Reserve Response Sets for Security-Constrained Unit Commitment with Wind

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Introduction

- **Operating reserve** is backup capacity that can respond to uncertainty.
- Growing uncertainty from renewables will make reserve requirements more critical.
- Reserves may be undeliverable due to transmission and voltage limits.
- Existing markets procure/price reserves on a zonal basis.

Objective

- Create reserve response sets that account for locational reserve needs and **improve reserve deliverability**.
- Develop locational reserve prices.
- Develop reserve policies that reduce costs and allow for practical solution times.
- Address wind and N-1 scenarios.

Scope

- Scheduling with security-constrained unit commitment (SCUC).
- Reserve response sets may be applied for various reserve products:
  - 5-min reserves (regulation)
  - 10-min reserves (contingency)* [1],[2]
  - 10–20-min reserves (load following)
  - 30-min reserves (supplemental)
  - Capacity requirements [3]
- The results in this poster are for 10-min reserves that protect against generator contingencies.

What Are Response Sets?

- Operators repair unreliable solutions by disqualifying reserves located behind transmission bottlenecks [4]–[6]. This is currently done manually.
- A response set defines resources that are qualified for one particular scenario.
- Response sets generalize reserve disqualification because they are scenario-specific.

Fig. 1. Response set for a generator contingency coupled with traditional reserve zones. Resources within white regions cannot contribute to the respective reserve requirement because of the anticipated congestion.

Locational Prices

- Prices are derived from the dual variables of the response set requirements [2].
- Prices are higher for resources that are qualified for critical scenarios.
- This example shows congestion affecting locational prices within a zone.

Results: RTS-96

- SCUC solved with various zonal reserve sharing limits (red diamonds).
- The proposed algorithm iteratively repairs contingency violations as shown.
- Converges on a solution that is as good or better as the best reserve sharing model.

Fig. 2. A decomposition algorithm that iteratively solves SCUC, adding cuts via stricter reserve requirements. The sub-algorithm of [1] or [3] is used to disqualify reserves (prune response sets).

Fig. 3. Progress of reserve disqualification algorithm when applied to unreliable SCUC solutions.

Conclusions

This work provides:
- A refined model to control reserve locations.
- A mathematical framework to disqualify reserves based on congestion.
- A reserve pricing scheme that rewards resources at prime locations.

Future work:
- Extend to other forms of uncertainty.
- Use an AC model to disqualify reserve.
- Develop probabilistic requirements.

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