STOCHASTIC VERSUS DETERMINISTIC GRID-EVOLUTION MODELS

- A CASE STUDY ON MISO

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OBJECTIVES

1. Model the lowest cost optimized build-up of natural gas and wind power plants capacities in the overall generation mix using deterministic and stochastic approach.
2. Compare the results of the outcome from using both the approaches
3. Investigate the cost trade-off of including stochasticity in input variables – fuel cost, and load prediction
4. Perform the analysis in the Midcontinent ISO (MISO) from 2020-2045

METHODS

A genetic algorithm optimization is used with economic dispatch model to search for generation build-out plans that minimize discounted expected total costs of meeting electricity load.

DATA INPUTS

- Synthetic Load Generation
  - Bins of historical seasonal, daily and hourly variations are considered to construct random load patterns from periods 2020-2035

  Random Generation of Load Patterns for a Sample Week in June 2020

- Distribution of Fuel Prices
  - Standard deviation of the historical prices is used to create the normal distribution of future price projections by EIA (2017)

- Quantity of wind and natural gas power plants built in each 5-year period

- Distribution offuel prices and load demand

- Generation of random fuel and load demand based on distribution

- 25-year system cost

- Amortized capital cost data of natural gas power plant and wind power plant

- Genetic Algorithm Search- searches for generation build-out plan that meet demand at lowest total cost

RESULTS

- Deterministic scenario model over-estimates the natural gas build-out by the end of 2040 as compared to stochastic approach

  Natural Gas and Wind Build-Out 2020-2035 (Deterministic Approach)

- In deterministic approach, a sudden deployment of 60 GW is estimated in 2040 and the overall transition is not as smooth as stochastic approach.

- Overall, uncertainty analysis will not only clarify the expected distribution of outcomes but also explore relationships in how sudden shifts in critical inputs would affect the outcomes of grid build-out.

  On the downside, running Monte-Carlo on dispatch model over a horizon of the 20-year time period is a computationally intensive process.

CONCLUSION

- Deterministic simulation captures the average behavior of a system, but evens out the natural randomness of critical inputs (e.g. fuel prices or carbon taxes).

- Stochasticity in the model aids in smoother transition of technologies as compared to deterministic models.

- In MISO, stochastic approach gives a gradual build-out of natural gas capacity reaching to a maximum capacity of 45 GW in 2035.

- In deterministic approach, a sudden deployment of 60 GW is estimated in 2040 and the overall transition is not as smooth as stochastic approach.

REFERENCES


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