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.

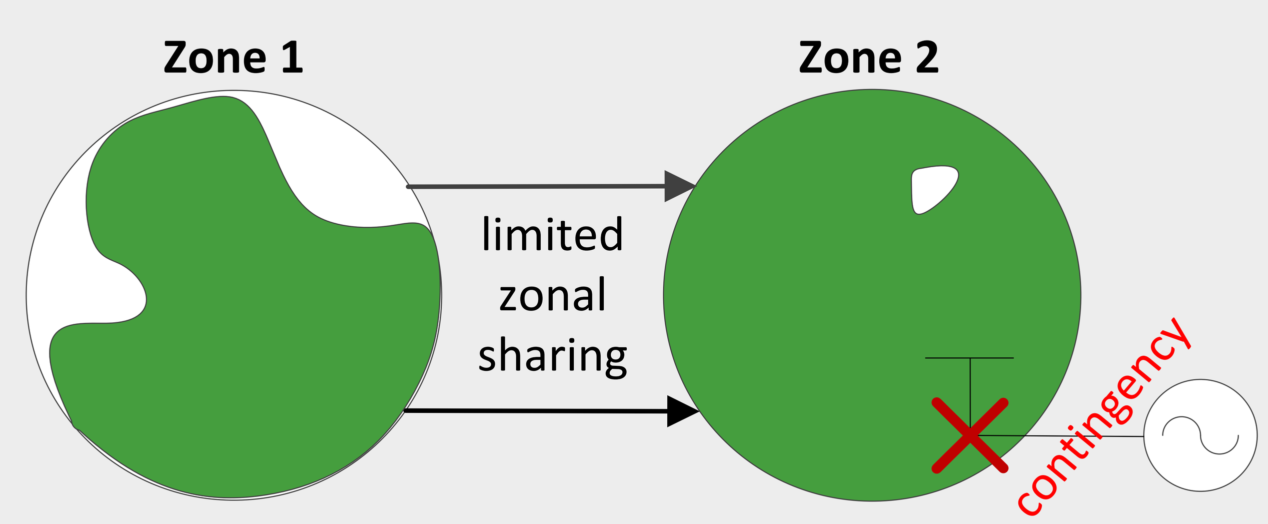

Fig. 1. Response set for a generator contingency coupled with traditional reserve zones. Resources within white regions cannot contribute to the respective reserve requirement because of the anticipated congestion.

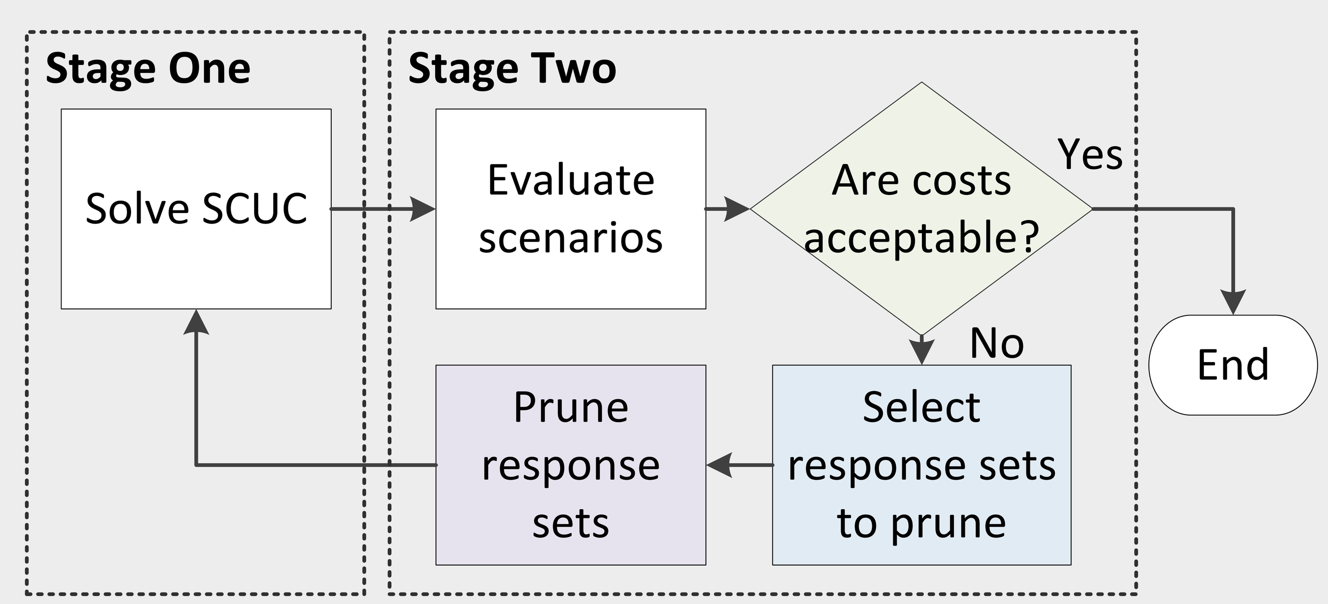

Fig. 2. A decomposition algorithm that iteratively solves SCUC, adding cuts via stricter reserve requirements. The sub-algorithm of [1] or [3] is used to disqualify reserves (prune response sets).

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.

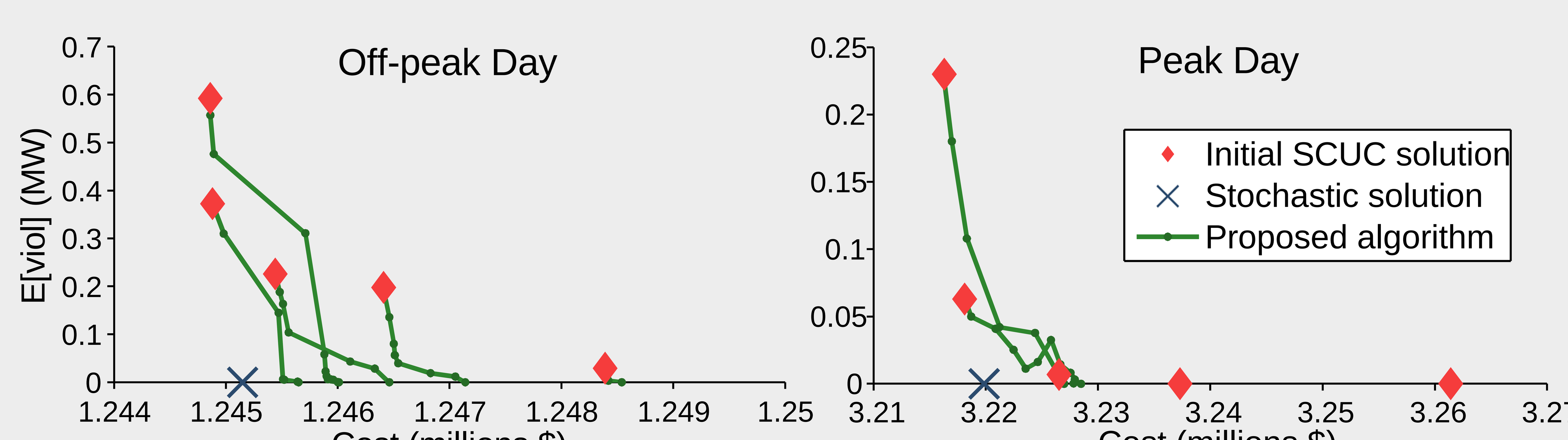

Fig. 3. Progress of reserve disqualification algorithm when applied to unreliable SCUC solutions.

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.

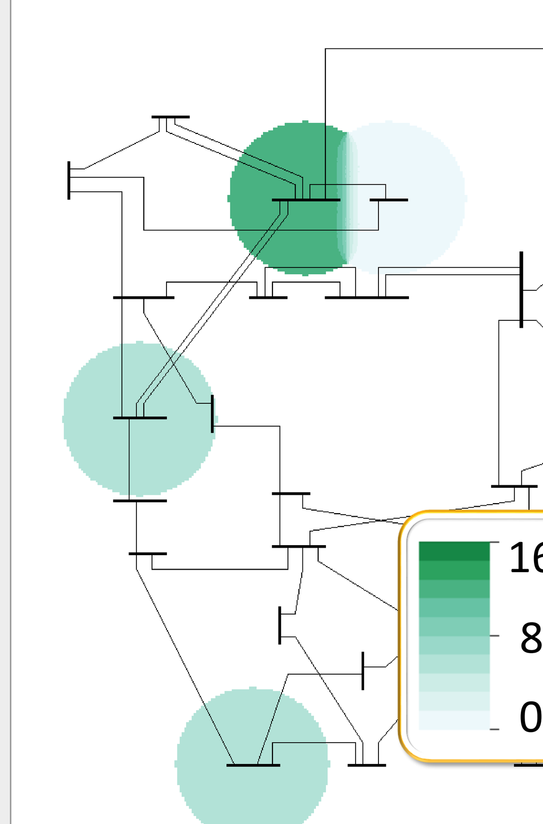

Fig. 4. Reserve locations and prices ($/MW).

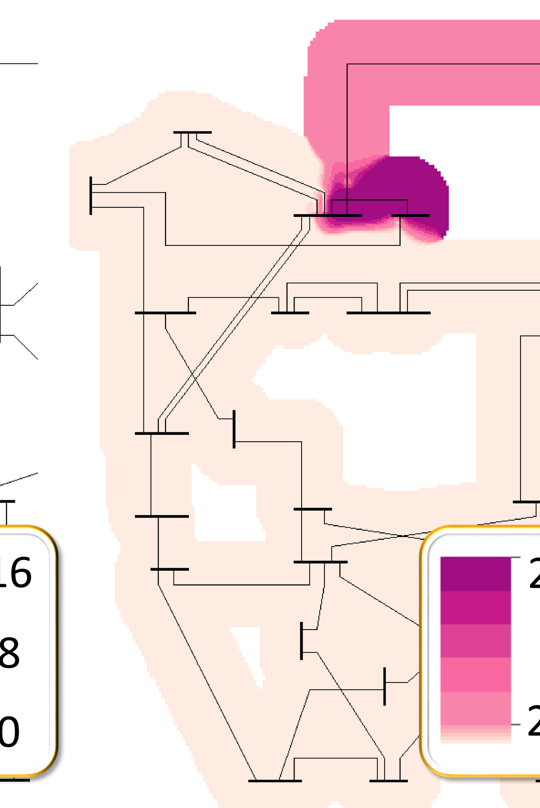

Fig. 5. Flowgate marginal prices due to congestion ($/MW).

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.

[1] J. D. Lyon, M. Zhang, and K. W. Hedman, "Locational reserve disqualification for distinct scenarios," *IEEE Trans. Power Syst.*, vol. PP, no. 99, pp.1–8, May 2014.

[2] J. D. Lyon, F. Wang, K. W. Hedman, M. Zhang, "Market implications and pricing of dynamic reserve policies for systems with renewables," *submitted for publication*.

[3] J. D. Lyon, M. Zhang, and K. W. Hedman, "Reserve response sets for security-constrained unit commitment with wind," *in preparation*.

[4] FERC, "Docket no. ER11-2794-000 – Order conditionally accepting tariff revisions – MISO," Jun. 2011. [Online]. Available: http://www.ferc.gov/EventCalendar/Files/20110628160939-ER11-2794-000.pdf.

[5] ISO-NE, SOP-RTMKTS.0060.0020, "Monitor system security v57," Feb. 2013. [Online]. Available: http://www.iso-ne.com/rules_proceds/operating/sysop/rt_mkts/sop_rtmkts_0060_0020.pdf

[6] Y. Chen, P. Gribik, and J. Gardner, "Incorporating post zonal reserve deployment transmission constraints into energy and ancillary services co-optimization," *IEEE Trans. Power Syst.*, vol. 29, no. 2, pp. 537–549, Mar. 2014.