Dynamic Stochastic Optimal Power Flow Control for Smart Grids

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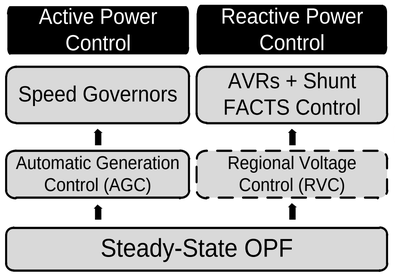
Problem Statements

- High penetration of intermittent renewables:
  - Uncertainty (high forecast errors)
  - Variability (fast changing rates)
- Increased complexity during real-time operation
  - Short-term redistribution of power flow
  - Nonlinearity
- Static OPF cannot handle fast stochastic/dynamic events
- Secondary frequency and voltage control cannot guarantee system-wide security

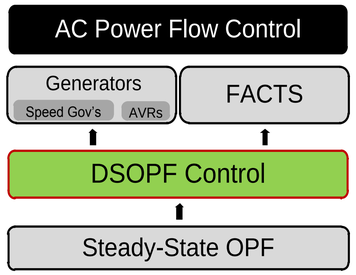
Dynamic Stochastic Optimal Power Flow (DSOPF)

- Coordinated AC power flow control solution – replaces existing linear secondary frequency and voltage control
- Interacts with dynamics of load and local controllers
- Simultaneously considers economy, stability, and security in real-time control
- Handles fast stochastic events (e.g., wind variations, and contingencies)

Traditional Power System Operation and Control

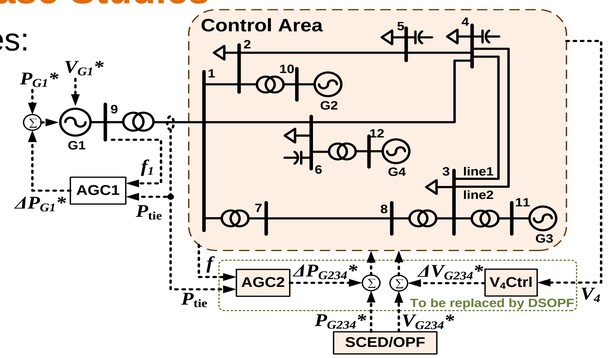


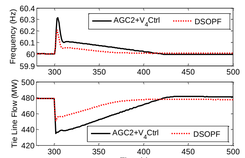
Power System Operation and Control with DSOPF



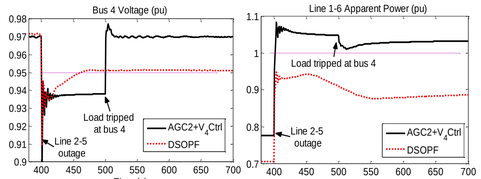
12-Bus System Case Studies

- DSOPF Ctrl Objectives:
  1) Area control error
  2) Voltage deviations
  3) Line loadings
  4) Total fuel cost
  5) Total line loss
  6) Control effort



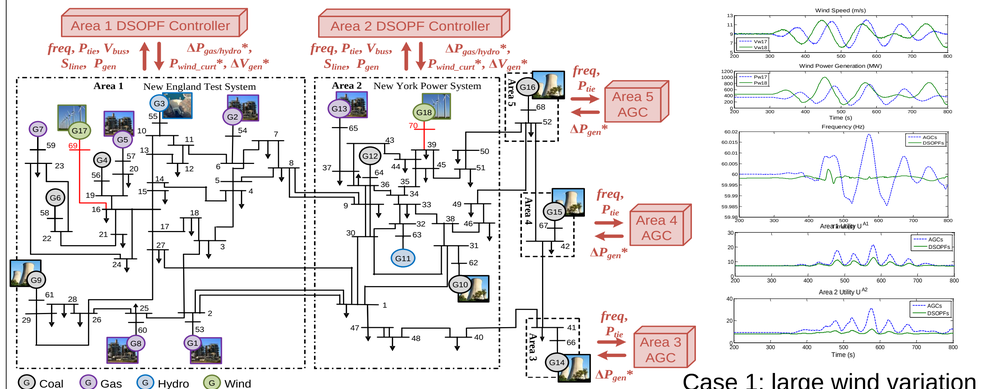


Case 1: load and cap tripped at bus 5

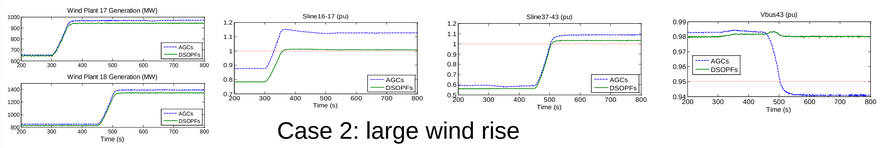


Case 2: line 2-5 outage

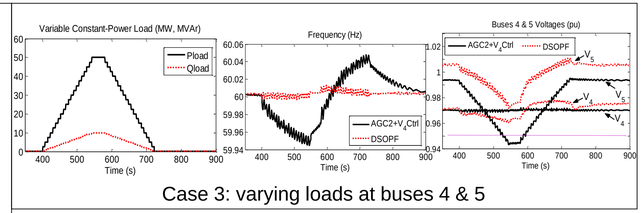
68-Bus System Case Studies



Case 1: large wind variation



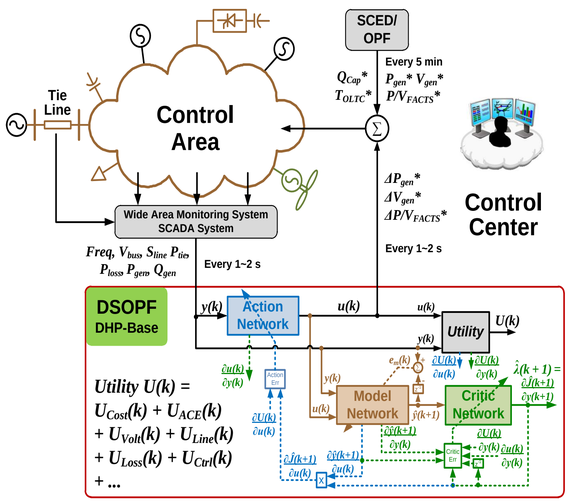
Case 2: large wind rise



Case 3: varying loads at buses 4 & 5

Implementation using Intelligent Control

- Adaptive critic designs – reinforcement learning & approximate dynamic programming
- Provides MIMO nonlinear optimal control
- Does not require analytical system models
- Continuous snapshots are assumed available from Wide Area Monitoring System



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