138 SolFieOpt
Optimal Heliostat Fields for Solar Tower Power Plants

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Publishable Summary

A solar tower power plant (also known as central receiver system, CRS) consists of a receiver on top of a tower and a field of thousands of heliostats. The heliostat field reflects and concentrates direct solar radiation onto a receiver placed at the top of the tower. At the receiver the reflected solar radiation is absorbed and the resulting high-temperature thermal energy is transferred to the heat transfer fluid in order to either directly produce electricity through a conventional thermodynamic cycle or to be stored. Currently several large tower plants are operating in the US (Ivanpah 1-3 and Crescent Dunes), three in Spain (PS10, PS20 and Gemasolar), one in South Africa (Khi Solar One) and Noor III in Morocco

The CRS technology is very well suited for converting solar radiation into dispatchable electricity. Dispatchability is important as the electricity demand hardly ever matches the supply delivered by renewable energies, such as wind and PV. While for small amounts of renewable energies the effect on the electric grid is negligible, countries with high shares of such energy (e.g. the USA, Italy and Germany) face a challenge. CRS operate at high temperatures, making thermal storage systems very cost-efficient. This helps to even out fluctuations of other renewable plants and thus help to further increase the capacity of the non-dispatchable renewable energy technologies.

The design of the heliostat field layout is a challenging task of exceptional importance. It is the sub-system with the highest cost and its optimal design highly depends on the specifications for each project. Within this project the partners, **Uni Seville, RWTH Aachen / KIT and TSK Flagsol**, have created a software suit that accomplishes a task that so far was not possible: the **optimisation of the cost efficiency of pattern-free heliostat fields,** which implies that the coordinates of each heliostat are an optimisation parameter. This task incurs various sub-optimisations:

- For each arrangement of heliostats that is processed in the course of an optimisation run, the routing of power and communication cabling has to be optimised, ideally using **minimum spanning trees**, as the cable cost become increasingly dominant for large fields.
- An optimized cleaning strategy has been studied and applied for these kind of “chaotic” field layouts, aiming to reduce the path length of the cleaning trucks or robots. Strategies similar to that of the “travelling salesman problem” have been investigated.
- Aim-points of each heliostat on the receiver leading to optimal flux distributions were dynamically found using a hybrid optimisation strategy, including **binary integer linear programming** (BILP).
- For the overall positioning optimisation, a hybrid optimisation procedure using **greedy**, **genetic** and **gradient-based** algorithms have been used to find advantageous layouts.

The developed simulation and optimization tools have been cross-validated against commercial and in-house tools of TSK Flagsol. Real data for the cost model and a reference field has been used.

The methods developed within this project will yield more cost-efficient heliostat fields, which leads to higher market penetration of this technology, benefitting the entire industry.

Project consortium

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Participating countries and financing:

Country	Number of organisations involved	Project costs in EUR	Public funding in EUR
Germany	2	436’872	345’456
Spain	1	120‘000	120‘000
Total	*3*	*556’872*	*465’456*

Funding agencies involved and contracts

Funding Agency	Contract N° and Title
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Projektträger Jülich	0324039 – „SolFieOpt- Optimale Heliostatenfelder für Solarturmkraftwerke”