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Systematic Testing and Comparison of Deterministic and Stochastic Unit Commitment by means of an 8-Zone Test System Based on ISO New England Data

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Introduction
Stochastic Security-Constrained Unit Commitment (SCUC) is an important tool for handling uncertainties introduced by increasing penetration of variable energy resources (e.g., wind, solar). The goal of this ARPA-E-supported project has been to develop an empirically-grounded test system permitting systematic comparison of Stochastic SCUC and Deterministic SCUC under a wide variety of possible system conditions, including wind power penetration levels, reserve requirement (RR) levels for deterministic SCUC, and months of the year. An agent-based method is developed and used to model wind power penetration. Our results demonstrate that the average cost saving resulting from a switch from Deterministic SCUC to Stochastic SCUC under an increasing RR level has a U-shape, with least (possibly negative) cost saving occurring at the RR turning point of the U-shape.

8-Zone Test System Based on ISO New England Data
The 8-zone test system developed by our group in Iowa State University is based on structural attributes and data from ISO-NE; see [1] for details.

Key features:
1. Open-source
2. Power market-oriented test system
3. Based on empirical conditions of an actual energy region
4. Small-scale test system
5. Permits users to configure attributes for generators, load-serving entities, the transmission grid, and the system operator.

Wind Power Penetration Modeling
Rather than simply scale up or down the historical wind, we propose an agent-based method to model wind power penetration. Specifically, we increase wind penetration level by queue build-out.

Wiring Data Source:
- Eastern Wind Integration and Transmission Study (EWITS) data set by NREL
- Provides 3 years of modeled time series data at a high wind penetration level
- New England Wind Integration Study (NEWIS) by ISO-NE
- Provides wind installation built-out queue with locations and capacities of planned wind power plants

Sensitivity Design

- Tested Settings for Treatment Factors
  1. Stochastic vs. deterministic SCUC
  2. Reserve requirement (RR) level for deterministic SCUC as % of peak net load
  3. Wind penetration (WP) level as % of energy demand: 2%, 10%, 20%
  4. Month of the year (different wind volatility levels): January, May, July

- Performance Metric: Total Cost Saving
  - Total Cost ($) = NoLoadCost + StartUpCost + ShutDownCost + DispatchCost
  - Total Cost Saving (%) = (TotalCost(Det) - TotalCost(Sto)) / TotalCost(Det) x 100%
    - TotalCost(Det) is deterministic total cost
    - TotalCost(Sto) is stochastic total cost

Simulation Results
- For each month M and wind penetration WP, the plot of Average Total Cost Saving (Avg. TCS) vs. Reserve Requirement (RR) has a U-shape with a turning point RR* at approximately RR = 30%
  - For WP = 2%, the RR turning point is RR* = 25%.
  - For WP = 10%, the RR turning point is RR* = 30%.
  - For WP = 20%, the RR turning point is RR* = 35%.
- Reason for positive correlation between WP and RR*: Higher WP leads to more net load uncertainty, resulting in higher reserve needs for deterministic SCUC