Bachelor / Master Thesis

Optimal Storage Strategy and Storage Size Optimization for Central Receiver Systems

Course of study: Mathematics, Computer Science, Computational Engineering
Kind of thesis: Programming, Simulation, and Optimization
Programming language: Python
Start: Winter term 2020/21

Topic

In this project we are looking at central receiver systems. The principle of concentrating solar thermal power plants seems to be very simple: Large mirrors are used to concentrate rays of sunlight on an receiver where a fluid (e.g. molten salt) is being heated up. The heat of the fluid is exchanged into steam which powers a turbine to generate electricity.

The placement of the mirrors may lead to individual mirrors being blocked and shaded; this affects the efficiency of the power plant. The model is later used for an optimization process which finds the most efficient arrangement of mirrors.

Storage in a central receiver system.

Preliminary work

A formulation of the optimization problem as Python code exists already.

Tasks

The following tasks have to be solved:

Optimal Storage Strategy

- Change the existing formulation (which bases on a molten salt cycle) to a thermal oil cycle, which uses a heat exchanger. Thus, the solar block delivers thermal power which is send to the heat changer. There an additional immersion heater uses the photovoltaic power to heat the molten salt to the desired temperature. Then, the power flows into the storage and then into the power block. The photovoltaic power is directly converted into AC power. A part of the power is used to heat the heat exchanger, while the remaining power is plugged into the grid.
- The needed photovoltaic power is a factor 1.4 higher than the delivered power from the solar block. The reason is that the temperature rise in the solarblock is 100°C, while in the heat exchanger it is once again 140°C.
- Consider that the solar block has a maximum flow rate into the storage.
- The powerblock operates in general just at 80 to 100 %. Thus increase the min load for the power block. Compute a temperature dependent efficiency of the power block. Compare the function with the function from PCTrough developed by *TSK Flagsol*.
- Consider startup and turn off times. For half an hour the efficiency is just 50 %.
- Change the time step to 15 minutes data.

- Investigate if a change from power to mass and temperature changes the formulation.
- Compare different branch and bound solver which solve the LP formulation, e.g. `Gurobi`, `glpk`, `Coin-or`, `lpsolve`, and `SoPlex`.
- Compare the results if as objective function the revenue or a simulation of PCTrough is used. Thus, the code needs to be coupled to PCTrough.
- Extend the objective function such that day-ahead forecasts are possible.
- As extension of the time-dependent tariff, the EEX energy spot curve can be loaded.

Storage Size Optimization

- Revise the existing multidimensional Newton-Raphson method, such that also local minima can be avoided. Maybe a multi-start strategy could help.
- Optimize the storage size for a planned power plant in Morocco.

Contact This project is offered by the *Theory of Hybrid Systems* (i2) research group headed by Prof. Dr. Erika Ábrahám and will be co-supervised by Dr. rer. nat. Pascal Richter. For further questions please contact us via email:

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