

# Modeling and Analysis of Value of Pumped Storage Hydro

NHA Annual Conference 2013

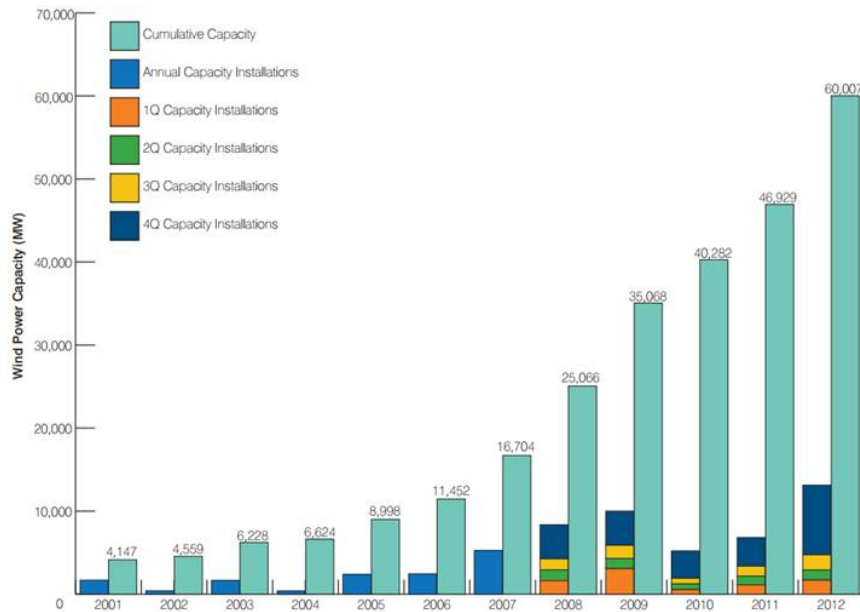
7B: Making the Business Case for Pumped Storage

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# Drivers for Energy Storage: Recent Growth in Wind and Solar



Wind capacity is now over 60 GW

Source: AWEA 2013

Figure 2.1 U.S. PV Installations and Global Market Share, 2000-2012

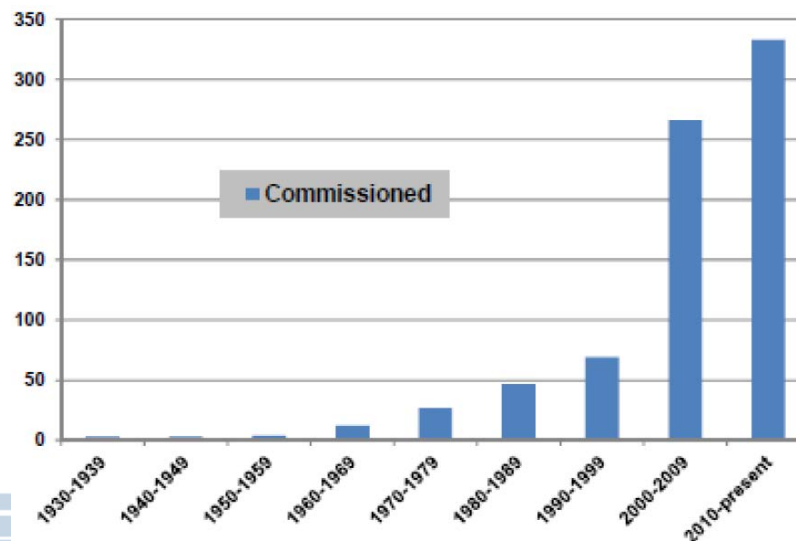


Solar PV is now about 7.7 GW

Source: SEIA 2013

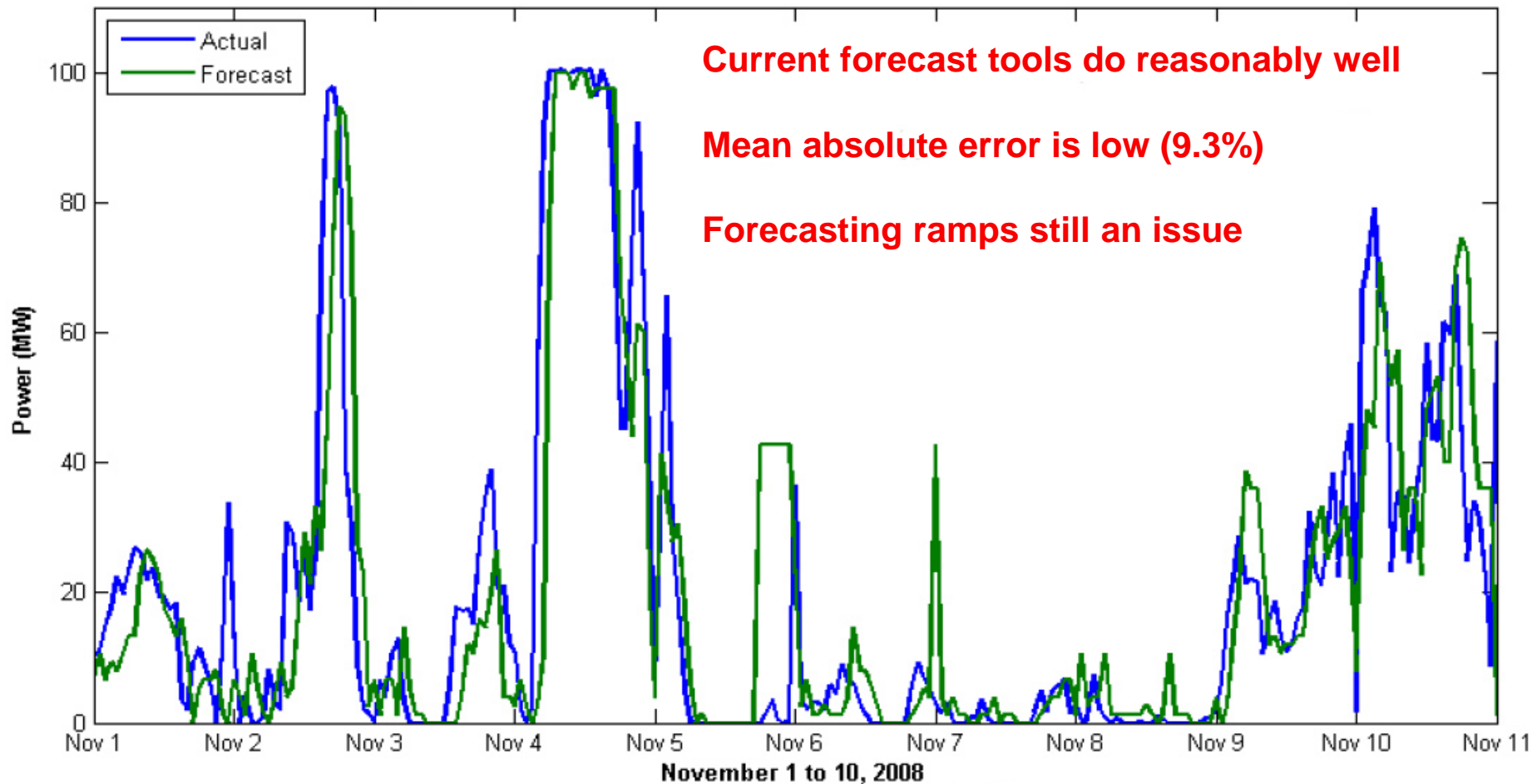
Worldwide energy storage projects by decade

Source: Pike Research 2012



# *Advanced Wind Forecasting Helps Reduce Uncertainty, Energy Storage Will Help Manage Variability*

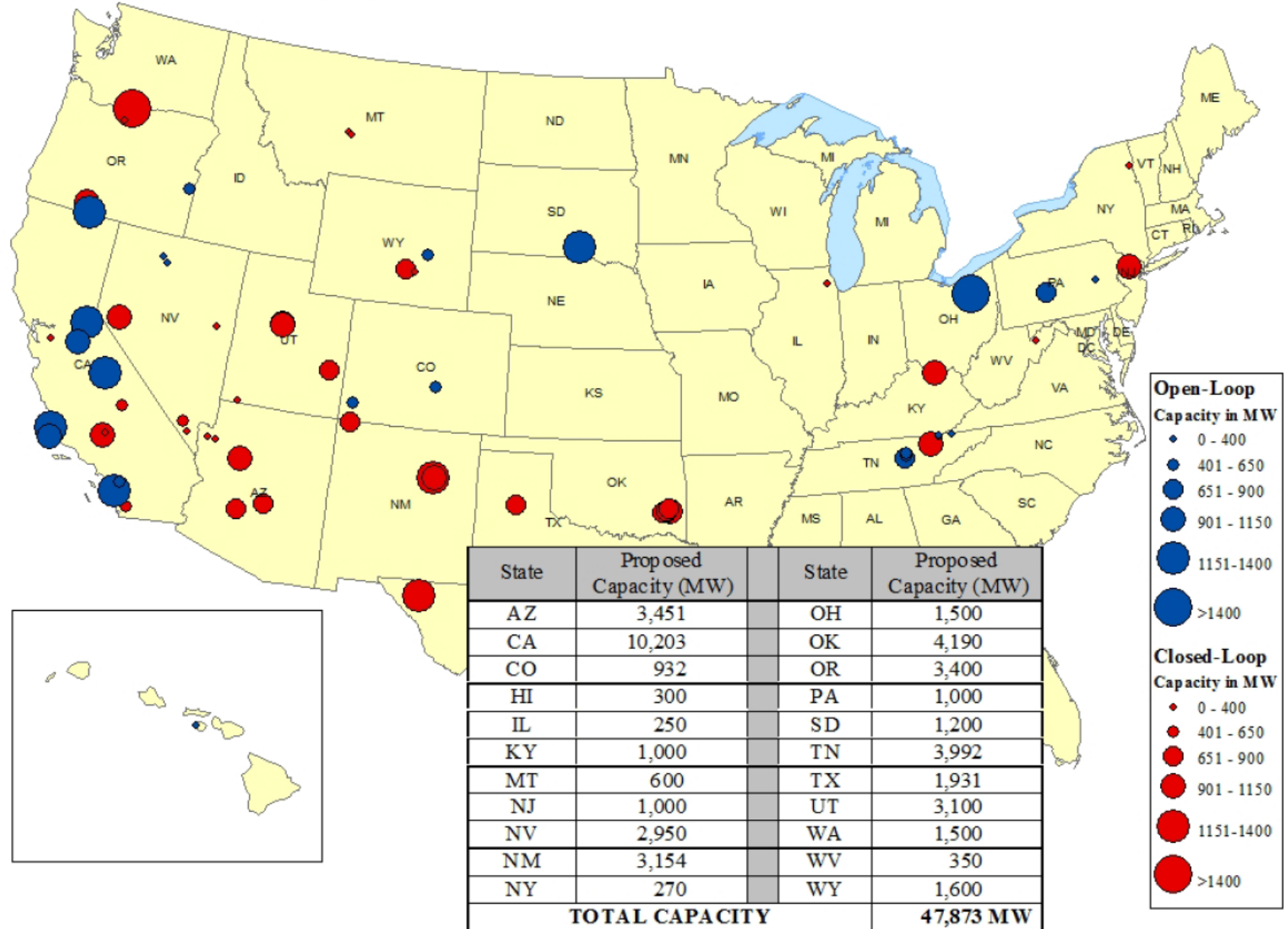
Comparison of Actual to Forecast For First Third Of November 2008



Source: Iberdrola, 2009



# Issued FERC Permits for New PSH in the U.S.



Source: FERC Staff, January 1, 2013

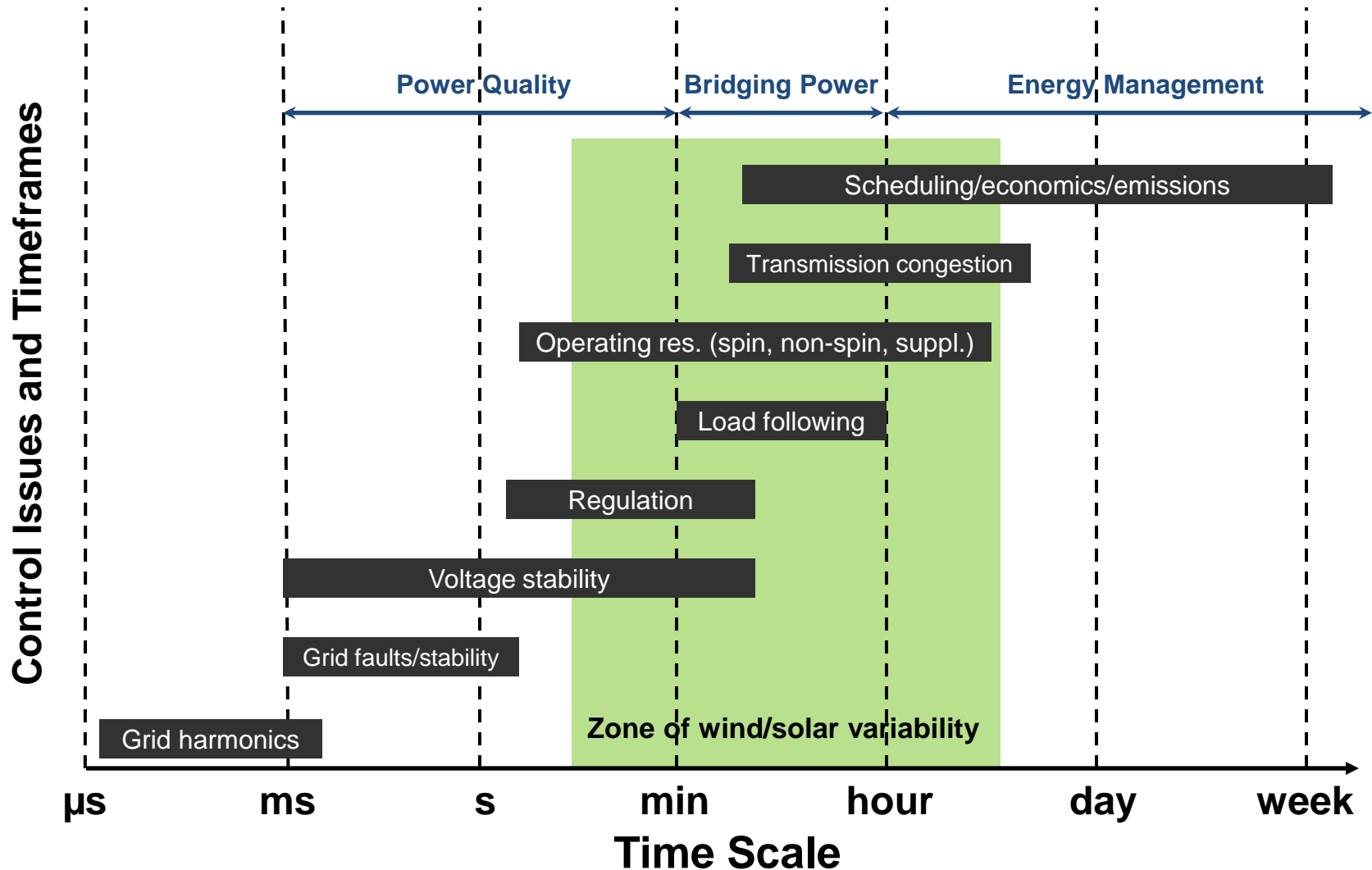
# ***Value of Energy Storage in Utility Systems***

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.)



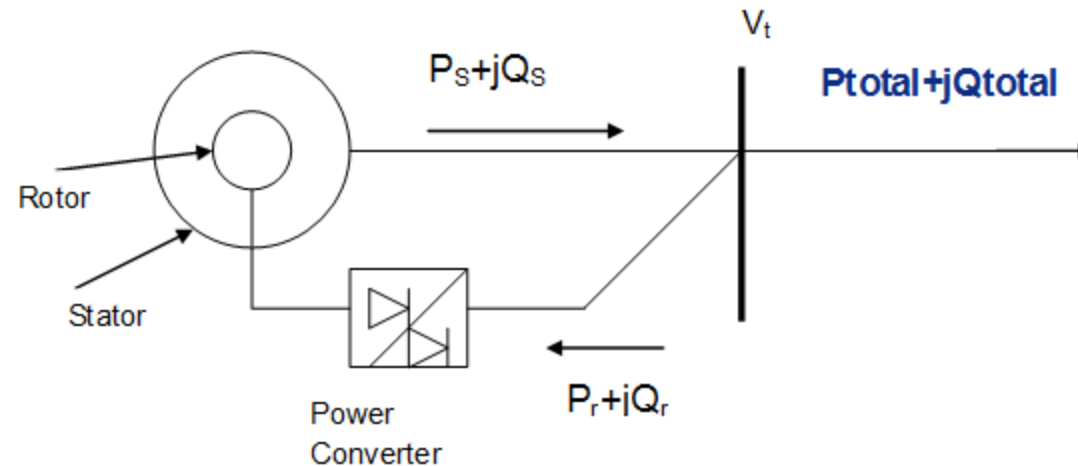
# *PSH Can Help with Many Short-Term Control Issues*



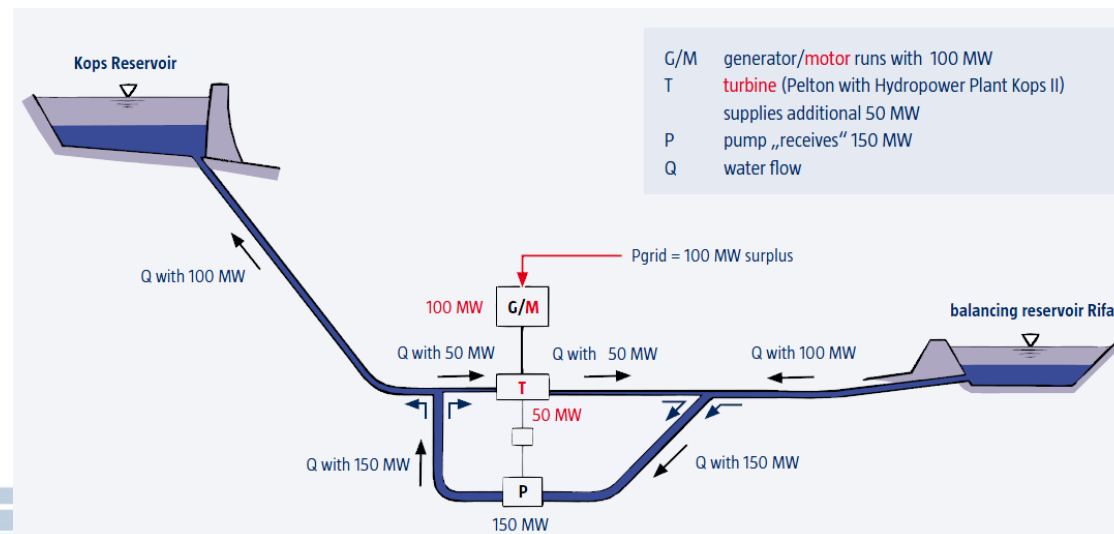
There is a need for better modeling and simulation of PSH plants at sub-hourly time scales.

# 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.

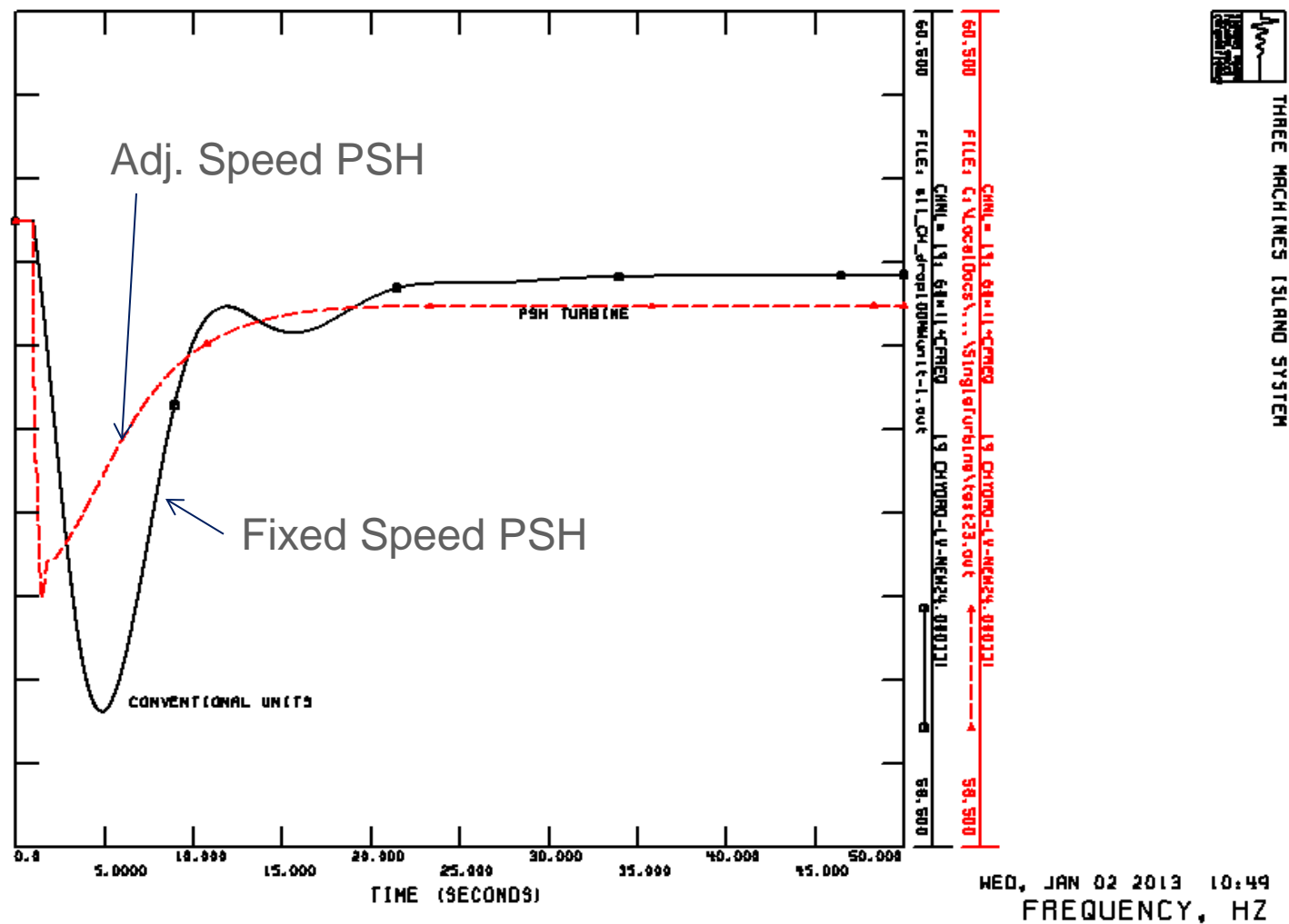
## **Main Objectives:**

- 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



# Adjustable Speed PSH Provide Faster Dynamic Response than Conventional Fixed-Speed Units

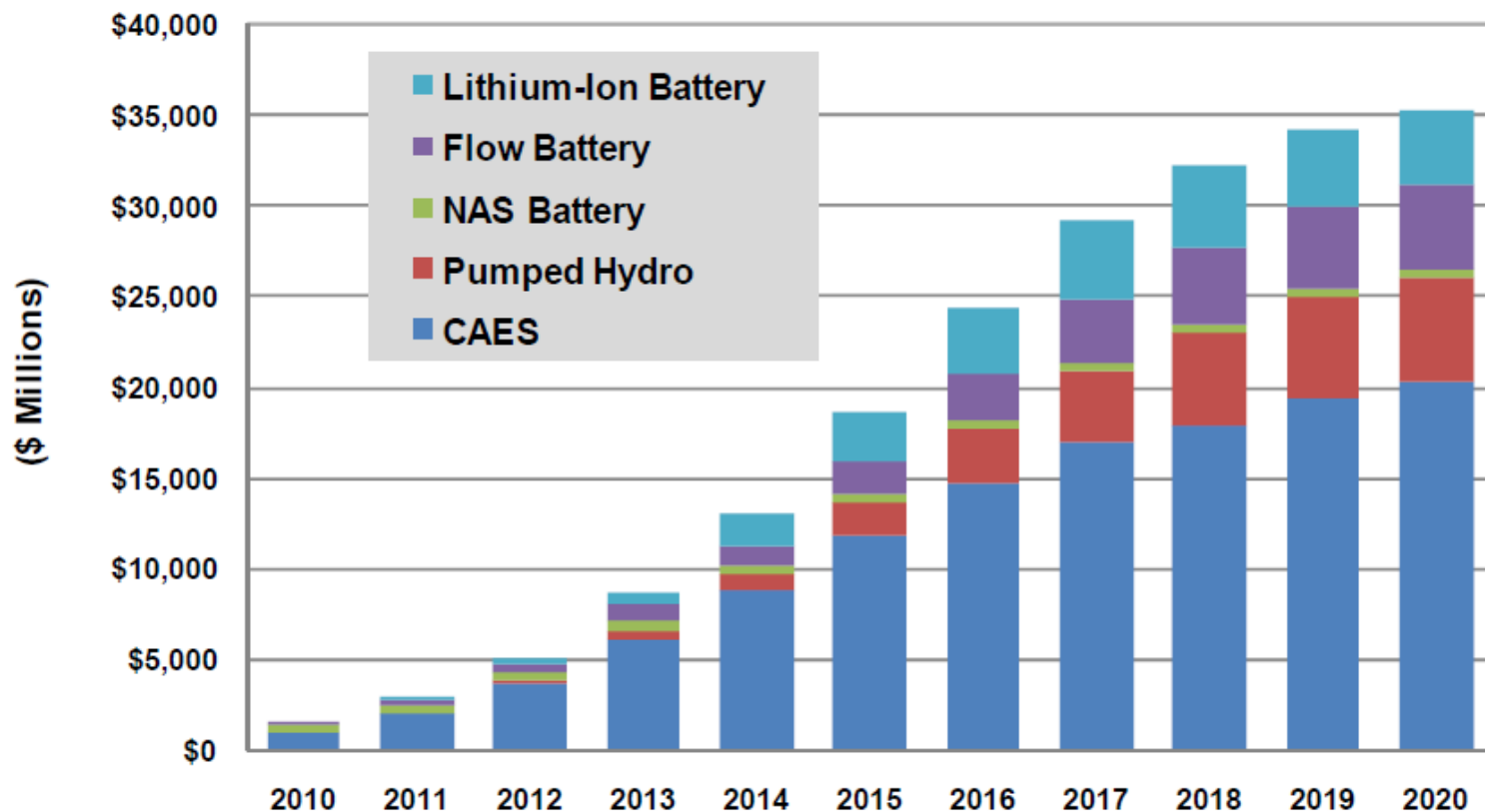
- AS PSH response vs FS PSH response in case of nearby generating unit outage



# 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!