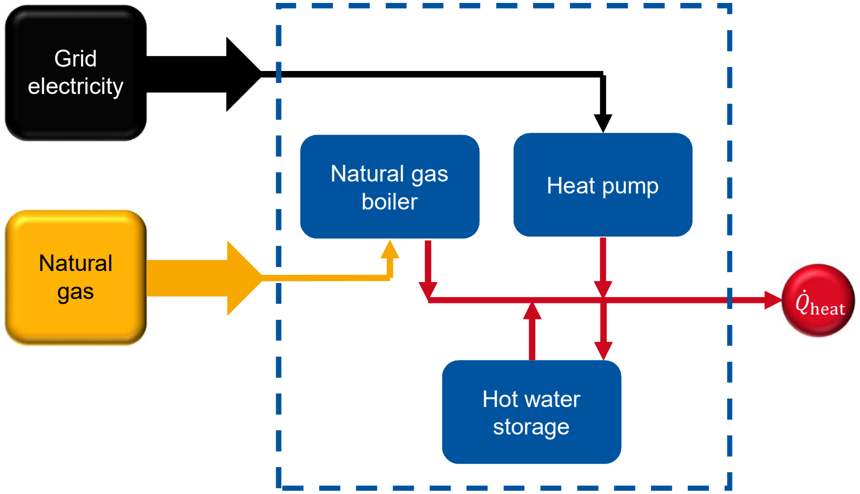
Methods of model-based Energy systems design

Exercise 3: Scheduling & Game theory

Lehrstuhl für Technische Thermodynamik | RWTH AACHEN UNIVERSITY

Lecture 8: Complexity reduction by temporal aggregation

You are the planner of an industrial energy system to provide process heat for a chemical park. You have been tasked with determining the **cost-optimal investment decisions.** The process heat demand to be covered is resolved hourly. Potential heat supply technologies are: **a natural gas boiler** and a **heat pump**. Furthermore, you can invest in a **hot water storage**. The industrial energy system is connected to the **electricity grid** and the **natural gas grid**. Electricity can be bought at an hourly resolved price $c_{\mathrm{el},t}^{\mathrm{buy}}$. Natural gas can be purchased at the hourly price of $c_{\mathrm{gas},t}^{\mathrm{buy}}$.



Please find and a JupyterNotebook Template in Moodle and upload it into your personal workspace on RWTH JupyterHub (https://jupyter.rwth-aachen.de) or your personal computer. The template contains an energy system design optimization model in which temporal aggregation has already been implemented.

Demo model with temporal aggregation

Diskussion starts at: 15:05

Your task:

Analyze the impact of different numbers of typical days and different time series aggregation settings on the installed capacities and costs

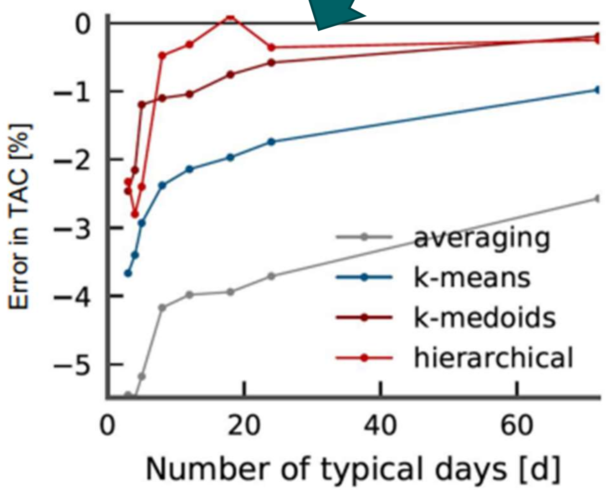
Change these parameters or add now ones

```python
# aggregate time_series with the tsam package
noTypicalPeriods = 2
hoursPerPeriod = 24

aggregation = tsam.TimeSeriesAggregation(
        timeSeries                  = time_series_data,
        noTypicalPeriods            = noTypicalPeriods,
        hoursPerPeriod              = hoursPerPeriod,
        clusterMethod               = 'hierarchical',
        resolution                  = 1
    )
time_series_data = aggregation.createTypicalPeriods()
```

Doc:
https://tsam.readthedocs.io/en/latest/timeseriesaggregationDoc.html

Focus on hierarchical clustering



Benchmark results with full time series resolution:

Total costs in k€/a	927.2
CAPEX in k€/a	37.86
OPEX in k€/a	889.34
$Q_{\mathrm{N,B}}$ in MW	10.00
$Q_{\mathrm{N,HP}}$ in MW	5.36
$Q_{\mathrm{N,storage}}$ in MWh	20.56

Lecture 6 – Game theory A1

Two researchers meet on the last day of a scientific conference. They talk about their research and decide that they want to work together in the future. To further discuss their envisioned collaboration, they agree on having lunch together. There are two possible places for lunch on the conference side: A little store where one can buy sandwiches and a large canteen, which is far away from the sandwich store. Researcher 1 prefers to go to the sandwich store, while researcher 2 would like to go to the canteen. Suddenly, researcher 2 gets an important call and leaves in a hurry. Later, both researchers realize that they neither exchanged their contact details nor agreed on a place for lunch. Both researchers would be equally unhappy having their lunch alone, be fine with having lunch together at the place favored by the other one, and be happy having lunch together at their own favorite place.

Hint:

A researcher can't visit both places at the lunch meeting because both lunch places are too far away from each other.

1. Which strategies do both researchers have?
2. Derive the payoff table for the described game.
3. Identify the existing Nash equilibria in the game.

Based on Holler et. al.: Einführung in die Spieltheorie

Lecture 6 – Game theory A2

Two power companies supply a village with power. Company 2 is specialized in solar energy and owns a solar power plant. Company 1 is a smaller company that owns a wind power station. Currently, company 2 has a revenue of 7, and Company 1 has a revenue of 4.

To increase its profits, Company 1 thinks about investing in new wind turbines. As a consequence, the revenues of company 1 would increase to 6, while the revenue of company 2 would reduce to 3. If Company 1 builds these new wind turbines, Company 2 considers extending its own power plant as well. In this case, the power stations would produce more power than the village can use, which could cause both investments to be unprofitable. The consequence would be that companies would have a revenue of -2.

1. Draw the game tree fitting the described situation.
2. Derive the payoff table of the game and identify existing Nash equilibria. Are all of them equally realistic? (Assumption / Hint: No conditional strategies necessary).
3. Company 2 has the possibility to invest in sunken costs. The investment would reduce the revenue of all strategy combinations that led so far to positive revenue by the fixed value C. Can company 2 improve its situation by investing in sunken costs? For which values of C?

Based on Holler et. al.: Einführung in die Spieltheorie