Modeling and Analysis of Value of Pumped Storage Hydro

NHA Annual Conference 2013

7B: Making the Business Case for Pumped Storage

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Drivers for Energy Storage: Recent Growth in Wind and Solar

Wind capacity is now over 60 GW

Source: AWEA 2013

Solar PV is now about 7.7 GW

Source: SEIA 2013

Worldwide energy storage projects by decade

Source: Pike Research 2012
Advanced Wind Forecasting Helps Reduce Uncertainty, Energy Storage Will Help Manage Variability

Current forecast tools do reasonably well

Mean absolute error is low (9.3%)

Forecasting ramps still an issue

Source: Iberdrola, 2009
Issued FERC Permits for New PSH in the U.S.

<table>
<thead>
<tr>
<th>State</th>
<th>Proposed Capacity (MW)</th>
<th>State</th>
<th>Proposed Capacity (MW)</th>
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<td><strong>TOTAL CAPACITY</strong></td>
<td><strong>47,873 MW</strong></td>
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Source: FERC Staff, January 1, 2013
Value of Energy Storage in Utility Systems

Three main components:

- Energy/price arbitrage (wholesale energy market)
- Ancillary services (reserves market)
- Portfolio effects (lower system operating costs, better integration of VER, reduced cycling of thermal units, increased system reliability, etc.)
PSH Can Help with Many Short-Term Control Issues

There is a need for better modeling and simulation of PSH plants at sub-hourly time scales.
Adjustable Speed PSH Technologies Provide Even More Flexibility than Conventional Fixed-Speed PSH

- Adjustable speed PSH with doubly-fed induction machines (DFIM):

- Ternary units with hydraulic short circuit:
Additional Benefits of Adjustable Speed PSH

- More flexible and efficient operation in generation mode
  - Minimum unit power output as low as 20%-30%
  - Increased efficiency and lifetime of the turbine at partial loads by operating at optimal speed

- Frequency regulation capabilities also available in the pumping mode

- Electronically decoupled control of active and reactive power
  - Provides more flexible voltage support

- Improved dynamic behavior and stability of power system
  - Improved transient stability in case of grid faults (e.g., short circuit faults in the transmission system)
  - Reduced frequency drops in case of generator outages

- Better compensation of variability of renewable energy sources
  - More flexible and quicker response in generating (turbine) mode
  - Variable power in pumping mode to counterbalance variability of wind
  - Excellent source of frequency regulation during the off-peak hours
An Ongoing DOE-funded Study looks into the Modeling and Value of Advanced PSH Technologies in the U.S.

Project goal:

Develop detailed models of advanced PSH plants to analyze their technical capabilities to provide various grid services and to assess the value of these services under different market structures.

Main Objectives:

- Improve the modeling representation of advanced PSH and CH plants in the power system and electricity market simulation models
- Quantify their technical capabilities to provide various grid services
- Analyze the value of these services under different market conditions and for different levels of variable renewable generation (wind and solar) in the system
- Provide information about the full range of benefits and value of PSH and CH plants

Argonne National Laboratory, MWH, Siemens, NREL
Adjustable Speed PSH Provide Faster Dynamic Response than Conventional Fixed-Speed Units

- AS PSH response vs FS PSH response in case of nearby generating unit outage
Some Projections Show Substantial Market for Energy Storage Technologies

- Pike Research forecasts that total energy storage market will grow from $1.5B in 2010 to about $35B in 10 years (that’s 37% average annual growth rate!)

**Installed Revenue Opportunity by ESG Technology, World Markets: 2010-2020**

(Source: Pike Research)
Potential Market Barriers to Widespread Energy Storage Deployment

- Cost of the technology
- Risk of cost recovery
- Lack of adequate market rules
- Understanding the role and benefits of storage
- How to assess the value of storage in a given application
- Inadequate planning and operation (methods, training, software tools, etc.)

(Adapted from EAC 2012 Storage Report – Progress and Prospects: Recommendations for the U.S. Department of Energy)
Questions?

THANK YOU!