Towards Sustainable Intra-Dispatch Real-Power Balancing

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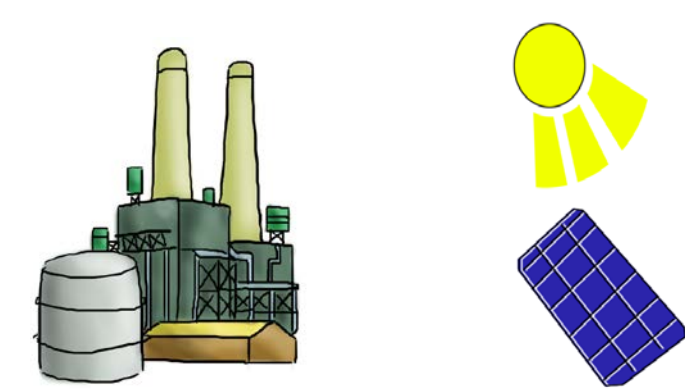nipun@cmu.edu; milic@ece.cmu.edu

Motivation

❖ Higher presence of wind energy in electric power systems, **requires more spinning reserves** *

❖ Align natural response of conventional generators with time-scales of variations in wind

❖ **Compensate for non-zero mean deviations in wind power output (Time Scale varies)**
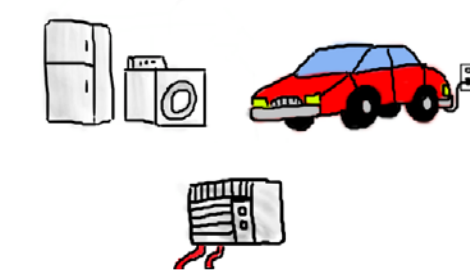
❖ Automate demand participation **to balance the system**

*Source: US Department of Energy,

http://www.ferc.gov/industries/electric/indus-act/reliability/frequencyresponsemetrics-report.pdf
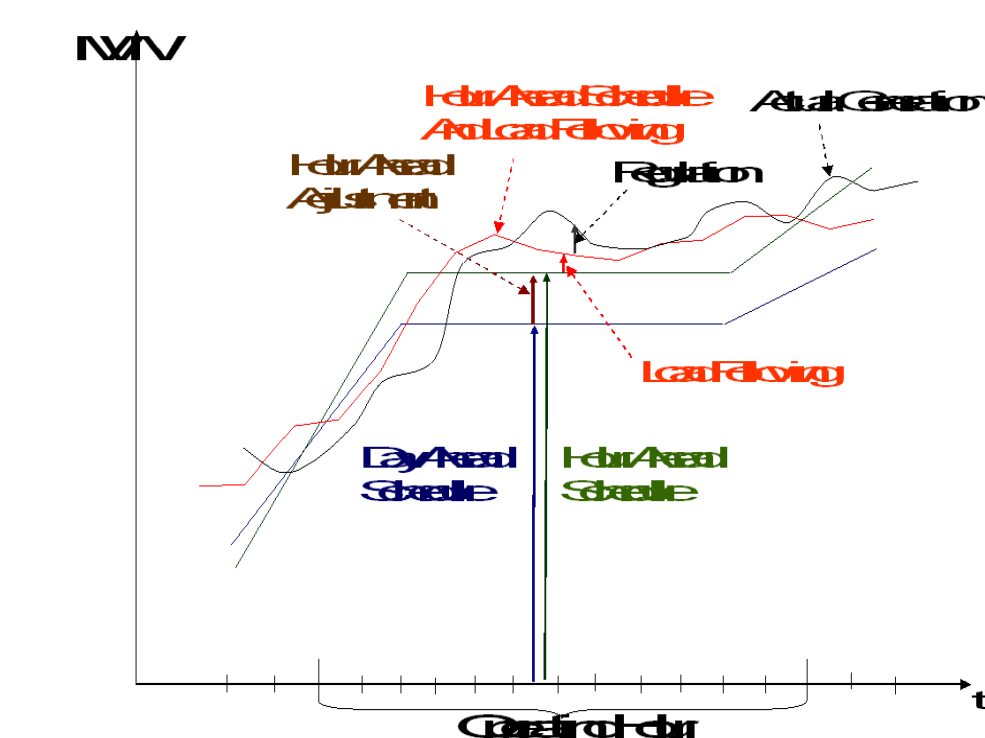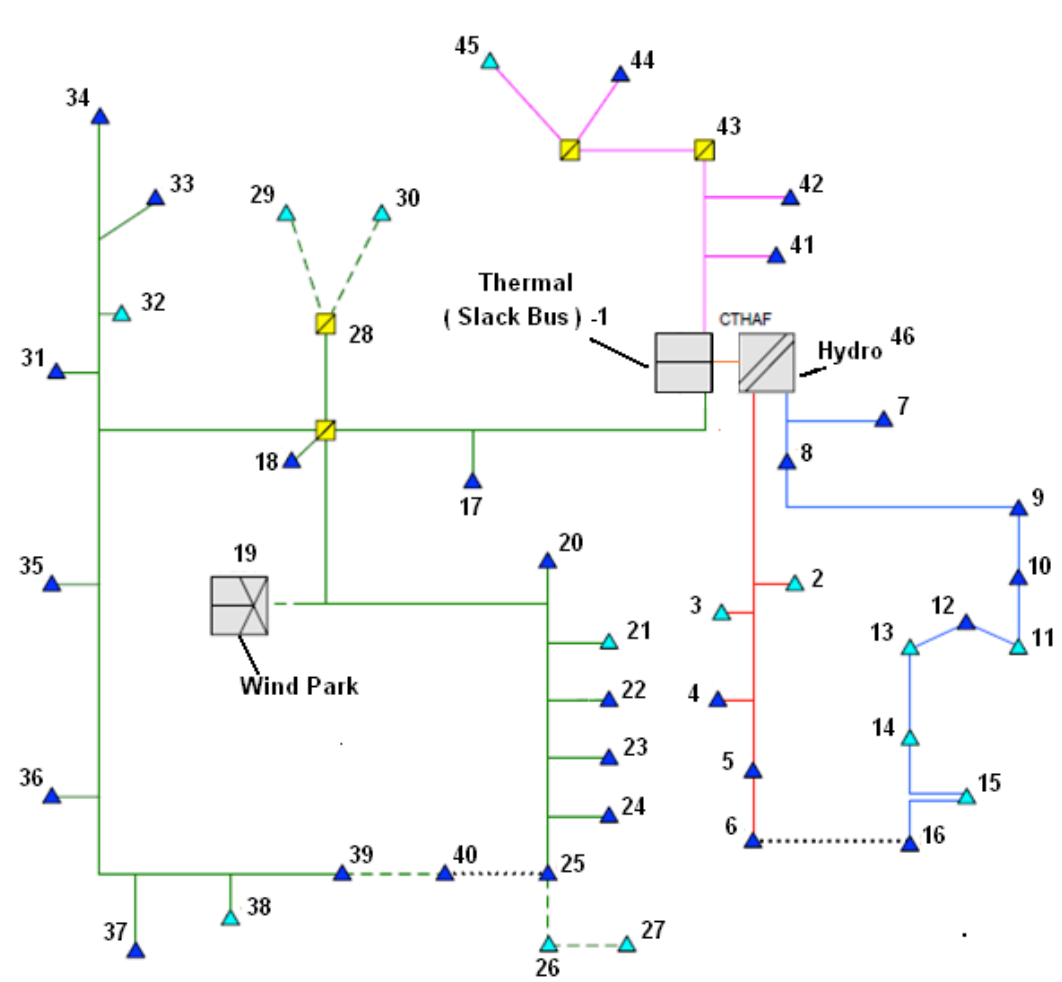
Sources and Sinks of Energy

❖ Controllable

❖ Dispatchable

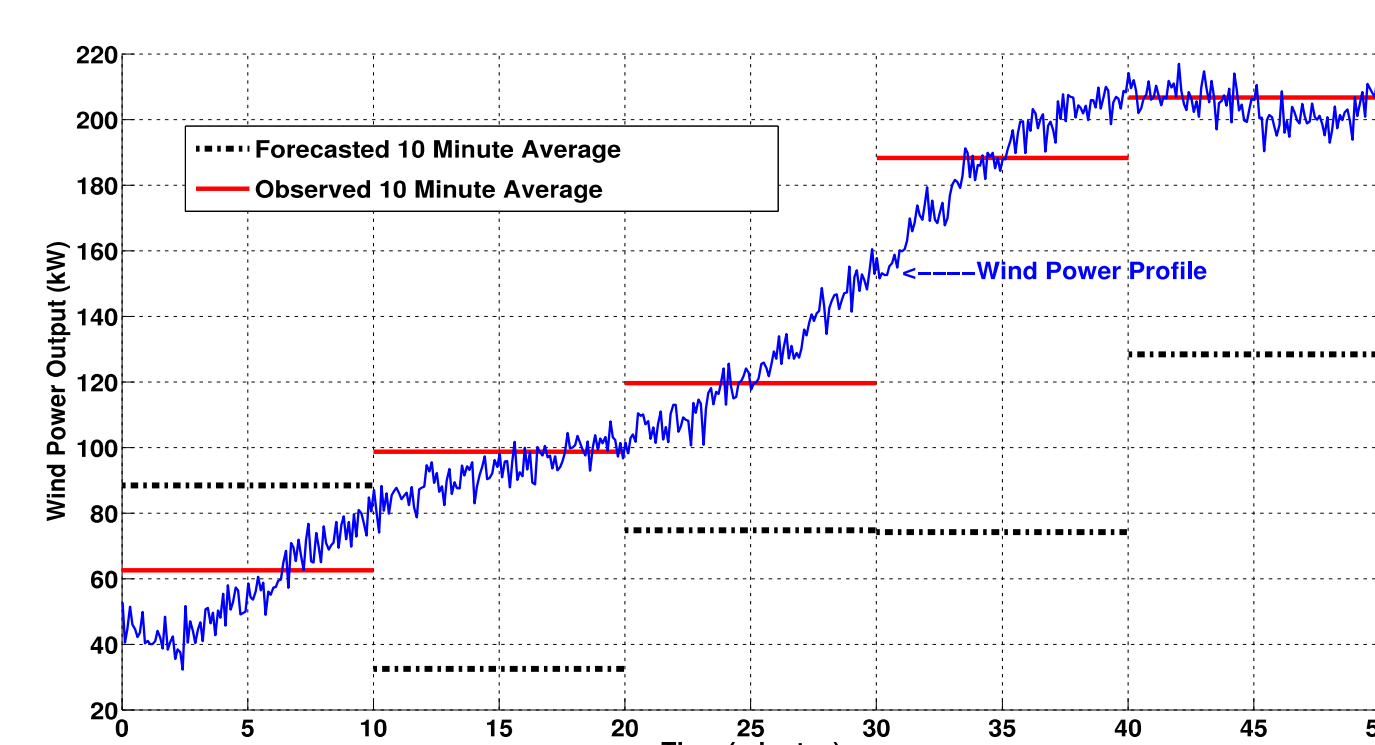❖ Time-Scale of Technology (Combustion/Steam/Hydro/Nuclear/Storage)

❖ Controllable/Responsive

❖ Nature (Inductive or Resistive)

❖ Residential/Industrial/ Commercial
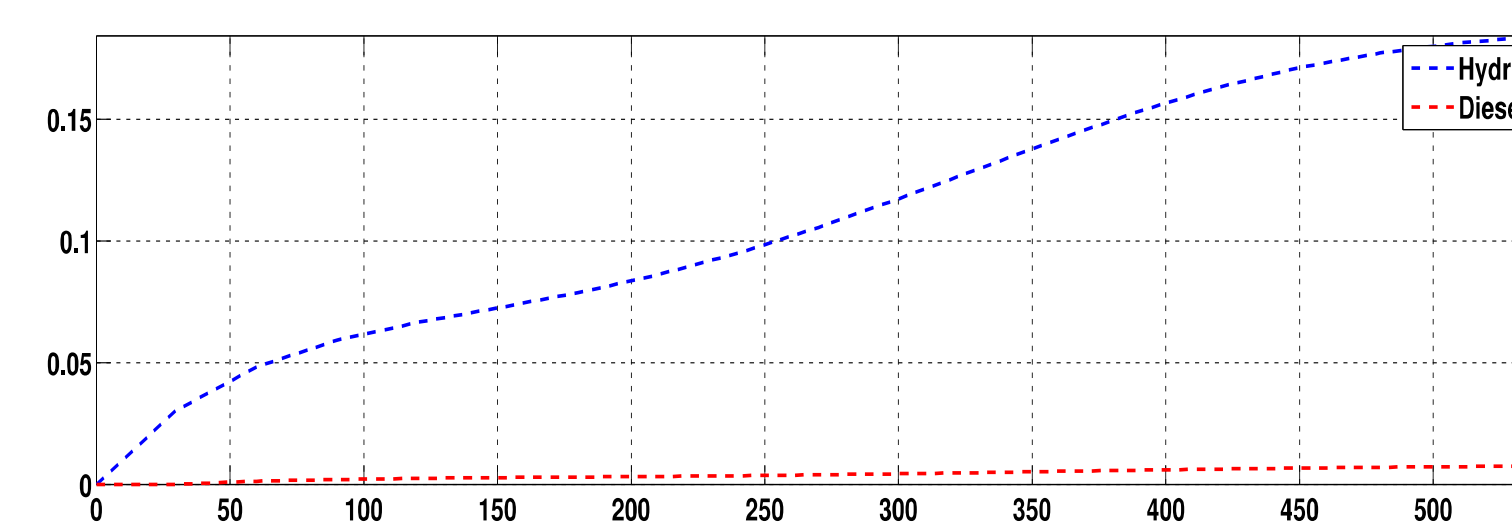
The Case of Flores Island

❖ Prediction Error

❖ Lack of Historical Data

❖ Hard-to-define Wind Ramps

❖ Controllable

❖ Dispatchable

❖ Time-Scale of Technology (Combustion/Steam/Hydro/Nuclear/Storage)
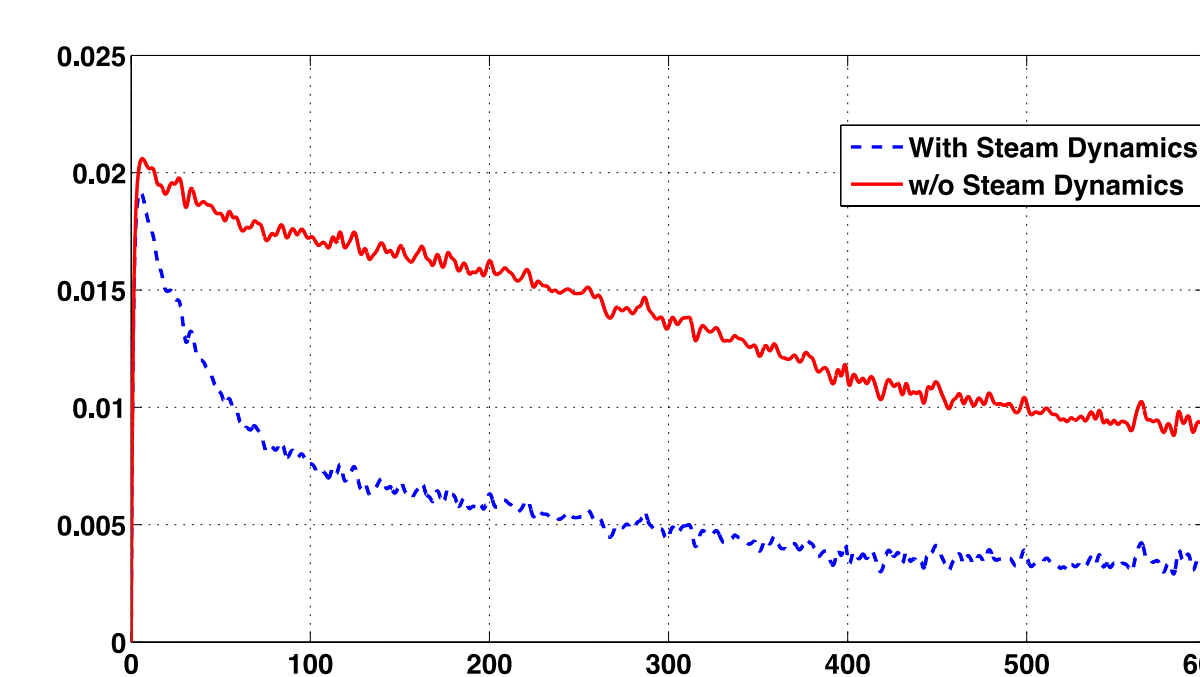
eesg

electric energy systems group

Sustainable Balancing through Generation

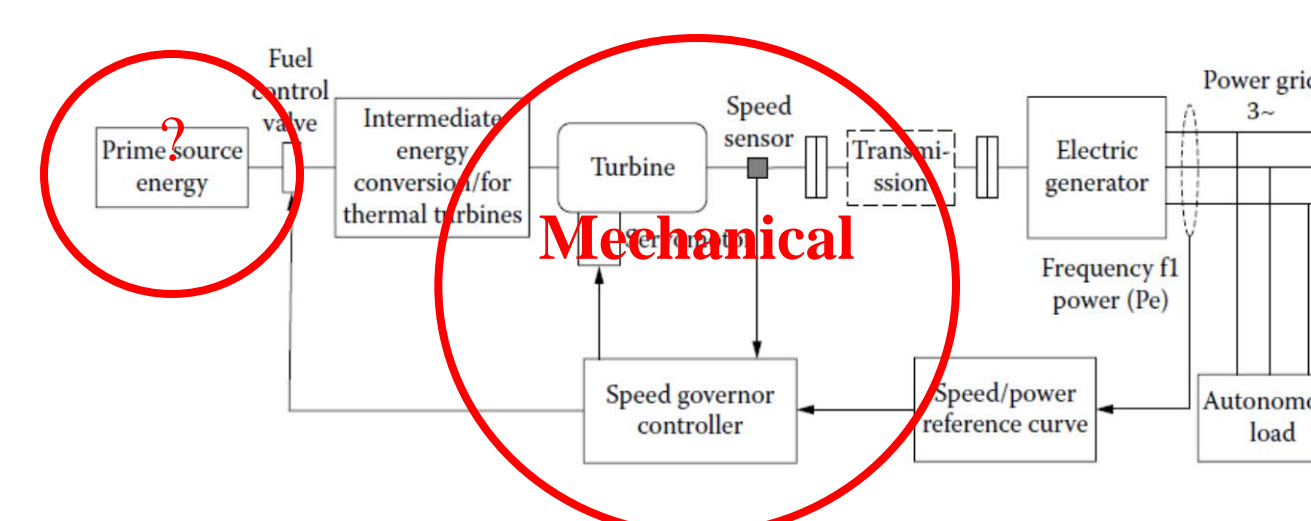## A Better Modeling Approach
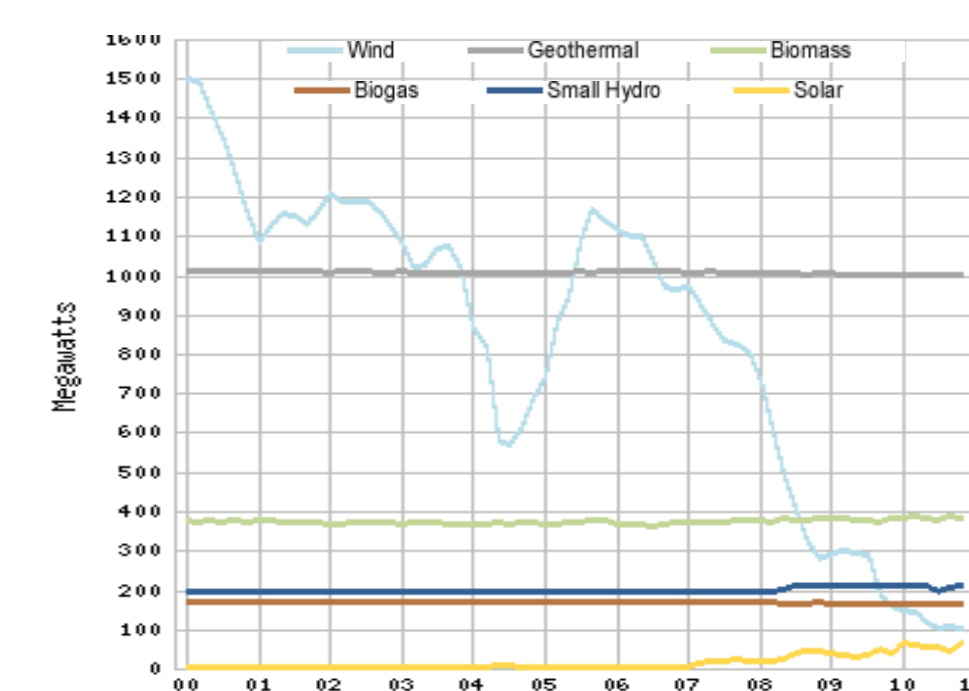
❖ CAISO (20th Feb 2012)

❖ Wind Loss- 500 MW

❖ Average Ramp Rates

❖ Rate of Energy Conversion

Energy Conversion Dynamics ?
Mechanical Sub-System
Electrical Sub-System
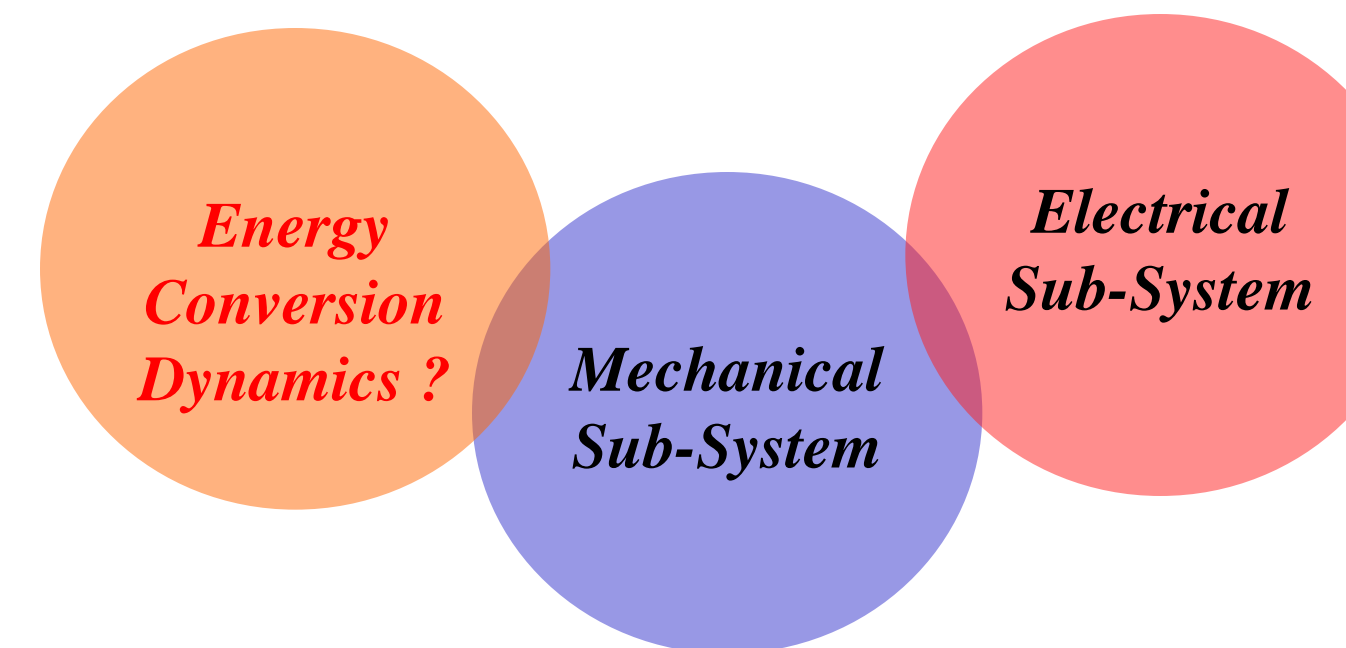
### Steam Power Plant

Hydro Power PLant
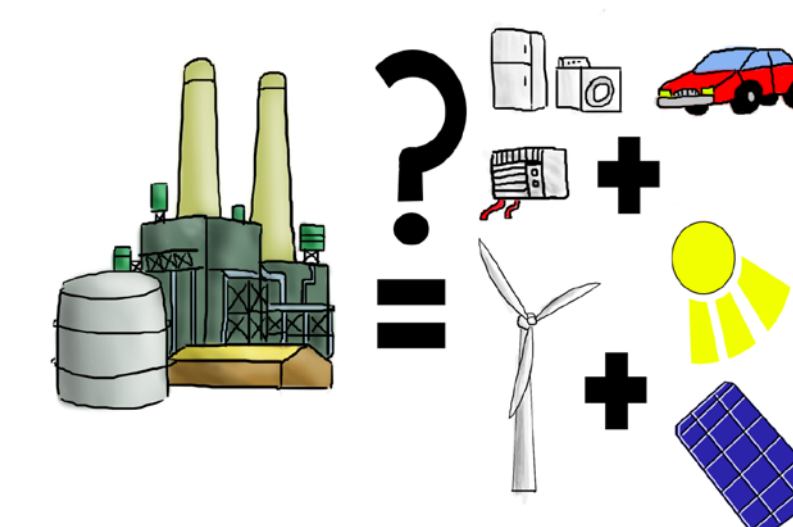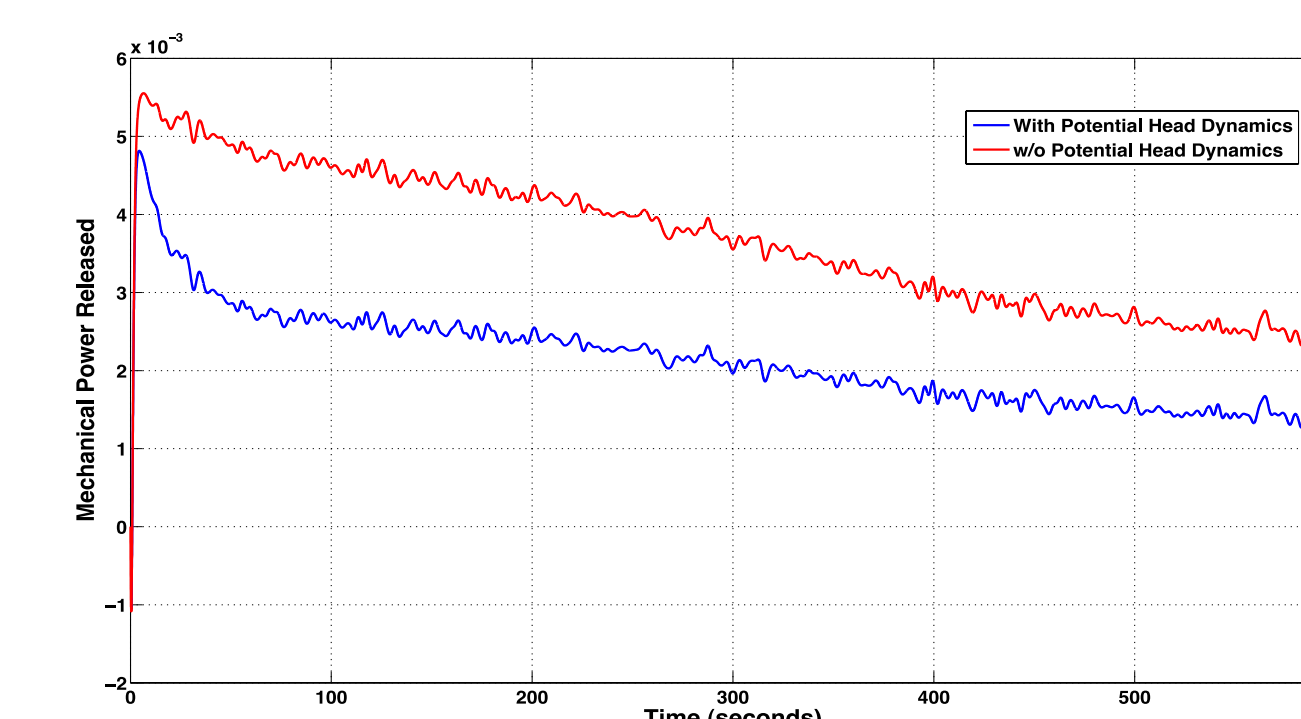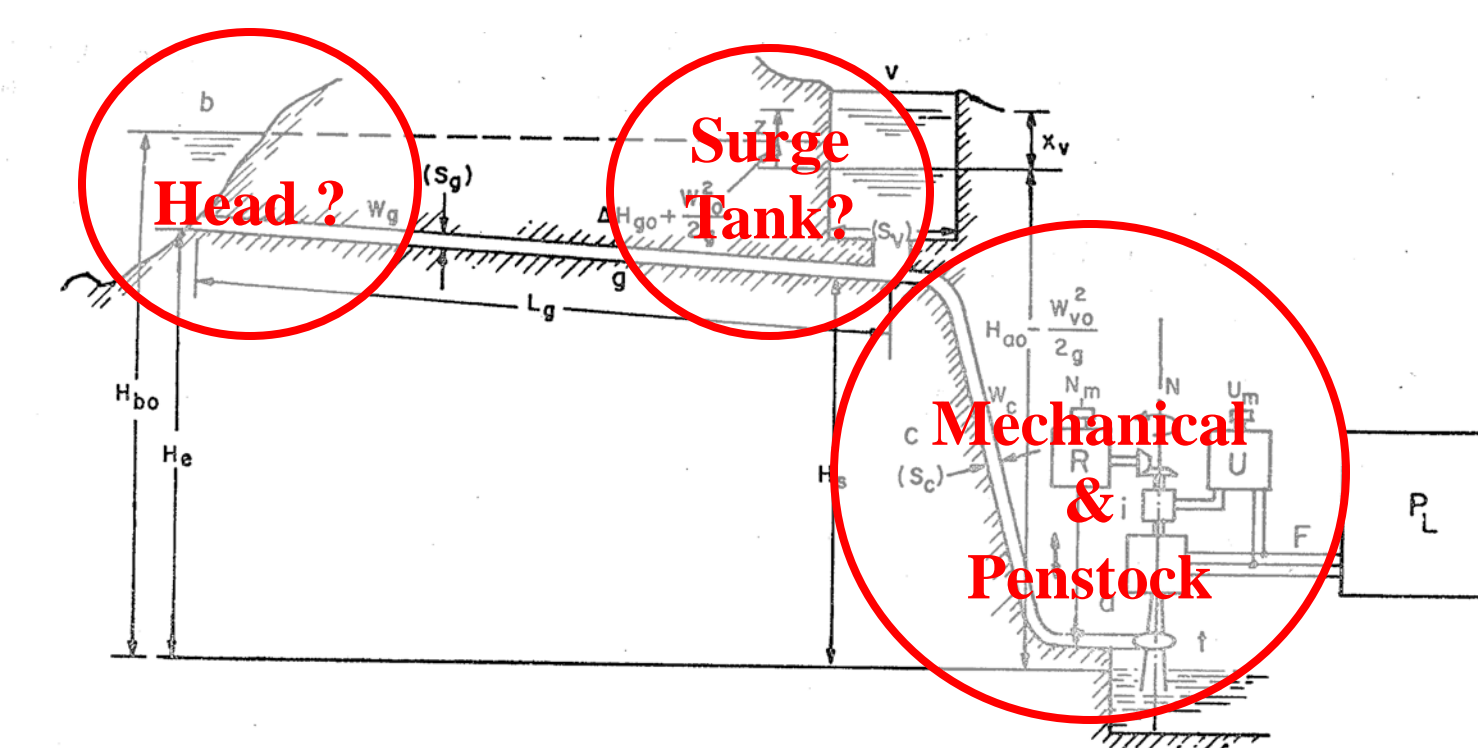
**Demand Response to offset need for one Natural Gas Plant ?**

[1] *M. D. Ilić, N. Popli, J. Y. Joo, and Y. Hou,* "**A Possible Engineering and Economic Framework for Implementing Demand Side Participation in Frequency Regulation at Value**", accepted for IEEE Power Engineering Society General Meeting 2011"

[2] *M. D. Ilić, N Popli* "**Self-Stabilizing response of Loads towards Frequency Excursions: A Multi-Spatial approach**", EESG WP, CMU

[3] *M. Ilić and J. Zaborszky*, **Dynamics and Control of Large Electric Power Systems**

Differential Quality of Service (QoS)

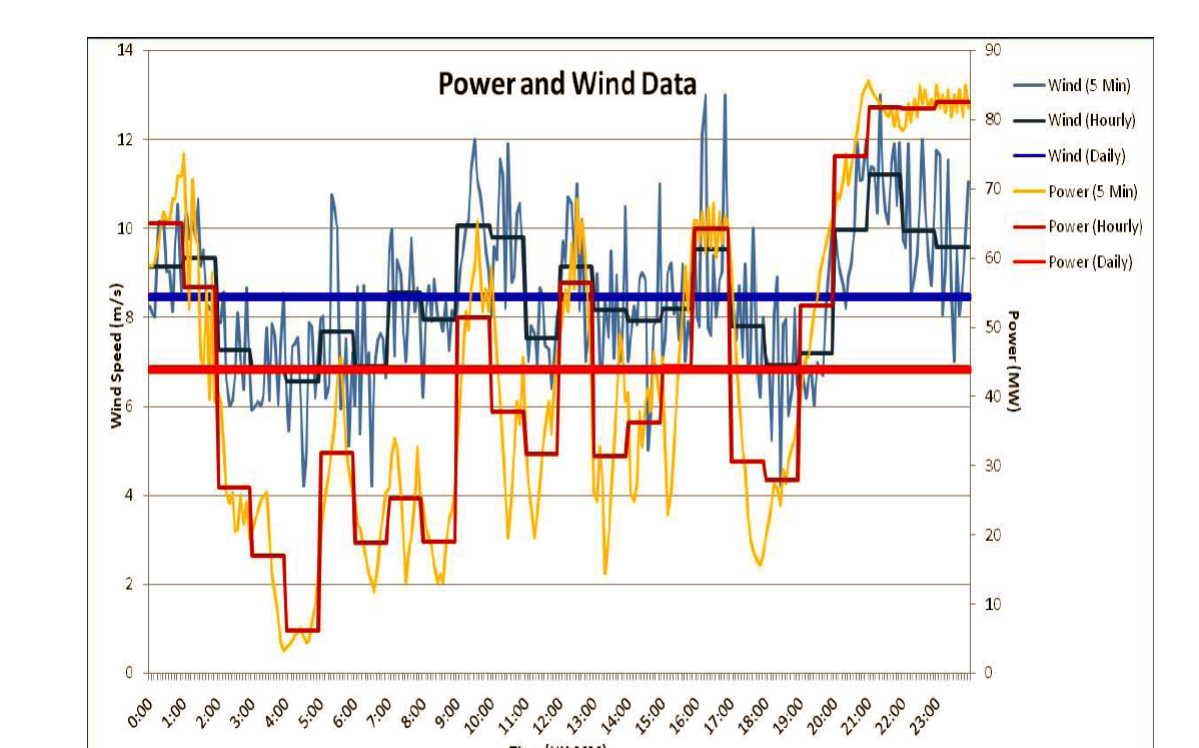### Contract Curve Structure
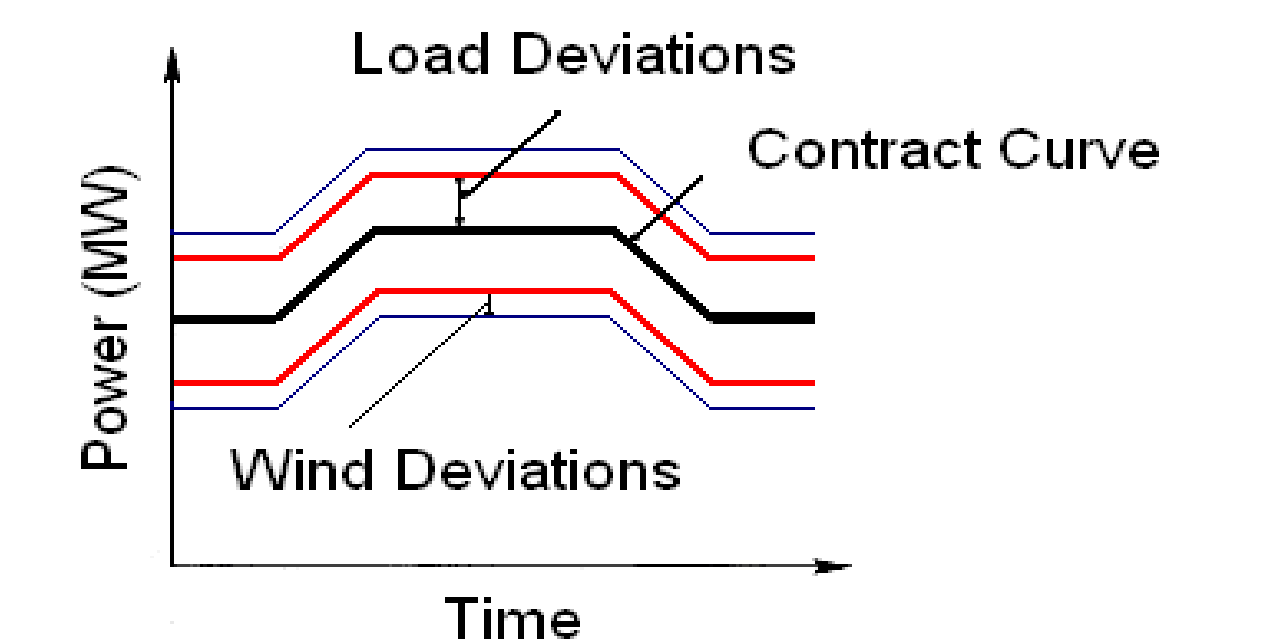
Bias Estimation
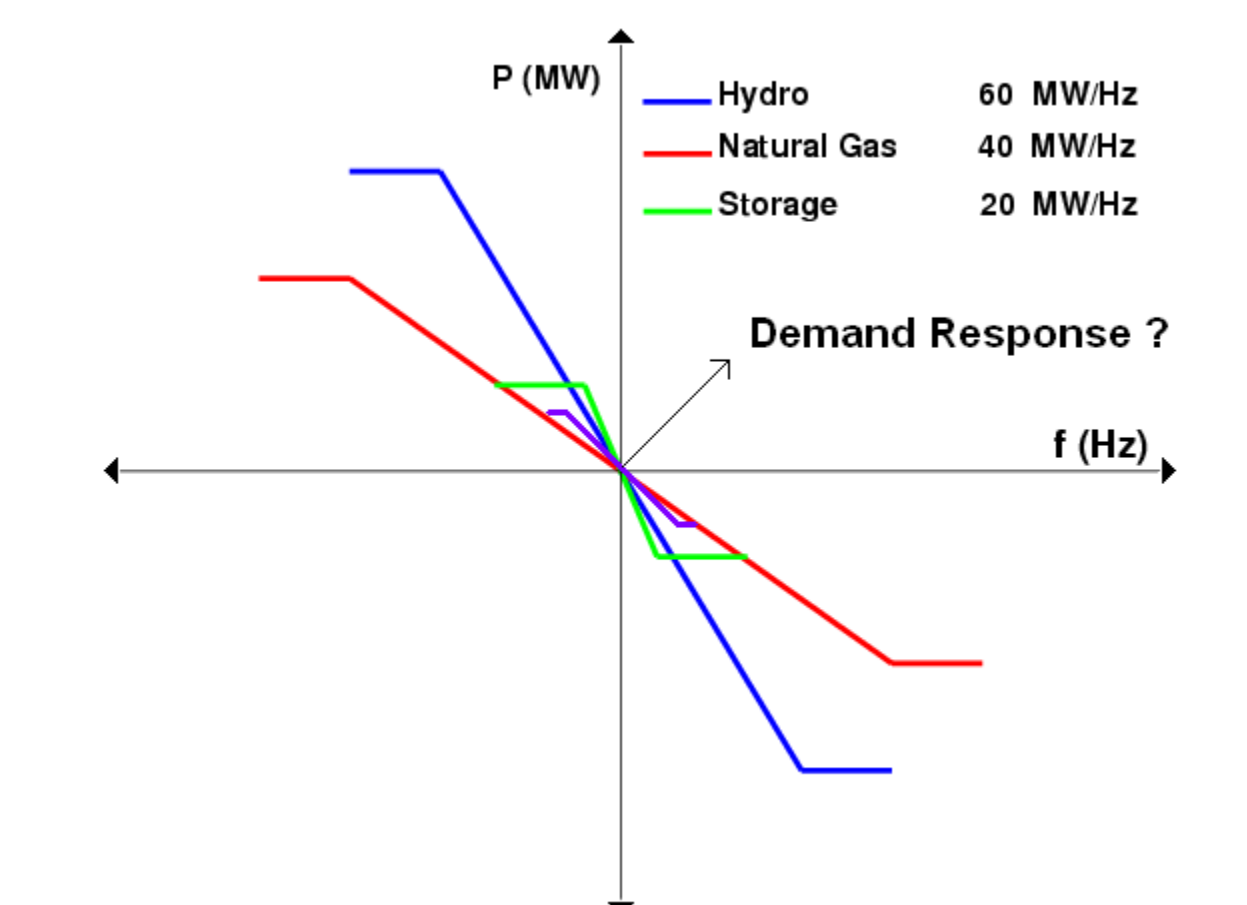
System Constraints

❖ Transmission/Locational Constraints

❖ Generator Energy Conversion Dynamics, Load Characteristics

❖ Sensing & Communication

Next Steps ?

❖ Modeling Energy Conversion Dynamics & Aggregate Load

❖ Restructuring of Ancillary Service market or Regulation Pricing Mechanism

❖ Incentives to encourage the use of Variable Speed Drive's Technology