Power

Started Operation on June 26th, 2006

NGK Insulators Ltd
S&C Electric Co.
DOE / SANDIA

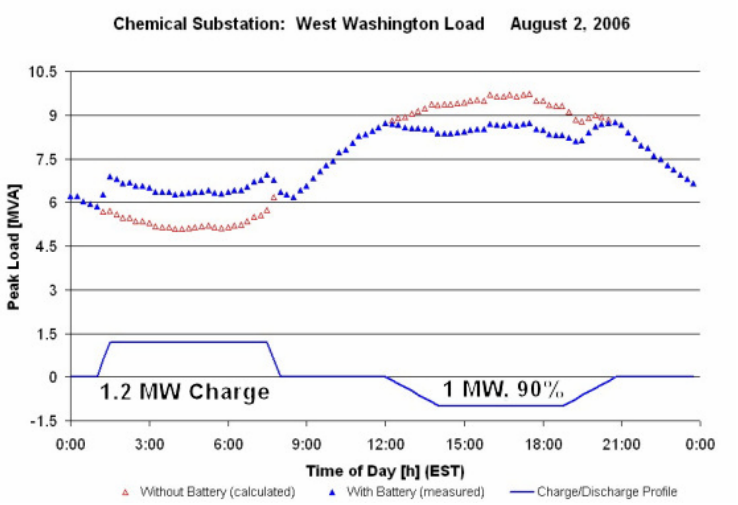
Distributed Energy Storage System (DESS) Components



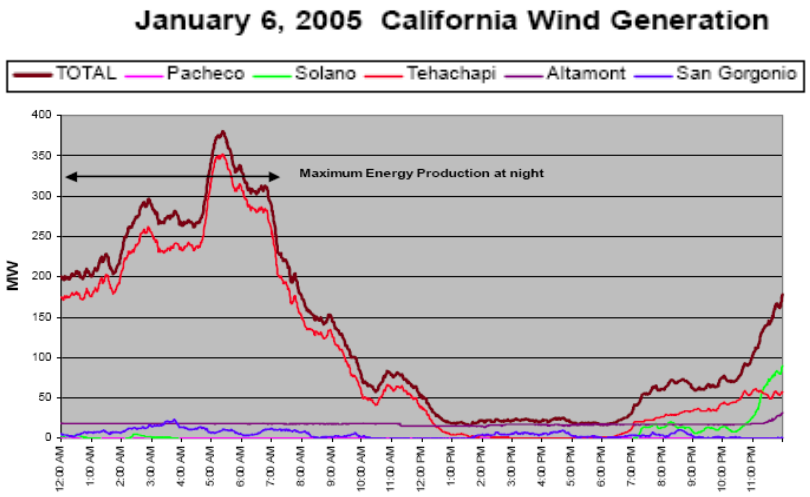
50 kW Battery Module

1.0-MW, 7.2-MWh NAS Battery

Example of Battery Peak Shaving



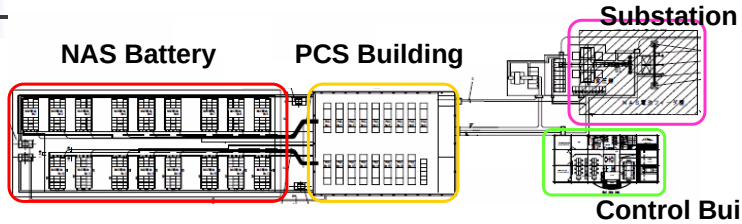
The Benefit of Time-Shifting Wind Generation



JAPAN WIND DEVELOPMENT CO., LTD.

NGK INSULATORS, LTD.

Construction of 34MW NAS Battery System




Battery Enclosure


Module Setting


PCS Building


Inside Building


Substation


Control Building

Storage Project Update - VRB

Wind site installation at Denmark's RISO National Laboratory, installed August 2007


20-kW – 4-quadrant PCS

Cell stack assembly and piping – with pulse capability

Storage Project Updates - VRB

12-meter container VRB-ESS:

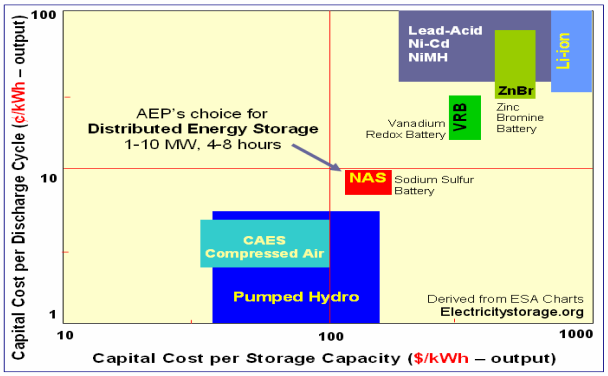
30-kW 60-kWh UPS, backing up a radar site

Installed in US facility in February 2007 as lead-acid battery replacement

20MW Flywheel Energy Storage System (FESS)

- Operational 24X7
- Provide ancillary services to ISO (faster response)
- Minimal operation and capital costs
- Liquid process cooling system to cool 200 flywheels and electronics
- Electrical System
  - One 20 MVA transformer
  - Ten ~2 MVA transformers

Cost & Benefits of Distributed Storage



NYSERDA[2] Study Report on Storage Values:

• Renewable Time Shift	$ 832/kW	30% - 40% of cost
• Renewable Capacity Firming	$ 323/kW	13% - 16% of cost
• T&D Upgrade Deferral	$1200/kW	50% - 60% of cost

2- "Guide to Estimating Benefits & Market Potential for Electricity Storage in New York", Final Report 07-06, March 2007

Distributed vs Bulk Storage

- Pumped Hydro and CAES are lower cost and larger scale solutions
- Distributed storage can potentially add more value to the grid by placing storage closest to the load
- Both types may be needed to meet the future demand

Value of Storage

- Do faster regulation energy sources have greater value than thermal units?
- Can storage have a long-term benefit on the true value of renewable energy?
- Can storage reduce or delay major T&D expenditures?

Storage in the Future Marketplace

The Energy Security and Security Independence Act of 2007:

- Envisions Smart Grid initiatives
- Views storage as feature of Smart Grids
- Barriers to storage need to be lowered to achieve Smart Grids