

# 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

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- Pumped hydro has provided long term bulk storage in the grid

USA..... >2%

Europe.....10%

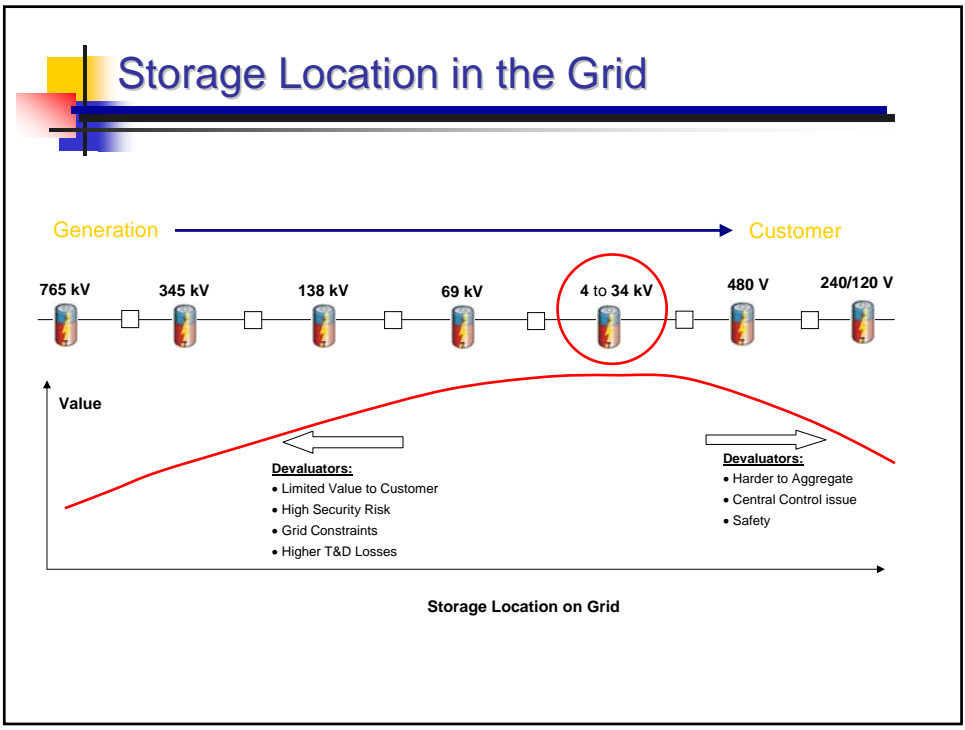
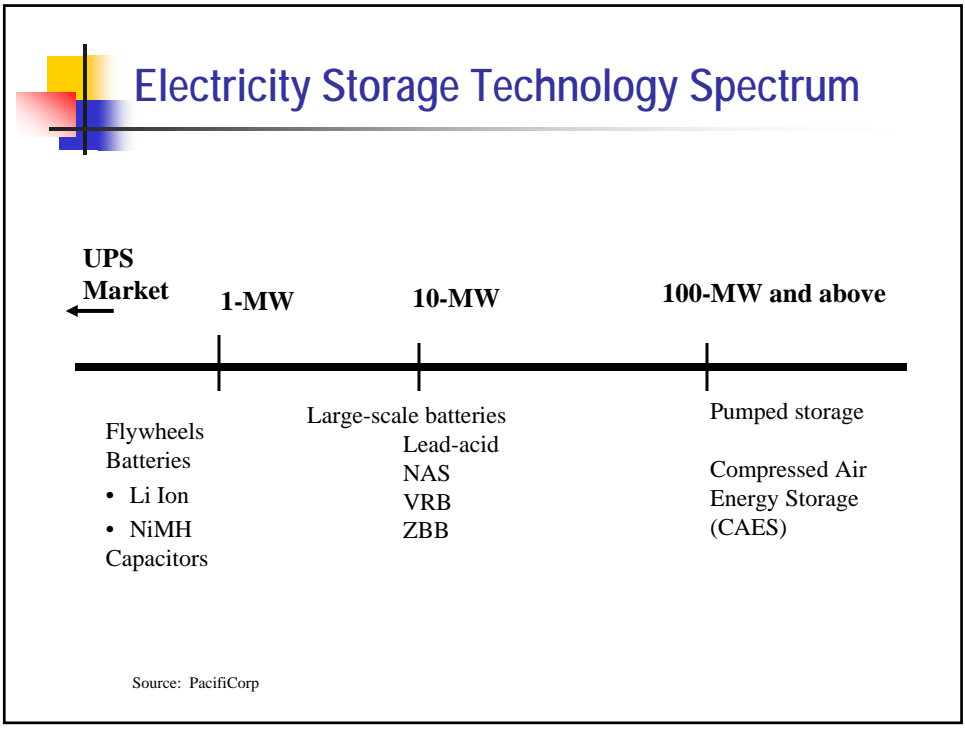
Japan.....15%



## Newer types of storage

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- 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





## 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

12kV / 480V  
Transformer

PCS

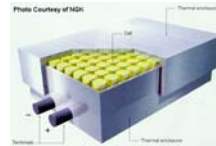
NAS Battery

Started Operation on June 26<sup>th</sup>, 2006

**AEP APPALACHIAN POWER**  
A unit of American Electric Power

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

## Distributed Energy Storage System (DESS) Components



50 kW Battery Module

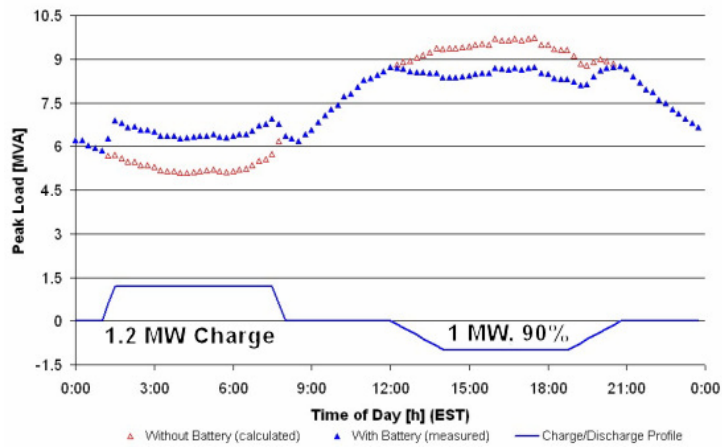
## 1.0-MW, 7.2-MWh NAS Battery





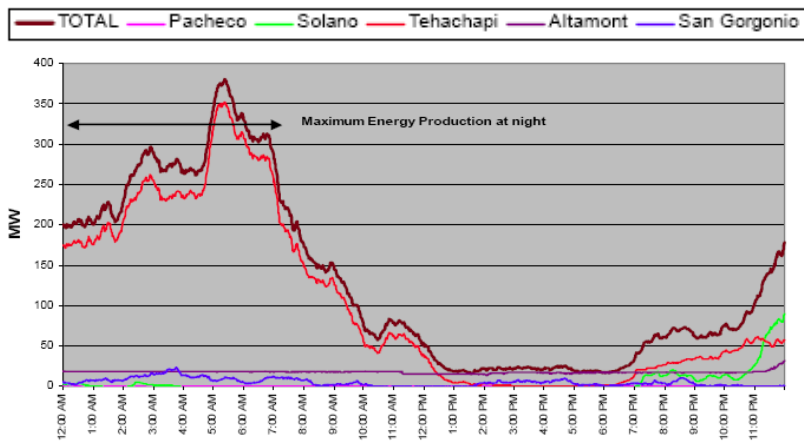
## Example of Battery Peak Shaving

Chemical Substation: West Washington Load August 2, 2006

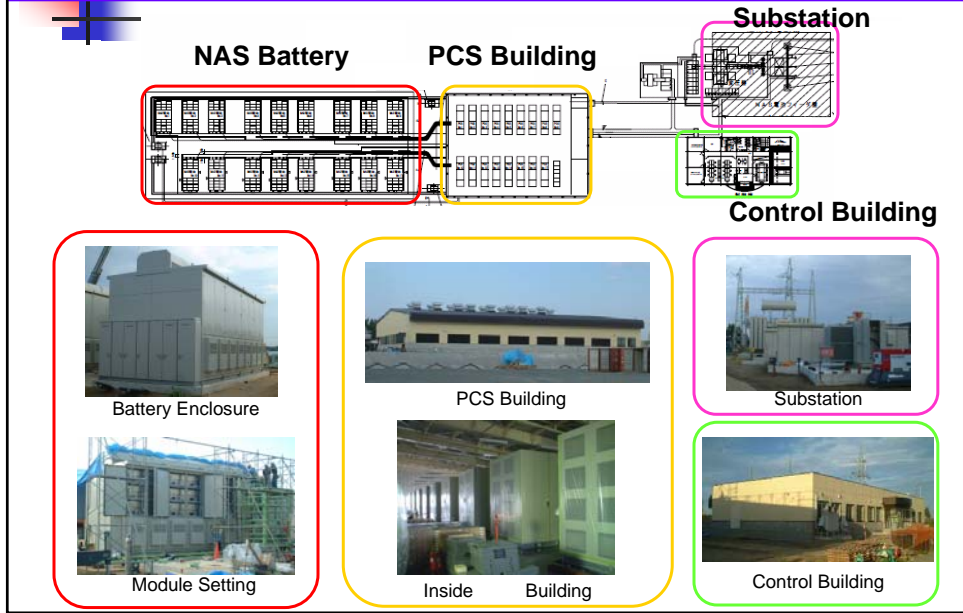


## The Benefit of Time-Shifting Wind Generation

January 6, 2005 California Wind Generation



Construction of 34MW NAS Battery System



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



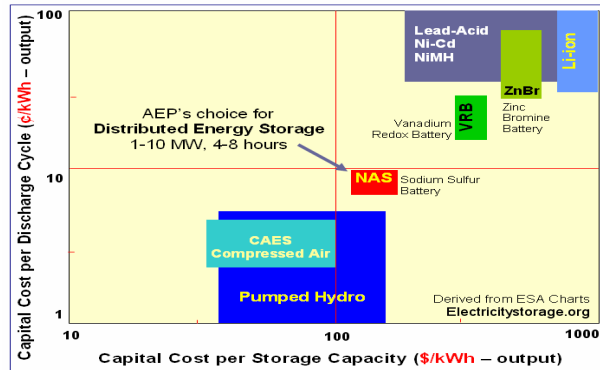
## 20MW Flywheel Energy Storage System (FESS)

- 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<sup>2</sup> 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

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- 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

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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