OPTIMIZATION OF REGIONALLY RESOLVED ENERGY SYSTEMS BY SPATIAL AGGREGATION AND DISAGGREGATION

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Content

Regionally resolved energy system models are a valuable tool to support decision makers in long-term strategy planning. The optimal synthesis of energy systems requires high spatial resolution to account for local constraints such as grid limitations and local fluctuations of renewable energy. Thus, high spatial resolution leads to large-scale optimization problems for the synthesis of energy systems, which are computationally challenging. Therefore, simplifications are typically used to solve these optimization problems. However, solutions based on simplifications might not be feasible for the original energy problem.

To provide feasible solutions for regionally resolved energy systems, we present the SpArta method for spatial aggregation and disaggregation. In SpArta, we initially aggregate the optimization problem but then decompose the aggregated solution to find a feasible solution to the original problem.

Method

The SpArta method finds feasible solutions for large energy systems in four steps (Figure 1):

1. Spatial aggregation of the regionally resolved system into clusters.
2. Optimization of the aggregated energy system: design and operation are simultaneously optimized but with the reduced spatial resolution. The design optimization considers all energy converters and the grid.
3. Re-optimization of each single cluster at full resolution: We conduct a second design optimization for each cluster but now with the original spatial resolution. The results of the clustered optimization in step 2 serve as constraints to impose the identified design and power flows.
4. Aggregation of the design for the full problem: We determine the design of the regionally resolved problem from the designs of the single clusters at high spatial detail.

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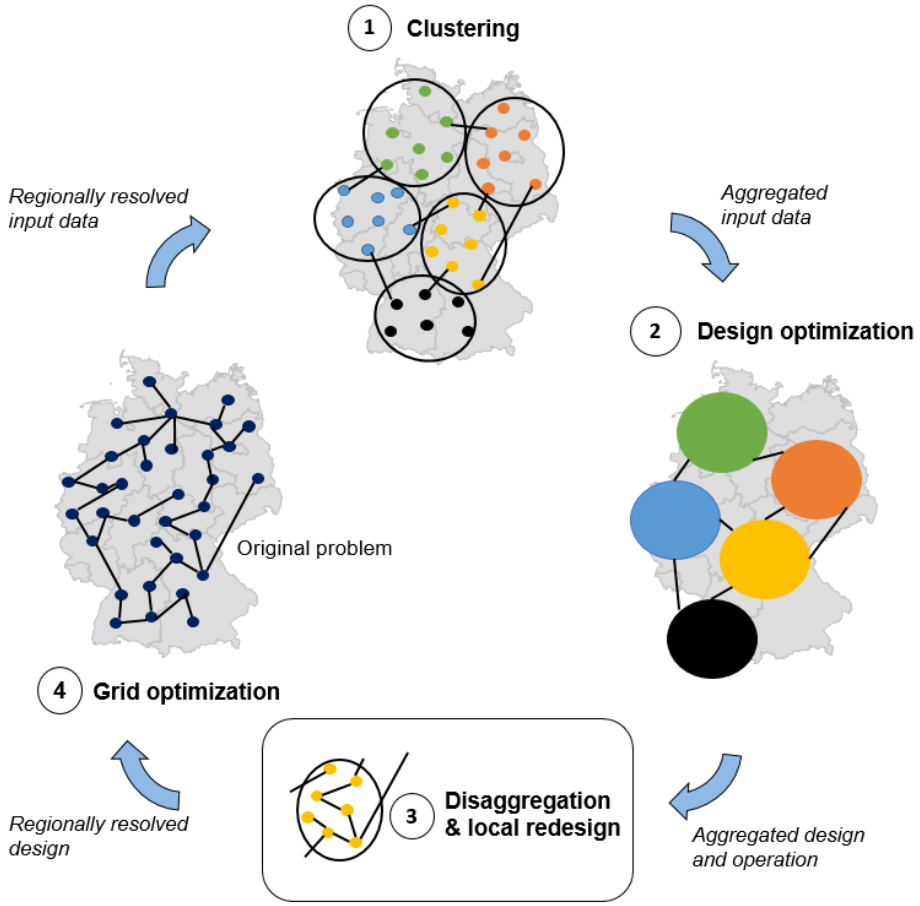

Figure 1: SpArta – Aggregation and disaggregation of regionally resolved energy systems for computationally efficient design ensuring feasible operation.

Results

As a case study, we consider the design of the future energy system for Germany, using a model with a spatial resolution of more than 400 nodes. We show that SpArta leads to feasible results at high solution quality while significantly reducing calculation time compared to the original optimization problem. The ability to resolve the local details enables a more realistic design of the energy systems. Thereby, SpArta deepens the basis for decision support in energy systems design.