Robust and Dynamic Reserve Requirements

Professors: Kory Hedman and Muhong Zhang, Arizona State University
Students: Joshua Lyon and Fengyu Wang

Objectives

- Examine current practices in determining reserves
- Analyze the impact of increased variable generation on reserves
- Analyze the impact on reserve requirements due to new smart grid technologies
- Develop systematic ways to determine reserve requirements (zones and levels)
- Improve market efficiency and reliability by improving reserve requirements
- Improve deliverability of reserves

Introduction

Reserve requirements (spinning and non-spinning):

- Required to ensure reliable operations (protect against N-1)
- Protect against uncertainties (load, area interchange, contingencies, variable renewable resources)
- Proxy method: specifies that there must be a minimum amount of reserve on standby but it does not explicitly enforce N-1
- Determined by ad-hoc, rule-of-thumb methods

Modeling of reserve requirements:

- Does not account for the location of reserves
- Does not ensure deliverability of reserves

Opportunity for a systematic framework to improve the robustness of reserve requirements

Tasks and Deliverables

- **Task 1: Current reserve requirements**: review and analyze the benefits of current practices
- **Task 2: Reserve zones and reserve levels:** Develop structured methodology to determine reserve requirements
- **Task 3: Impact due to integration of new resources:** Analyze the impact of new resources (variable generation) on reserve requirements
- **Task 4: Impact due to a more flexible grid:** Examine how smart grid technologies may impact reserve requirements (transmission switching)

Task 1: Overview of Current Practices

Reserve levels based on:

- Single largest contingency
- Percentage of demand
- Generation uncertainty
- Historical information

Reserve zones based on:

- Utility ownership
- Geographical boundaries
- Historically congested paths
- Zones traditionally treated as static

CAISO:

- max(Single largest contingency, 5%×Hydro+7% Non-hydro + Interruptible imports)

ERCOT congestion zones

- Statistical clustering technique
- Each bus in the congestion zone has similar impact on commercially significant constraints (CSCs)

Task 2: Reserve Zones and Reserve Levels

Statistical clustering methods

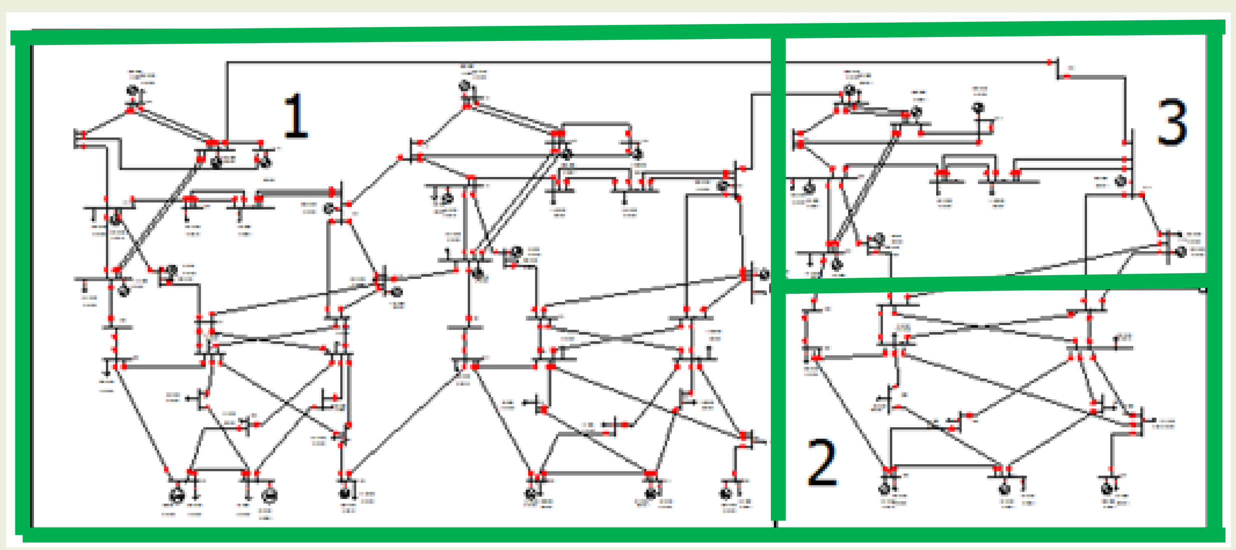
- Heuristic
- Optimality not guaranteed
- Clustering results depend on initial points
- Fast and easy to implement

Centrality measurements:

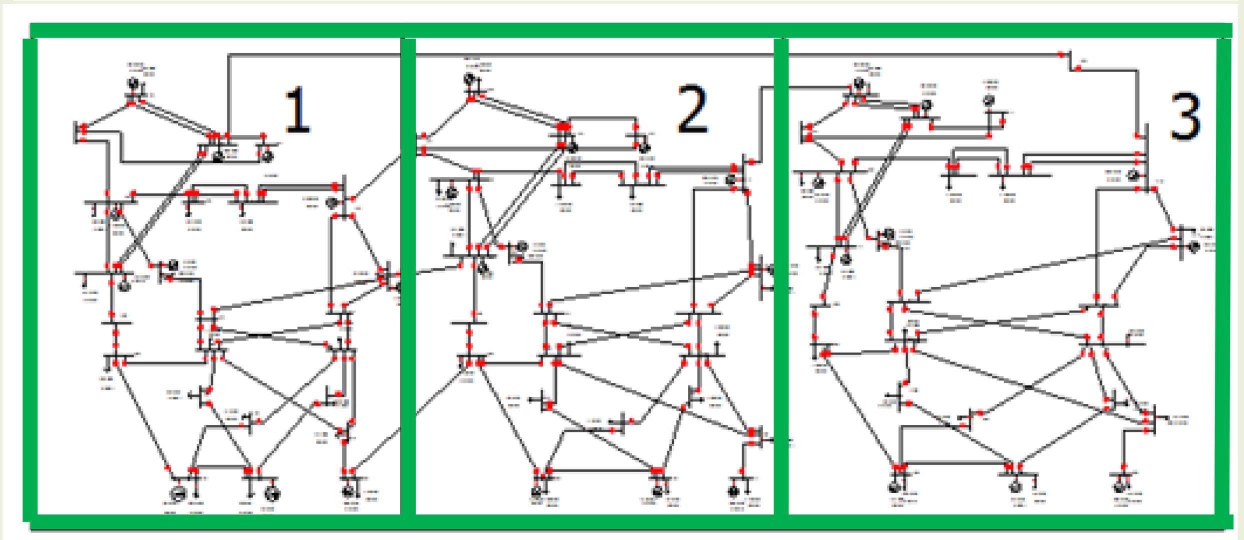
- Electrical Distances (ED):
  - The voltage drop when current is injected at bus *i* and withdrawn at bus *j* : $D_{ij} = Z_{ii} + Z_{jj} - 2Z_{ij}$
- Power Transfer Distribution Factor (PTDF) Differences between buses *i* and *j*:

$$PTDFD_{ij} = \frac{\sum_{k=1}^{N} |PTDF^{Ref}{}_{i,k} - PTDF^{Ref}{}_{j,k}|}{N}$$

ED Clustering Results

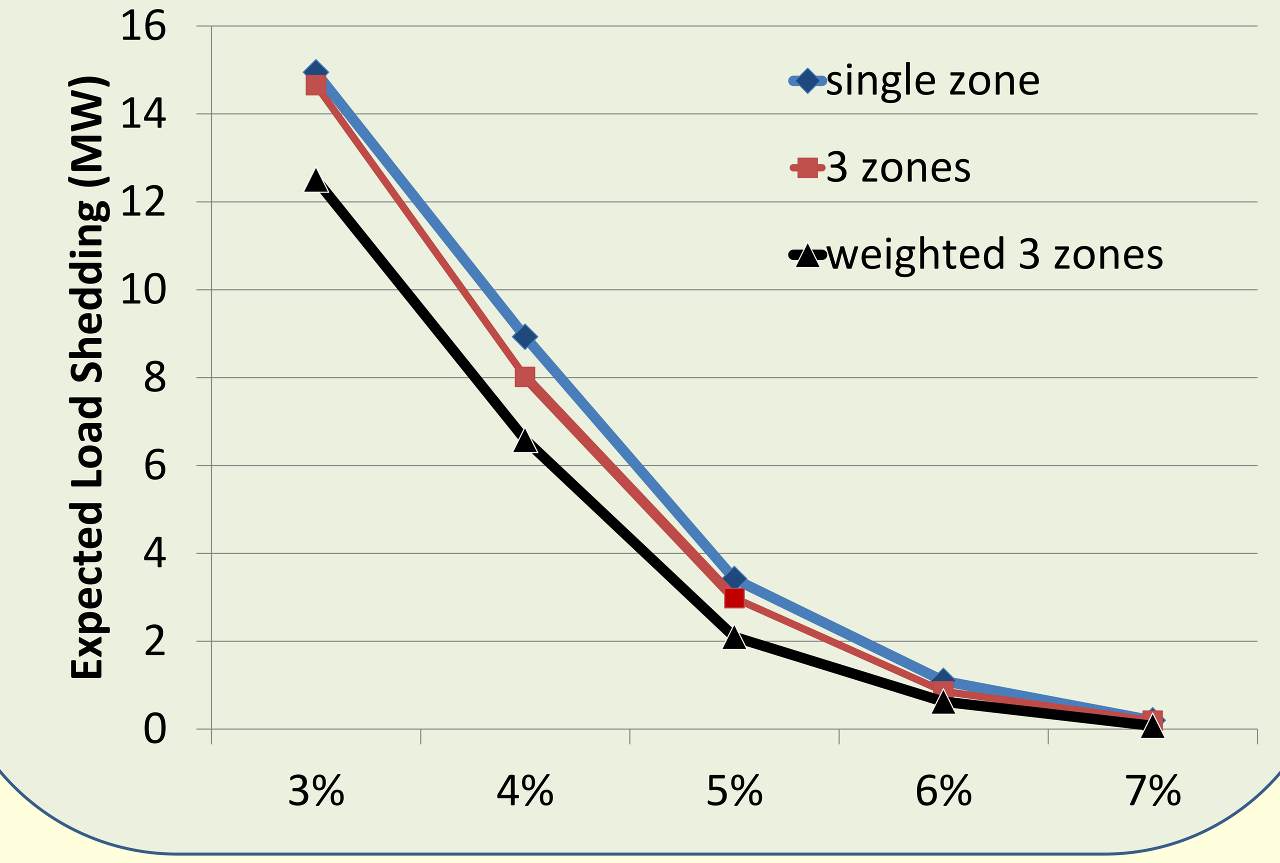


PTDFD Clustering Results



Task 2: Results

- RTS-96 3-zone model
- 24-hour unit commitment with reserve requirements
- Weighted 3-zone PTDFD clustering result improves reliability



Potential Applications

General:

- A systematic framework to determine reserve zones and levels
- Complement to stochastic optimization methods

Variable renewable resources:

- Update reserve requirements for systems with renewable resources
- Accommodate dynamic reserve requirements depending on system operating conditions and variable renewable resources

SMART grid technologies:

- Ability to update reserve requirements for systems with future smart grid technologies that improve reserve deliverability (FACTS, transmission switching)

Future Work

- Develop mathematical framework for the co-optimization of reserve zones and levels
- Modeling and investigation of zone connectivity
- Modeling of reserve sharing and overlapping zones
- Complete tasks 3 and 4