Combing novel methods for the selection of representative days to fasten the optimization of the European electricity system under climate uncertainty

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Climate change influence on electricity systems

- Based on climate projections from euro-cordex [1]
- Impacts on
  - Demand
  - Hydro power
  - Thermal power
  - Solar power
  - Wind power
- Use of multiple climate models, RCP scenarios and years → large amount of input data, exceeds computational resources → reduction of input data necessary

Case study

- European electricity sector
- Investment and scheduling optimized with model backbone [4]
- No fossil fuels
- Investment in solar and wind power, batteries and hydrogen

Choice of representative days with new method *obpc*

Combination of two methods, **o**ptimization result **b**ased clustering [2] and **p**riority **c**lustering [3]

1. Divide time series in time periods of 24 hours length
2. Run individual optimization for each time period.

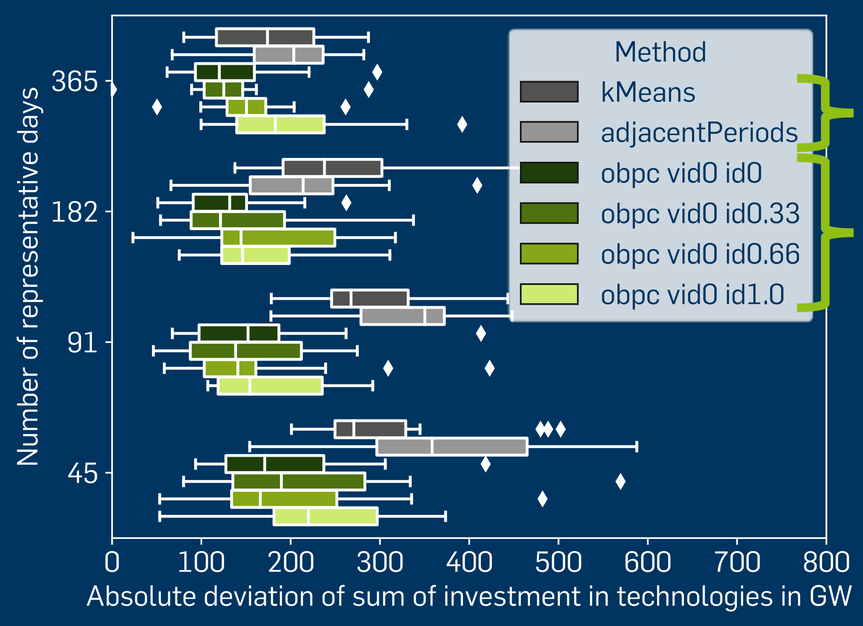
Example results	Day 1	Day 2	Day 3	Day 4	Day 5
Invested capacity Tech. 1	10	5.5	5	7	12
Invested capacity Tech. 2	3	7	8	5	0
Total system costs	100	100	60	90	120
		vid = 1, *id* = 2	important	not important	very important

3. Assign “very important” to the *vid* days with highest total system costs and “important” to the *id* days with the next highest total system costs.
4. Merge the two neighbouring days with the lowest Euclidean distance between their investment decisions into one cluster.

Example results	Day 1	Day 2	Day 3	Day 4	Day 5
Invested capacity Tech. 1	10	5.5	5	7	12
Invested capacity Tech. 2	3	7	8	5	0
		Lowest Euclidean distance			

5. Calculate cluster centre based on importance:
   - Same importance: cluster centre = average of clustered days
   - Different importance: cluster centre = more important day
   - Two very important clusters cannot be merged
6. Replace the clustered days with the cluster centre.
7. If desired number of representative days is reached: finish, else: go back to step 4.

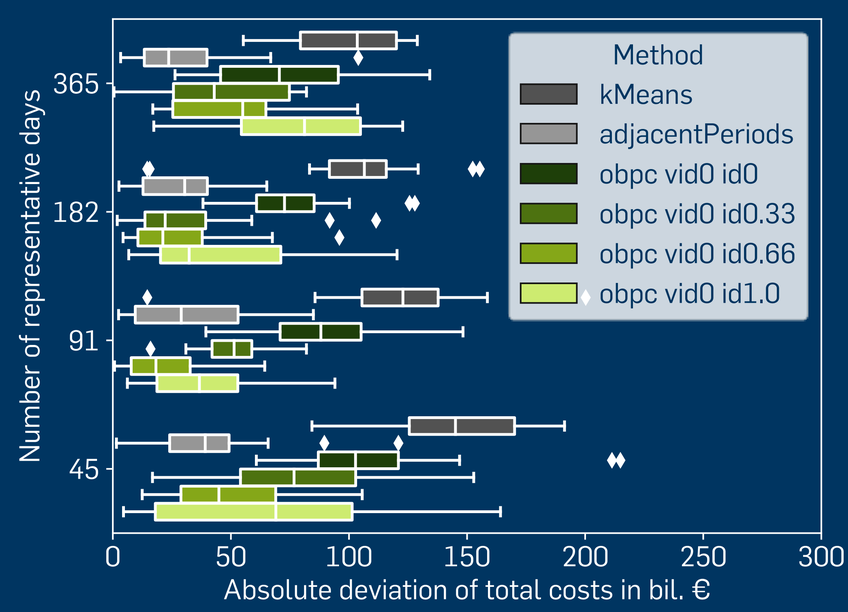
Results



Established methods for comparison

New method *obpc* with varying number of important days (share of representative days)

Boxplots show deviation from reference case with full time series of 1825 days.



- Using investment decisions for clustering decreases error in investment decisions, but worthens system cost accuracy
- Assigning importance to days based on the system costs increases system costs accuracy, while only minorly decreasing investment accuracy
- Possibility to choose, which results shall be most accurate
- Calculation time decreases from 96 hours (for full 1825 days) up to 1 hour (for 45 representative days)

References

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[3] A. Garcia-Cerezo, R. Garcia-Bertrand, and L. Baringo, “Priority Chronological Time-Period Clustering for Generation and Transmission Expansion Planning Problems With Long-Term Dynamics,” *IEEE Trans. Power Syst.*, vol. 37, no. 6, pp. 4325–4339, 2022, doi: 10.1109/TPWRS.2022.3151062.

[4] N. Helistö *et al.*, “Backbone—An Adaptable Energy Systems Modelling Framework,” *Energies*, vol. 12, no. 17, p. 3388, 2019, doi: 10.3390/en12173388.

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