Modelling forecast errors in operation scheduling: The case of microgrids

Presenter: Hamid Zareipour, University of Calgary, Canada
Students involved:
Hamed Chitsaz, Manijeh Alipour

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Context

- In this research, we explored how uncertainty modeling impacts the operation costs of a microgrid.
- A typical microgrid is modeled that consists of a small load, a conventional generator, renewable energy resources (wind and solar), energy storage and an interconnection to the grid.

Context

- The microgrid has the option of producing its own energy or purchase energy from the competitive electricity market.
- Trading with the market will be at market prices.
- Future market prices are uncertain. Thus, the scheduling becomes an optimization under uncertainty.

Uncertainty Modeling

- We have considered three alternatives to model the uncertainty of next-day electricity market prices:
  - Deterministic forecasts
  - Probabilistic forecasts→ Prediction intervals
  - Price scenarios

Integrating Uncertainty Into Scheduling

- The uncertainty of next-day electricity market prices are integrated into the optimal scheduling models for the microgrid:
  - Deterministic forecasts→ deterministic operation scheduling model model
  - Probabilistic forecasts→ Prediction intervals→ Robust operation scheduling model model
  - Price scenarios→ stochastic operation scheduling model model

Forecasting Framework

- Two forecasting frameworks:
  - Fixed-horizon forecasts: forecasting are generated for the next day at mid-night current day. The associated optimal schedules are fixed. No updates.
  - Rolling-horizon forecasts: the forecasts are generated for next 24 hours and the associated schedules are found. The forecasts, and the associated schedules, are updated ever hour after.

Simulation Data and Results

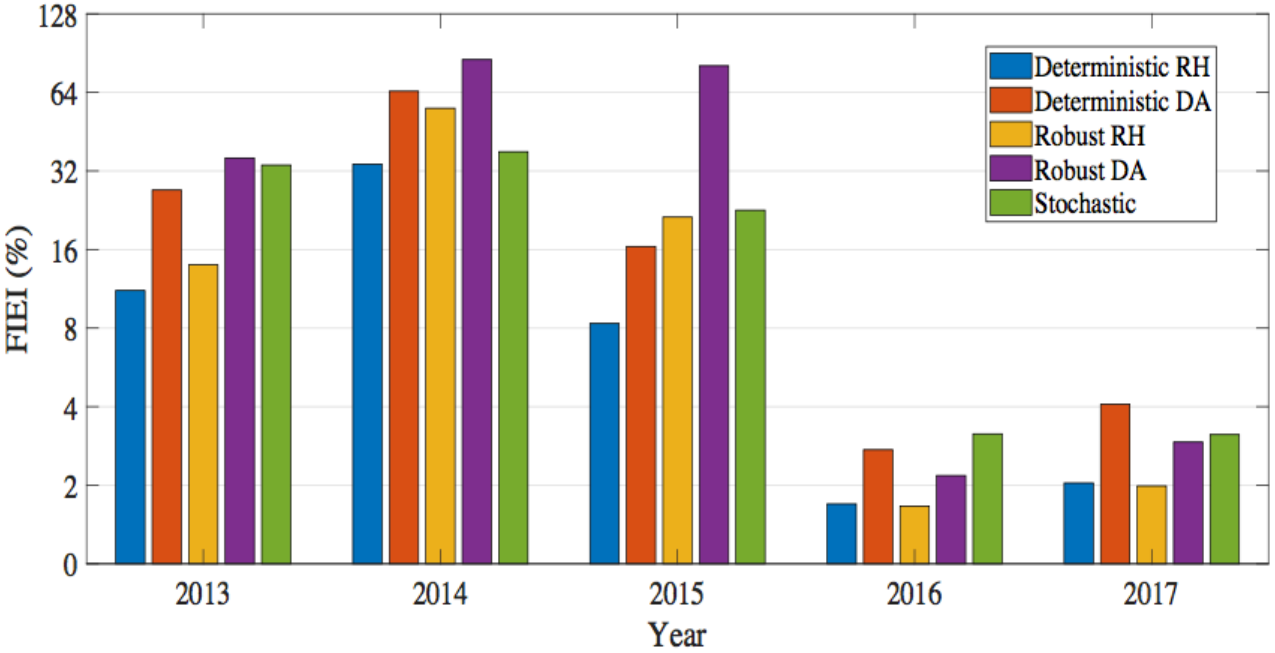
- We have used the load data for a building at the University of Calgary with a peak load of 980 kW.
- Alberta pool prices are used for the years of 2013-2017.
  - 2013-2015 had high prices with significant volatility
  - 2016-2017 pool prices collapsed and price volatility was significantly lower than the previous years.
- Wind/solar power data and forecasts for local sites in Alberta are used.
- The base case has no storage, and wind and solar uncertainty is eliminated by using perfect forecasts.
- Sensitivity analysis is then performed with respect to:
  - Adding energy storage
  - Adding wind/solar uncertainty
  - Adding ramping limits to the conventional genset

Simulation Data and Results

- The impact of uncertainty on the total cost of microgrid operation is measured, over each year as,:

$$FIEI(\%) = \frac{Cost^{Forecast} - Cost^{Perfect}}{Cost^{Perfect}} \times 100$$

Simulation Data and Results



Base case results

Key Finding

- Among the tested methods and for the evaluated test cases, the rolling horizon deterministic model either outperformed or performed equally well.
- For the years with high prices and high price volatility, in particular, the economic risk is high, and the deterministic rolling horizon performs considerably better than other methods.

Base case results