Selecting **Real Best-Case Representative Periods** for Energy System Optimization

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1. Background

Energy systems need to expand to accommodate more renewables. The required optimization problems quickly become too heavy to solve directly.

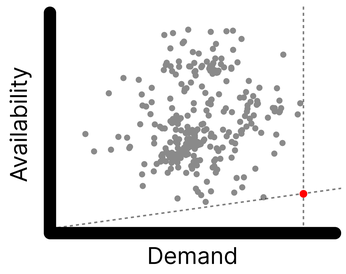
Clustering into representative periods:

Full year → Clustering → **Representative days** → Optimization → Investment plan

Advantage:
Significantly improves computability

Limitation:
Selects for typical behaviour
→ extreme situations not sufficiently accounted for

An artificial worst-case period accounts for extreme situations, but results in an **upper bound** on costs, choosing investments that are too expensive. [1]



Tulipa

- An energy system optimization model for investment decisions
- A clustering model to group into representative periods

2. Research question

"How can real periods representing the best cases be obtained and how does including them affect the performance of the aggregated model?"

3. Methodology

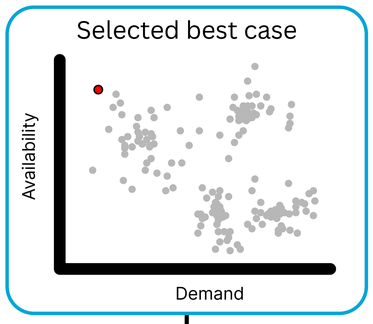
Baselines:

- K-medoids (clusters into representative days)
- K-medoids + Artificial worst-case (weight = 10%)

Main experiment:

1. Select best-case periods
2. Integrate them into the worst case baseline

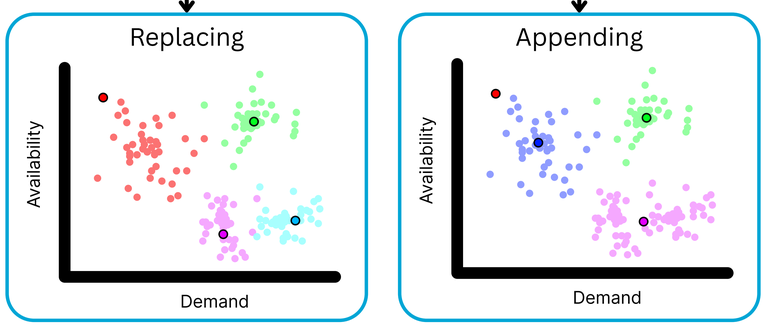
Selection:



Best case heuristics

- Max Availability
- Min Demand
- Max Availability/Demand ratio
- Max. Demand-adjusted Availability

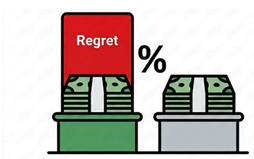
Integration:

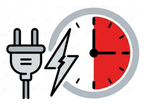


Extreme setting:
Replace each medoid with its worst-case version, then replace part of them with best-case or random days.

Metrics

Regret
Relative cost difference vs. optimum





Loss of load
Hours with unmet energy demand

4. Results

Main experiment: All four best-case strategies plateau at similar regret levels, indistinguishable from the worst-case baseline.

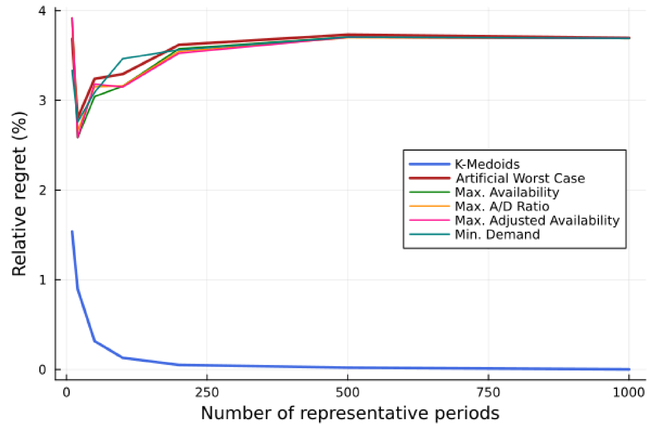


Fig. 1: Regret across best-case strategies (main experiment)

Extreme setting: Best-case selection performs no better than random.

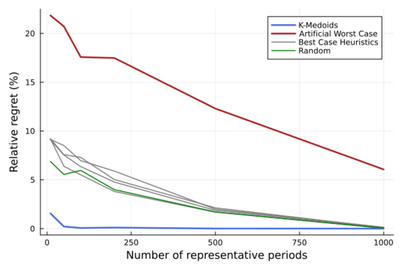


Fig. 2: Regret (extreme setting)

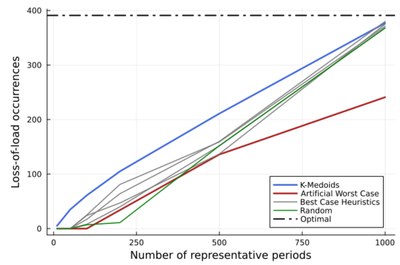


Fig. 3: Loss of load (extreme setting)

5. Conclusions

- Best-case selection likely **not an effective complement** to the worst-case approach
- Observed improvements most **likely stem from variety**, not best-case characteristics
- **More research required** to confirm this result

References

[1] L.A.A. Kremer, "Stochastic Programming for Energy Models: A Blended Cross-Scenario Representative Periods Approach," MSc thesis, Delft University of Technology, 2025. url: resolver.tudelft.nl/uuid:0e87f306