



# **Renewables Integration** **Shaping the U.S. Electric System** **for Variable Renewables Integration**

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# Balancing Generation and Demand with a High Penetration of Renewables

- ▶ Today's grid has little flexibility- not enough for tomorrow's variable renewables
  - Essentially no capacity to store energy
  - Very little ability to control demand
- ▶ Today's power system operators control very few loads, so they must control generation to balance
- ▶ As variable renewable penetration increases, there will be less ability to control generation yet more variability that must be managed (i.e. the problems is getting worse)
- ▶ Not considering transmission issues and financial issues, *if 25% of loads were served by variable renewables tomorrow, the variability effects on the grid would result in unacceptable reliability.*

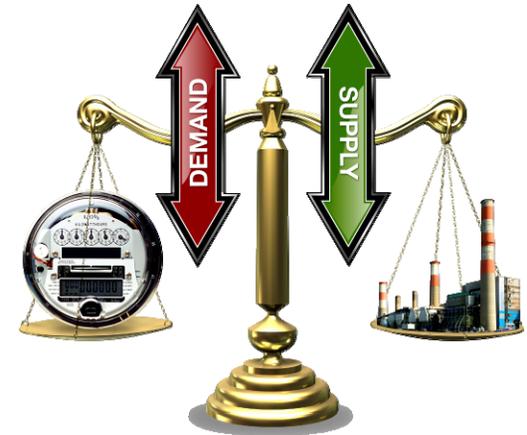
# How Can the Issue of *Balance* Be Addressed in the Emerging Grid?

- ▶ There is a solution, but no silver bullet (the solution is a combination of technologies, not a single technology)
  - Grid Operational Solutions
    - Sharing resources across BA's
    - Managing variability through geographic diversity
    - Advanced Wide-Area Controls
  - Grid Technology Solutions
    - Advanced Forecasting
    - Storage (many types for many purposes)
    - ***Demand Response***

# How can Demand Response Aid Renewables Integration?

## *Bring Real-time Communications And Control To Demand*

- ▶ Demand-side resources can be used for many different ancillary objectives
  - Load following reserves
  - Some forms of regulation
  - Contingency reserves
  - Peak demand reduction
  - Congestion management
- ▶ More throughput with existing assets; reduce need for new assets
- ▶ Enhanced reliability for the entire grid



# Smart Grid at the Distribution Level -- GridWise Demonstration Projects

- ▶ Olympic Peninsula GridWise demonstration
  - Explored how consumers respond to real-time pricing
  - Tested smart appliances in 112 homes for one year
  - Real-time, two-way market with real cash incentives
- ▶ Grid Friendly™ Appliance demonstration
  - Tested device response to stress on grid and consumer acceptance of device in appliances
  - Installed in 150 dryers for one year



# A Few Steps PNNL is Taking



## Industry Challenges

- ▶ Predicting wind ramps
- ▶ Meeting regulation/load following needs
- ▶ Managing overgeneration conditions
- ▶ Impact of regulation requirements on hydro units
- ▶ Better prediction of “tail” events such as Texas in spring 2008

## Current / Emerging PNNL Projects

- ▶ BPA Wind generation impact studies
- ▶ Wide area energy management system with energy storage to support renewables integration (BPA, CAISO)
- ▶ Integration of wind forecasts into operations procedures (CAISO)
- ▶ Framing demos to validate value of demand response for “fast regulation” support to renewable integration