Clustering techniques for stochastic weather modelling in energy systems

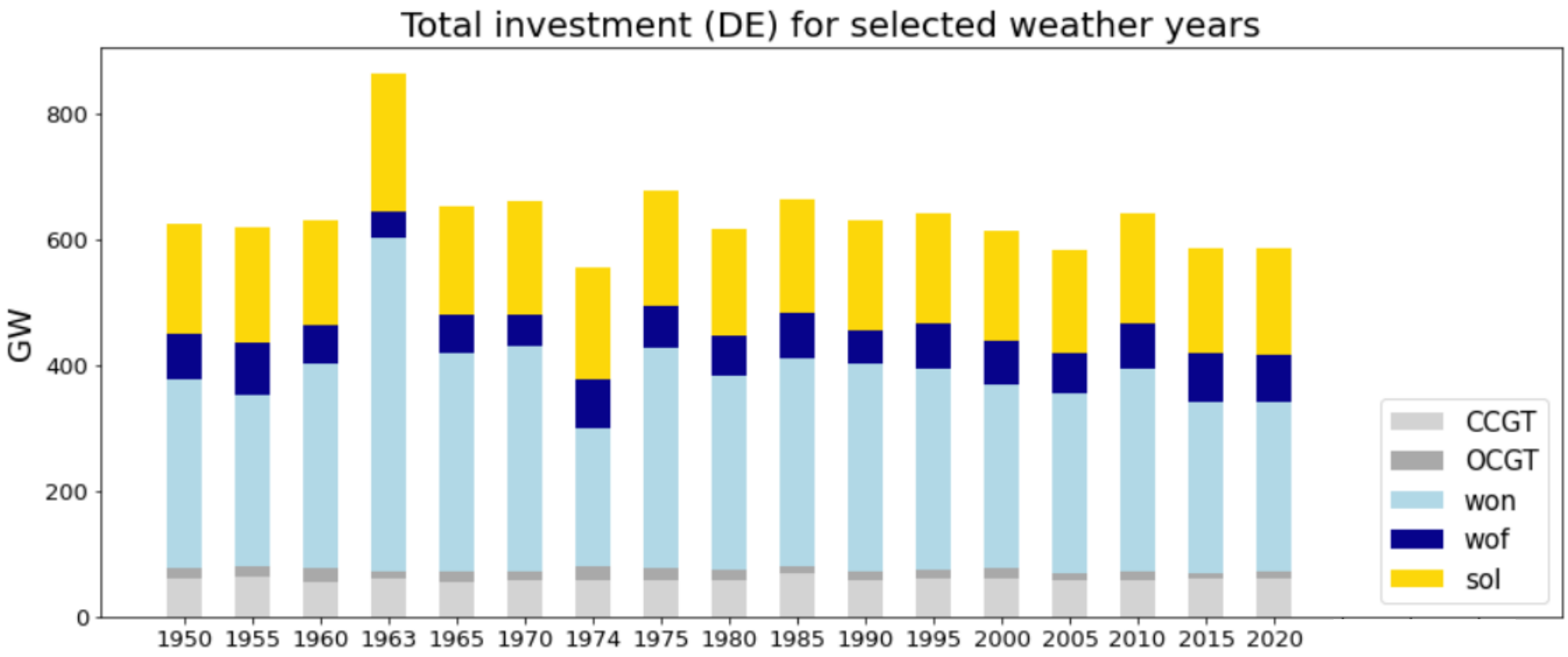
Smaranda Sgarciu; Raffaele Sgarlato; Iegor Riepin; Felix Müsgens

Conference on Climate, Weather and Carbon Risk in Energy and Finance | June 1st | Oslo

Brandenburg University of Technology Cottbus - Senftenberg

Hertie School

Research focus



Idea

Building on recent contribution → (Bloomfield et al., 2022) “Hourly historical and near-future weather and climate variables for energy system modelling”

We test different time series aggregation methods to represent the inter-annual weather variability.

- ***How can inter-annual weather variability be encoded in energy system models?***

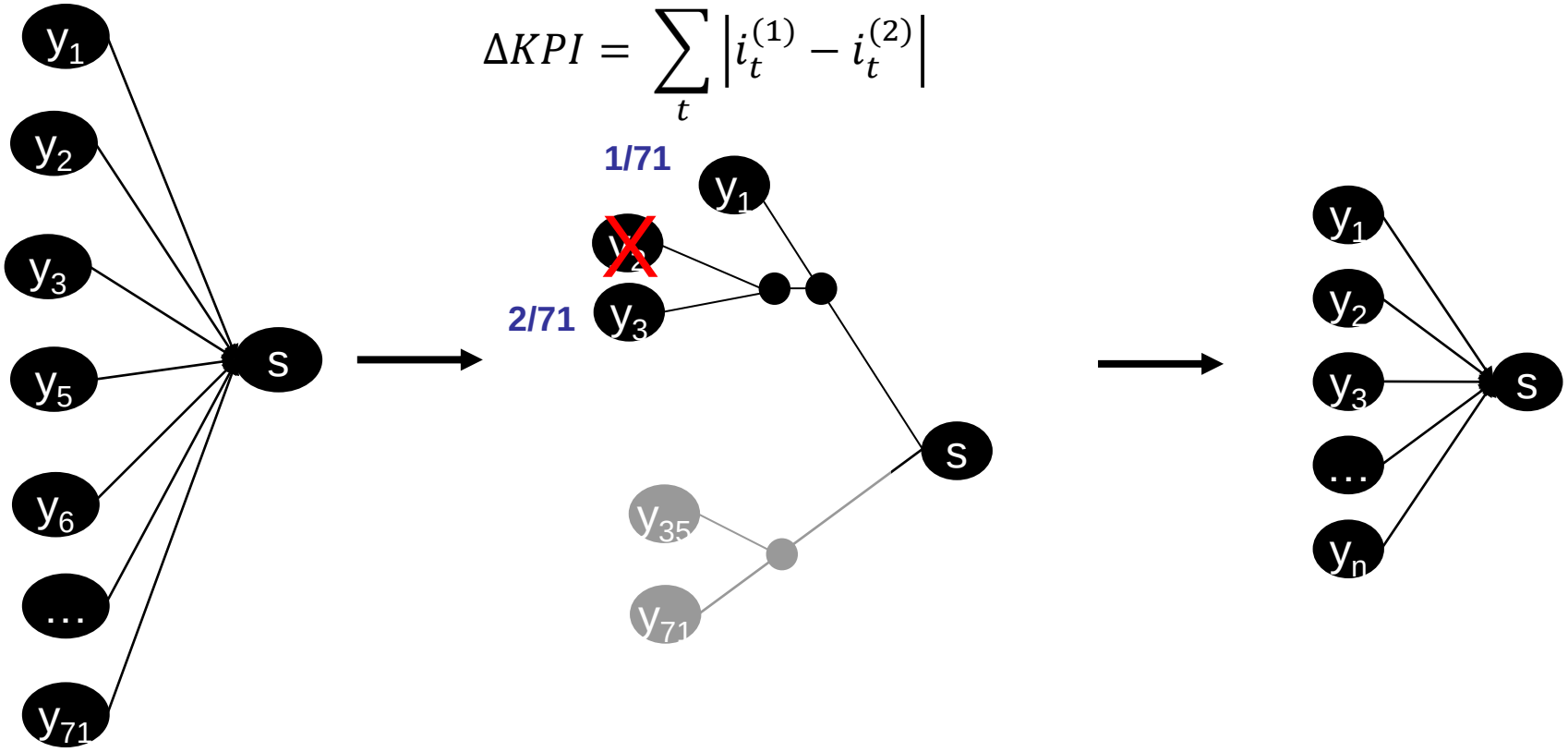
- ***What are the trade-offs between the computational complexity and results’ tractability?***

- ***Do we obtain deteriorated results but faster?***

Methodology – Output driven clustering

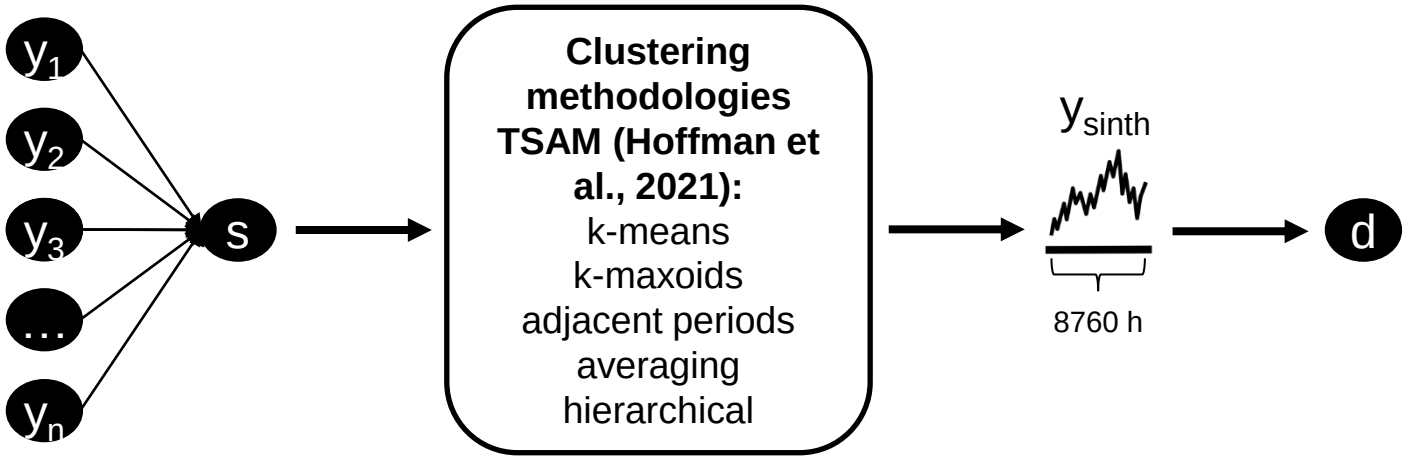
- Stochastic programming (weather years → branches for decision tree)

$$\Delta KPI = \sum_t \left| i_t^{(1)} - i_t^{(2)} \right|$$



Methodology – Input driven clustering

- Time series aggregation approaches (synthetic year → deterministic model)

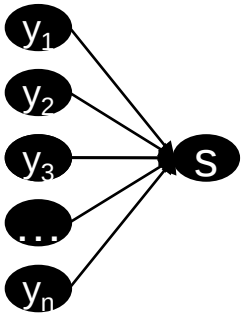


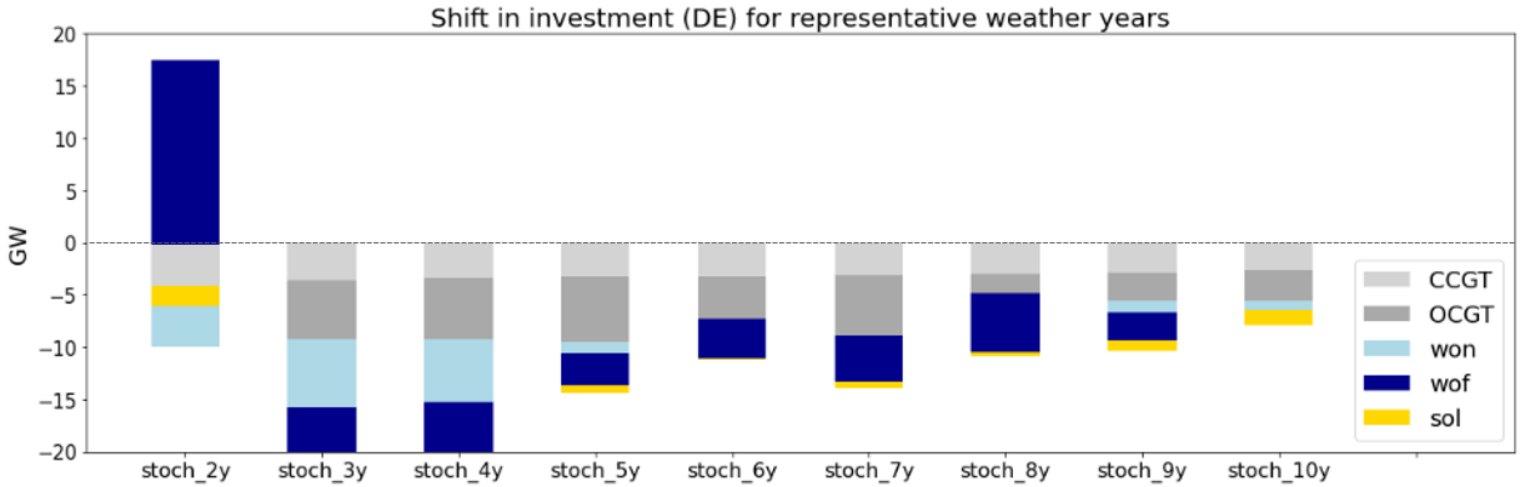
Results: Stochastic optimizaiton with representative years

Brandenburgische Technische Universität Cottbus - Senftenberg

Hertie School

We increase amount of branches in stochastic problem until with it converges to the optimal stochastic solution (with 71 years).

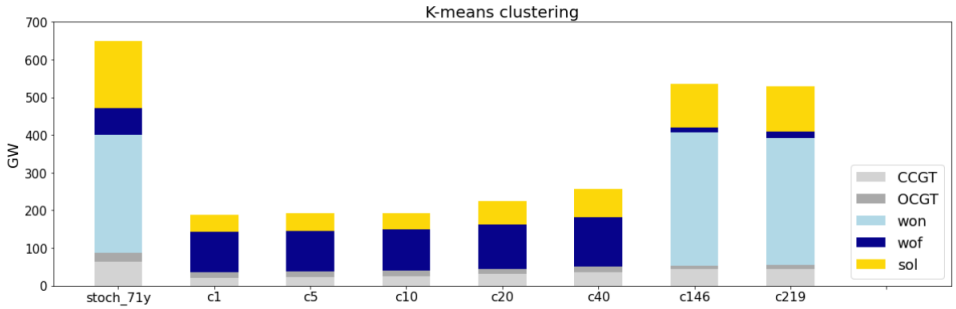


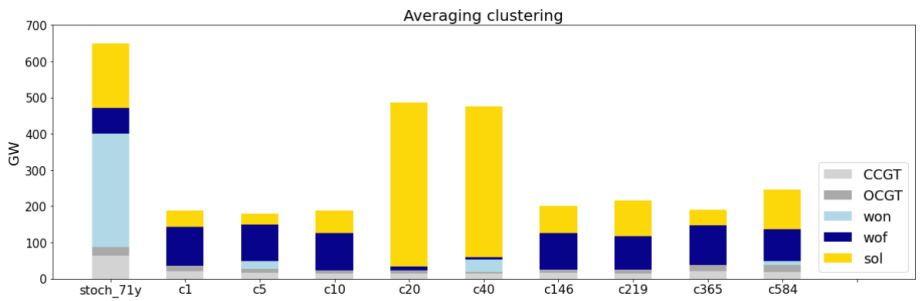


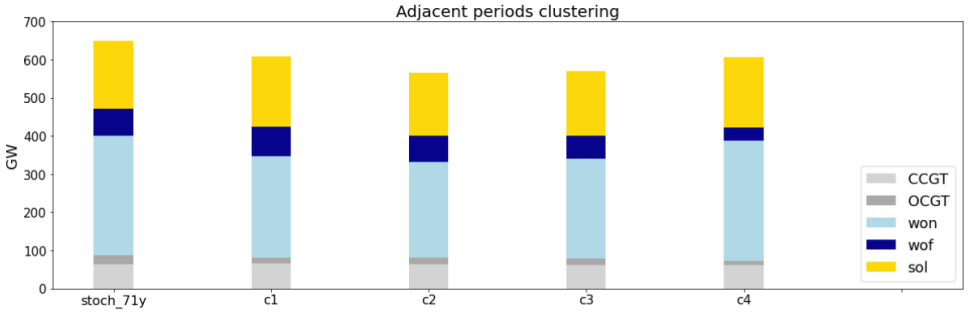
Results: Clustering techniques for a synthetic year

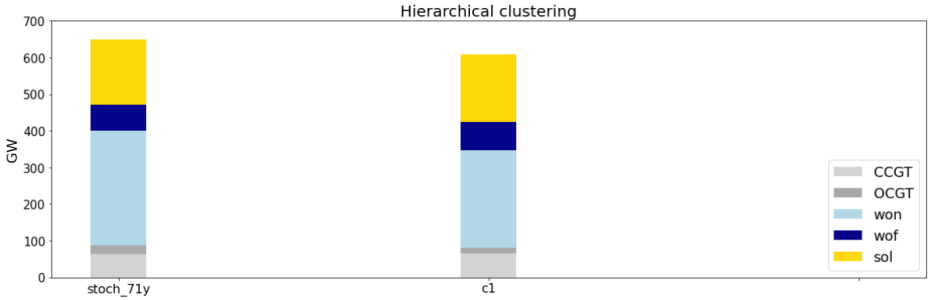
Brandenburgische Technische Universität Cottbus - Senftenberg

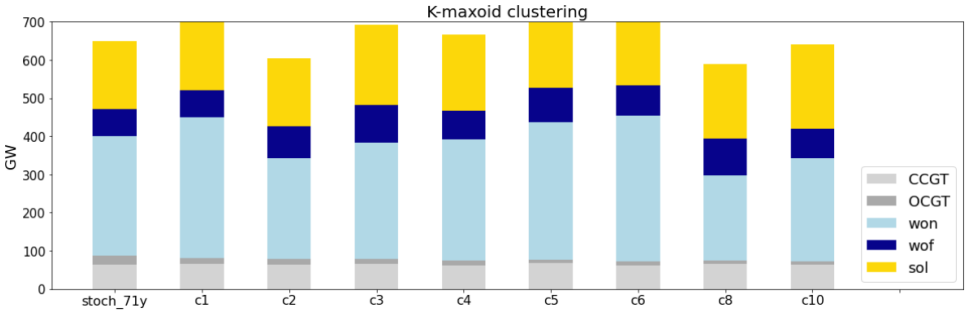
Hertie School









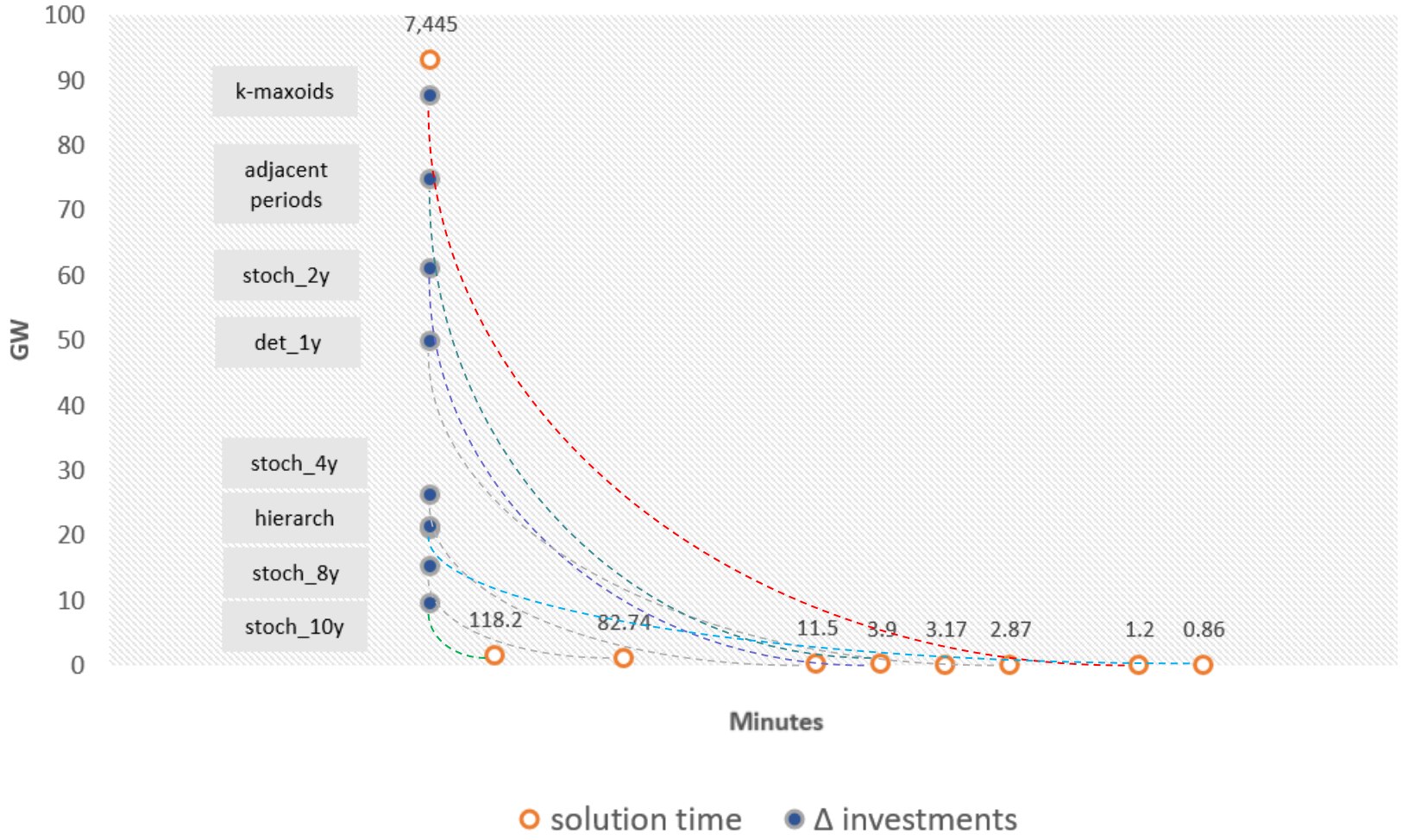


K-maxoid cluster optimal: ten clusters

Hierarchical clustering optimal: one cluster

Adjacent periods clustering optimal: four clusters

Results: Quantifying precision loss



Contributions

- Develop and test several methods to cluster inter-annual weather variability so that it can be encoded in the power system model with endogenous investments
- Results show primising methods of achieving results tractability

Follow-up research:

- Quantify precision loss (distance in investments, delta in objective value, etc.)
- Quantify compexity vs precision loss trade-off
- Scale-up model (nodes, technology mix, etc.)

Thank you!

Brandenburg University of Technology
Smaranda Sgarciu
Chair of Energy Economics
smaranda.sgarciu@b-tu.de
https://www.b-tu.de/en/fg-energiewirtschaft

Backup I: Modelling framework

Weather data extraction from (Bloomfield et al.; 2022)

↓

Profiles slicing based on demand and weather data

1) Model each branch individually

Deterministic optimisation model

2) Reduction 71 years → 10 representative years (output driven clustering)

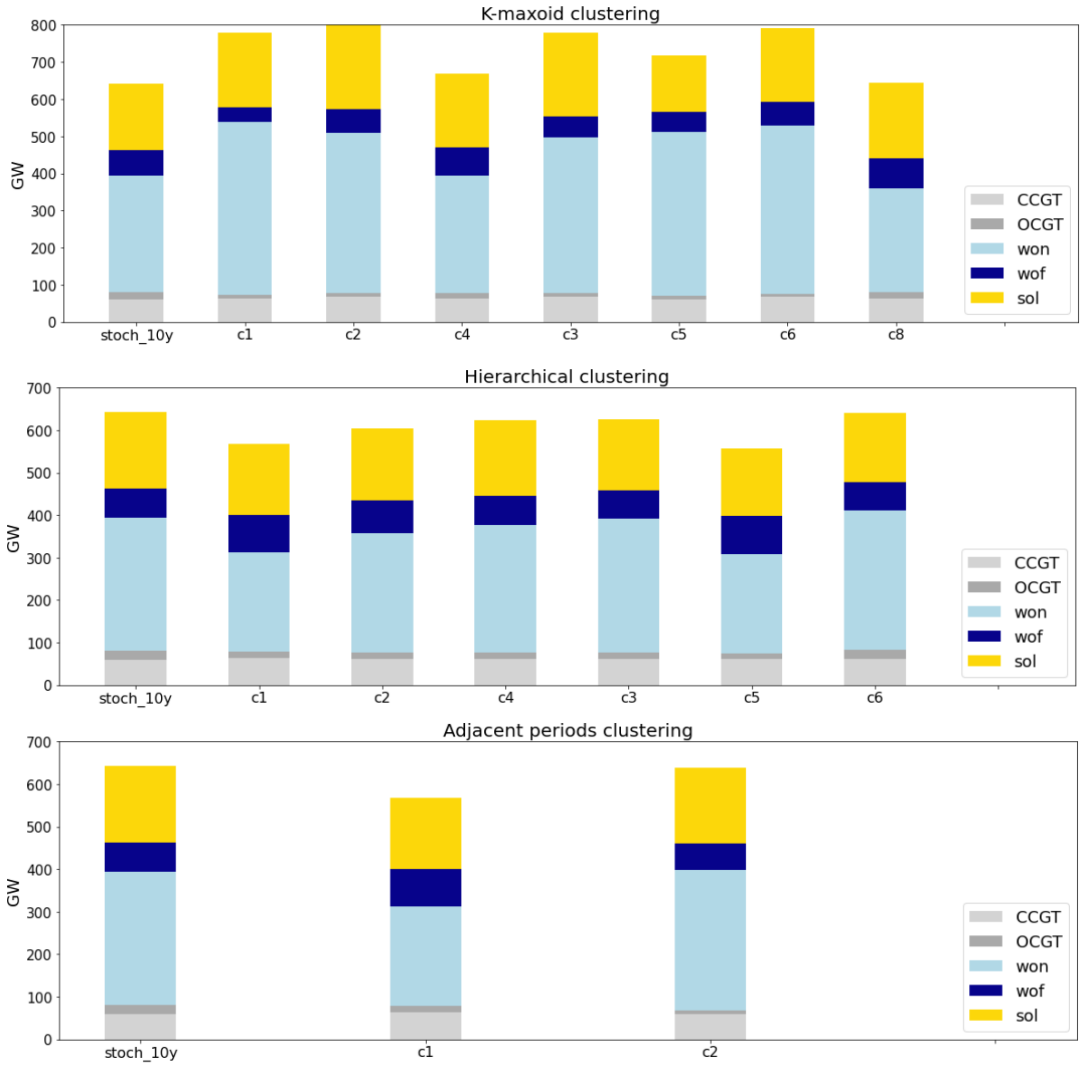
3) Model representative years

Stochastic optimisation model

4) Time Series Aggregation (input driven clustering)

Deterministic optimisation model

Backup II: Clustering representative years into synthetic year



K-maxoid cluster - optimal: 8 clusters

Hierarchical clustering - optimal: 6 clusters

Adjacent periods clustering - optimal: 2 clusters