Stochastic modelling of intermittent renewables in TIMES models

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Motivation

• Assessment of the Value of Flexibility Services from the Norwegian Energy System (ASSETS)

• Important to model intermittent renewables in a proper manner to provide good model insights on the low carbon transition

• This work investigates how to model wind and PV generation that provides reasonable results
  • Demonstrated in IFE-TIMES-Norway
Intermittent renewable has a high short-term uncertainty. In Norway the weather changes rapidly throughout the days. For a good representation of wind and PV in the model, uncertainty is needed to be taken into account.
Stochastic programming of short-term uncertainty

- **Stochastic programming (SP)** is a mathematical framework to consider uncertainty & value flexibility in optimisation models.
- Ignoring uncertainty can give misleading decision support from TIMES models.
  - Depending on analysis
  - SP can be used to explicit model uncertainty and value flexibility
Short-term uncertainty

• Two-stage stochastic model
• Scenarios represent realisation of uncertain parameters
• Scenario independent investment decisions & scenario dependent operational decisions
• Minimise: Investment costs + expected operational costs
Stochastic scenario generation

- Scenario is a discrete representation of uncertainty with a given probability to occur
- Number of scenarios effect the computational effort
- Poor scenarios can give misleading results and insights
- Important to evaluate the quality of the stochastic scenarios and model solution

Objectives:
- How many scenarios is needed to provide reasonable model insights?
- What is a good method to generate stochastic scenarios?
Stochastic scenario generation

- **Stochastic scenarios considerations**
  - Temporal and regional correlations
  - Statistical properties/moments

- **Scenario generation methods**
  - Random sampling (2 seconds per season)
  - Statistical methods: Moment matching
    - Repetitive sampling (10 min per season)
    - Optimization (Time limit of 6h per season)

- **Solution evaluation methods**
  - In-sample and out-of-sample stability tests
Stochastic scenarios

- **Input** – 19 years of hourly resolution capacity factors for solar and wind in Norway

- **Total of 65 sets of scenarios created**
  - M = 3, 9, 15, 21, 30

- **Optimizing** – 1 set for each M

- **Random Sampling** – 10 set for each M

- **Repetitive Sampling** – 10 set for each M

- **Total 21 set of scenarios created for each M**

- Also created deterministic scenario of median values
Model result: In-sample stability

- Is the scenario generator creating scenarios resulting in similar optimal values?

- The energy system cost depends on how PV and wind is modelled

- More scenarios gives less variations among sampling methods
The solution time depends highly on number of stochastic scenarios.
Model results: Wind and PV in 2040

PV capacity depends highly on model representation of intermittent generation
Conclusion and further work

• Stochastic modelling of short-term uncertainty in TIMES models gives more realistic representation than a deterministic approach

• Stochastic scenarios, number of scenarios and methods used, affect the solution quality
  • PV is influenced the most in our analysis

• Further analysis and quality tests on in-sample and out-of-sample stability will give insights on
  • Required number of scenarios
  • Suitable methods for scenario generation