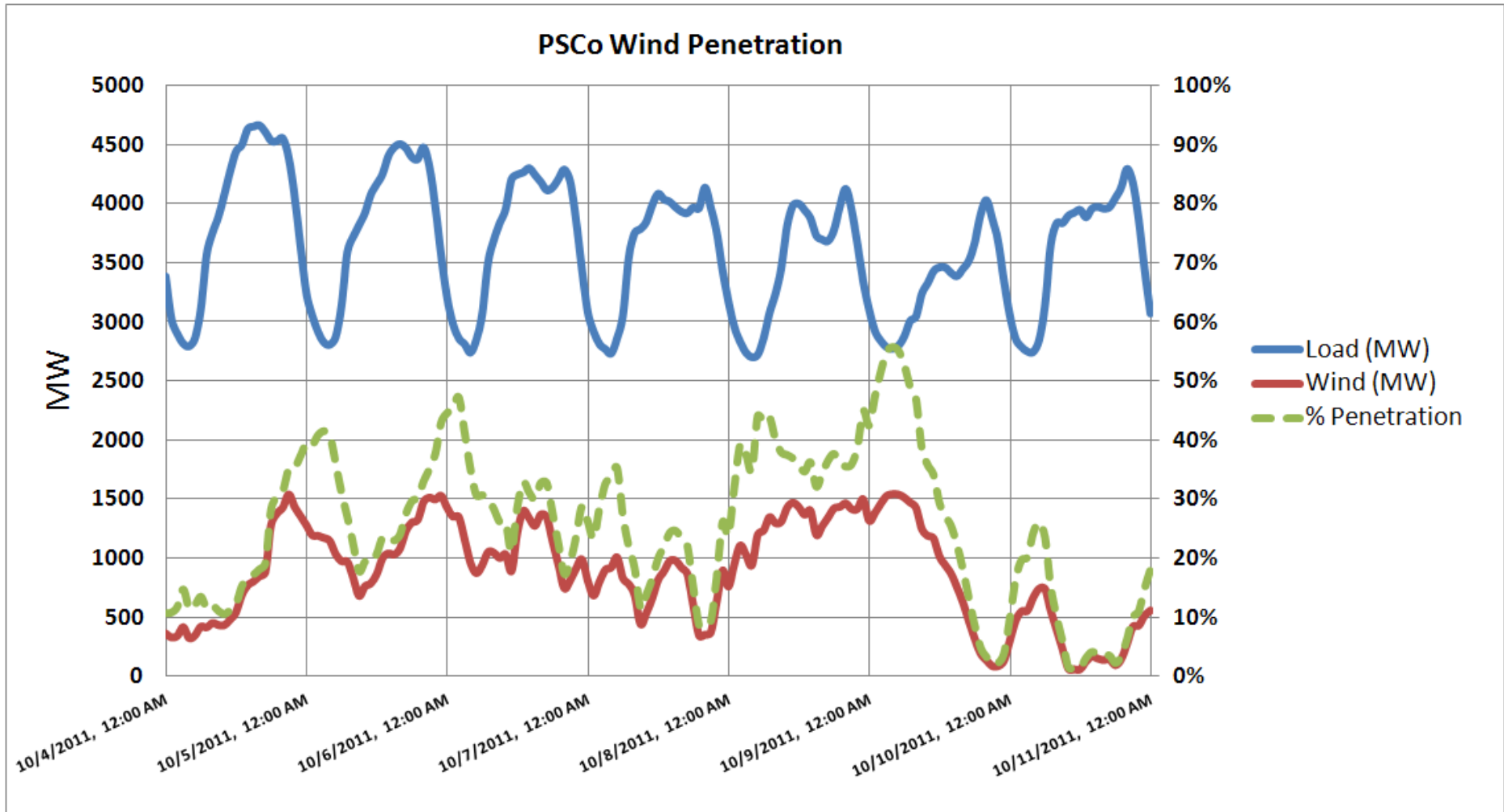


# RE Integration and PMUs- How can we use synchrophasors

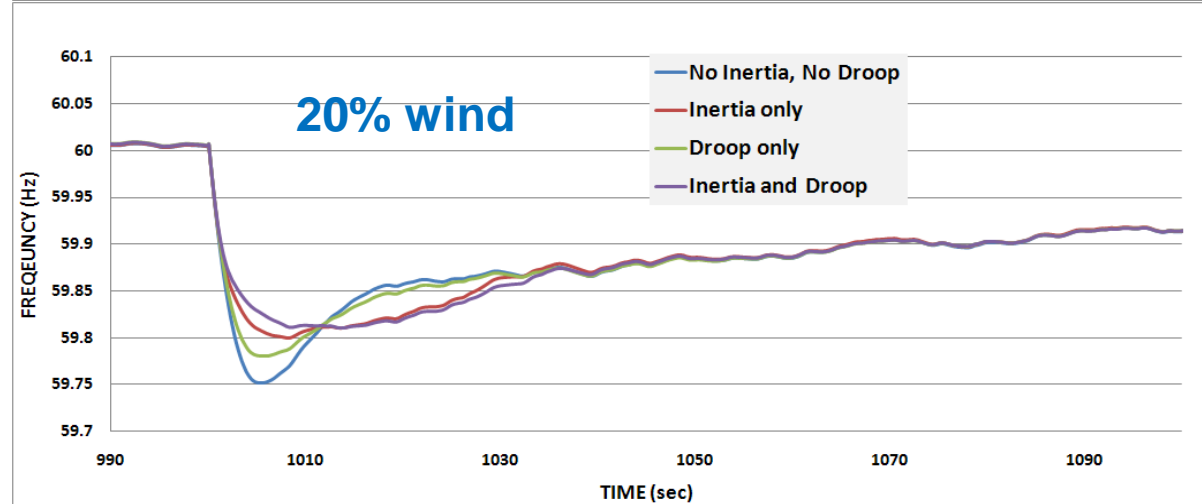
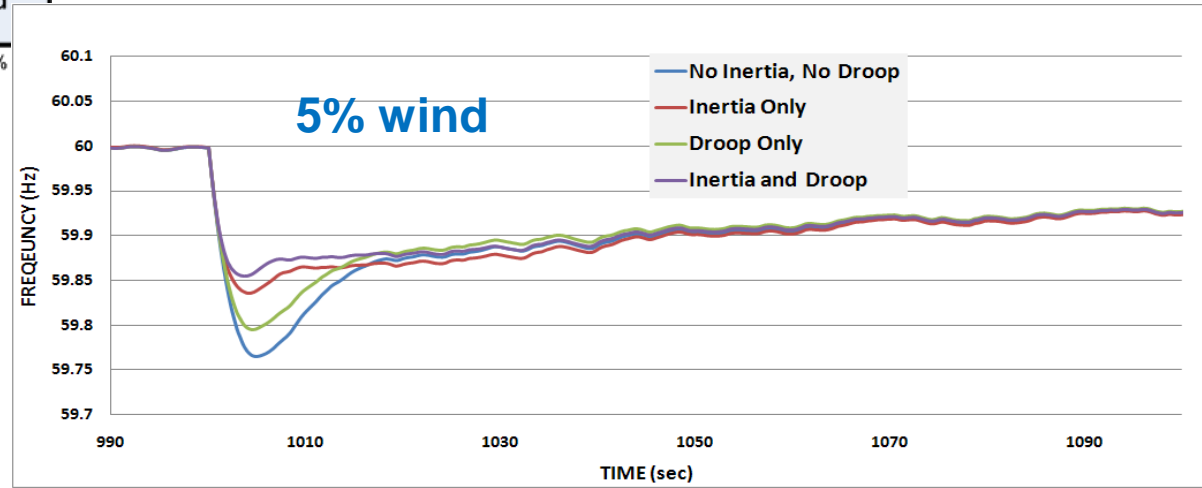
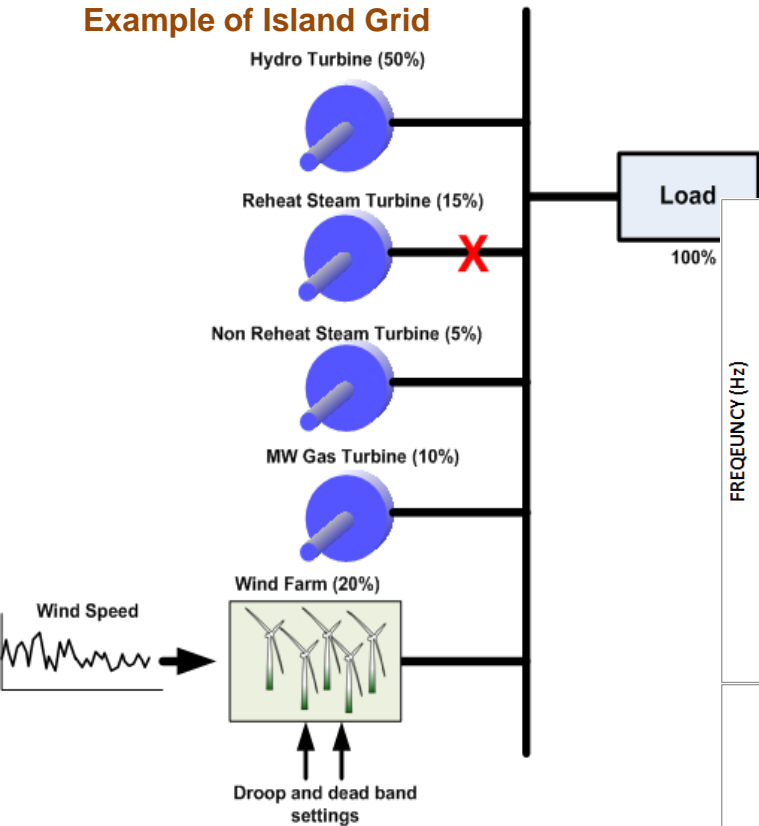
- **Real-time monitoring of primary frequency**
  - **determination of variable generation impacts on primary frequency and inertia**
  - **oscillation detection and damping**
  - **assessing real-time inertia**
- **Active, automated control of wind and solar plants using PMU data collection and feedback**

# 56% Power Penetration Example in PSCo



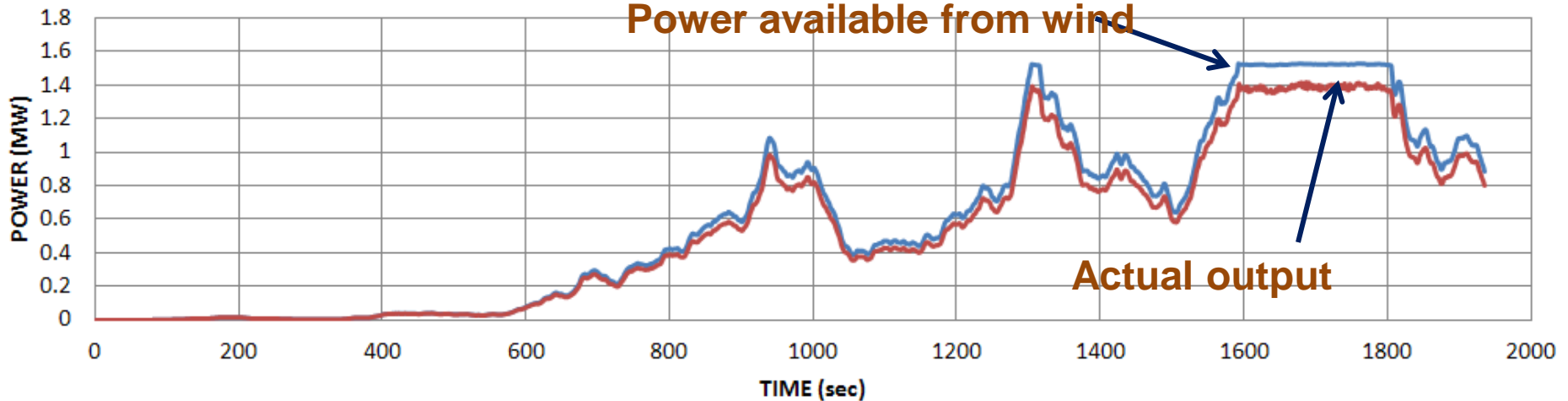
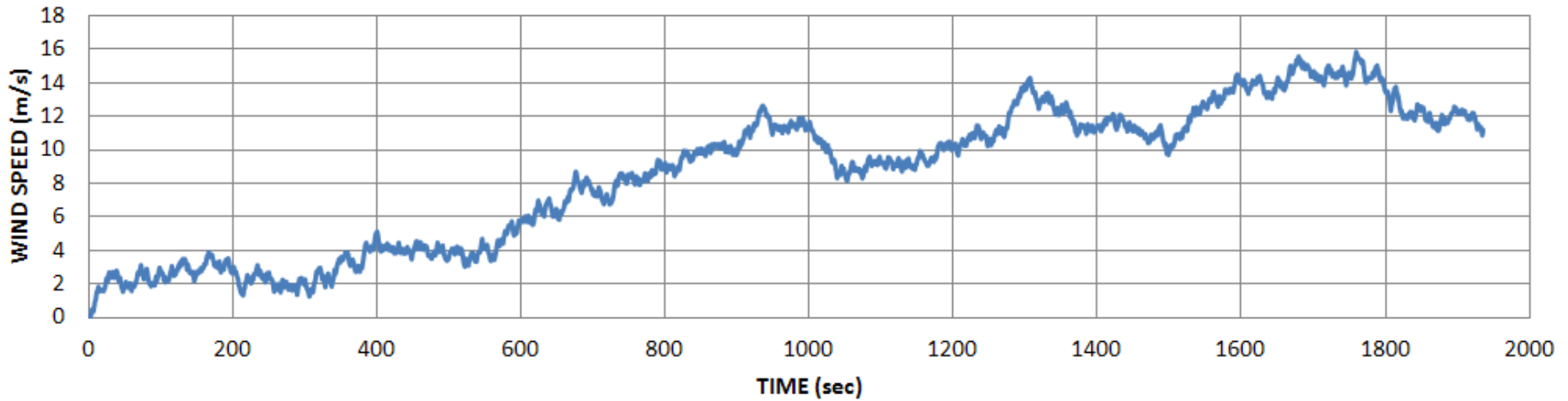
# Wind Power to Provide PFR

## Example of Island Grid



# Wind Power to Provide Secondary Reserve

## Operation with 10% reserve



# RE Integration and PMUs

- **Voltage monitoring of renewable energy systems using PMUs**
- **Model validation for renewable energy plants (plants not turbine)**
- **Operations prediction – what actions can operators take to resolve problems identified by the tools above?**

# Some Issues Not Specific to RE

- Fault location
- Available Transmission Capacity determination, dynamic line ratings and congestion management using both real-time monitoring and dynamic controls
  - Wind conditions cool lines for more ATC
- Equipment and control diagnostics on renewable plants and on plants providing primary frequency response (e.g., stabilizers)