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.

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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.

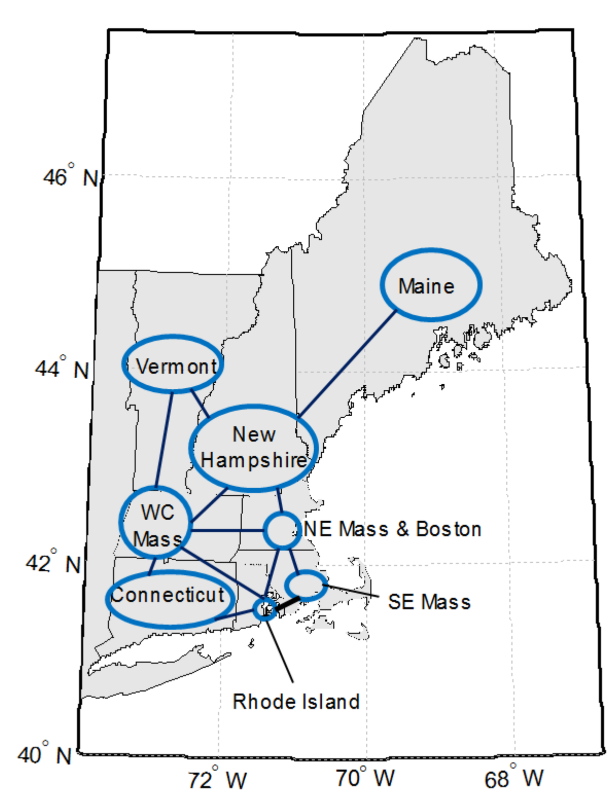

Fig. Transmission grid for the 8-Zone ISO-NE Test System.

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Wind Power Penetration Modeling

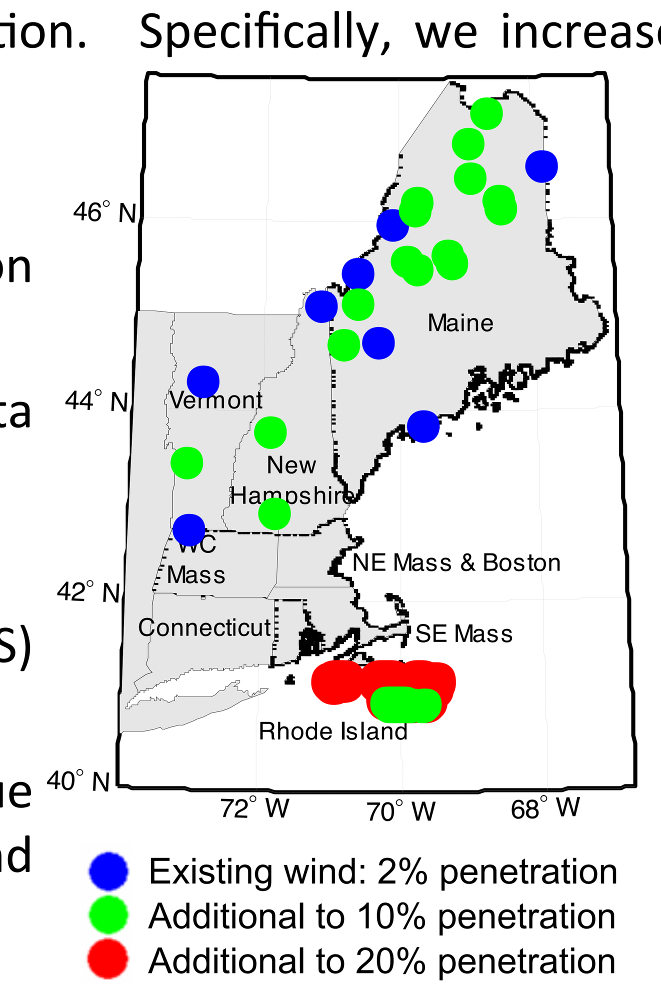
Rather than simply scale up or down the historical wind, we propose an **agent-based method** to model wind power penetration. Specifically, we increase wind penetration level by queue build-out.

Wind 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

Wind Power Queue Build-out Plan:

- New England Wind Integration Study (NEWIS) by ISO-NE
- Provides wind installation built-out queue with locations and capacities of planned wind power plants



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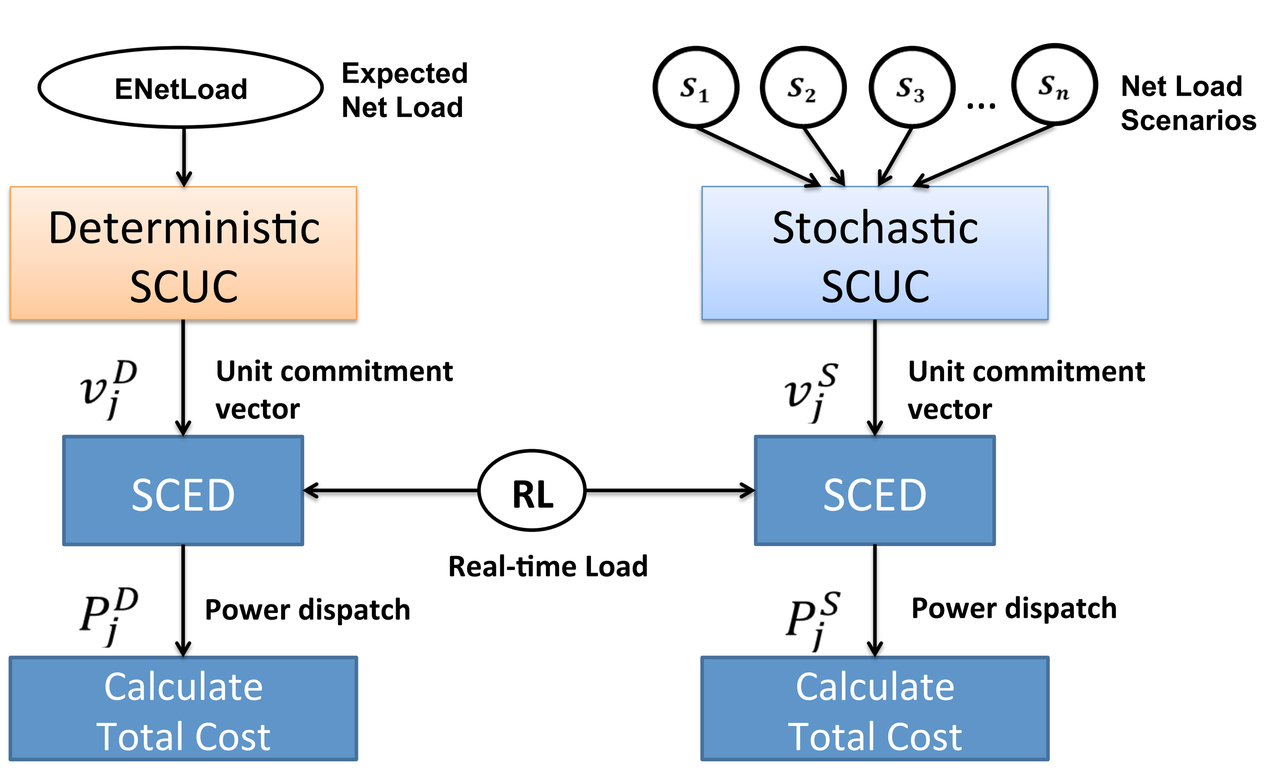
Sensitivity Design



- **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 ($)**

TC = NoLoadCost + StartUpCost + ShutDownCost + DispatchCost

➢ **Total Cost Saving (%)**

$$\text{TCS} = \frac{\text{TotalCost(Det)} - \text{TotalCost(Sto)}}{\text{TotalCost(Det)}} \times 100\%$$

where

- TotalCost(Det) is deterministic total cost
- TotalCost(Sto) is stochastic total cost

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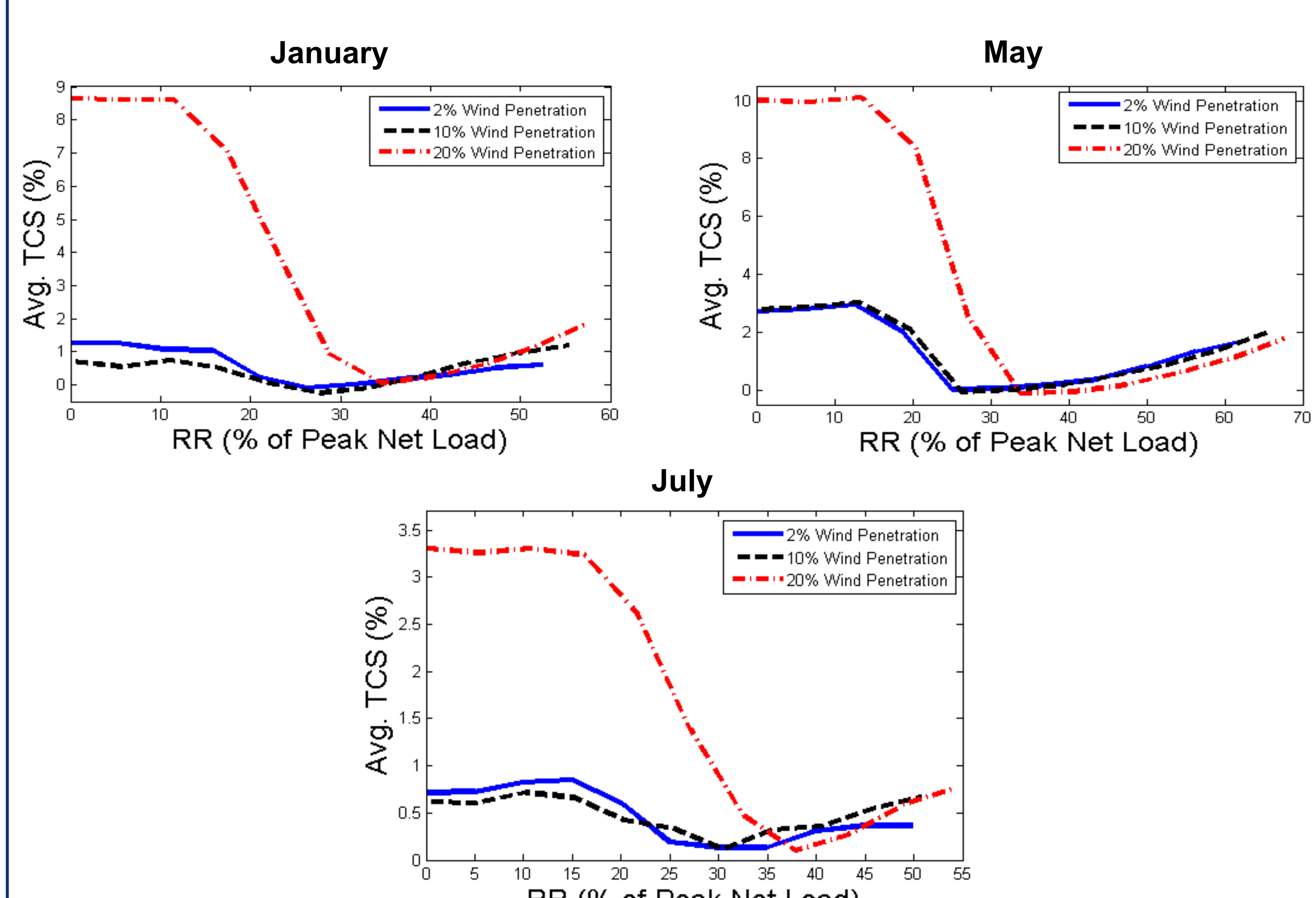
Simulation Results



- 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

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[1] Dheepak Krishnamurthy, Wanning Li, and Leigh Tesfatsion, 2015, **"An 8-Zone Test System based on ISO New England Data: Development and Application,"** *IEEE Transactions on Power Systems*, to appear.