Case Study

AI based grid planning

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Challenge

The planning of reliable, efficient and cost-effective electricity grids is a challenging process. Furthermore additional requirements on the grid such as an amalgamation of centralized and decentralized electricity generation units as well as bi-directional energy flows present additional complexities. In order to assist the grid planning and automate parts of the process a concept tool was to be developed which requires less modeling effort but also is less computationally intensive than existing network planning algorithms. Goal of the planning is to deliver an optimized network topology, that constitutes in less construction costs, less energy transmission losses, as well as an increased level of reliability.

Approach

Since the underlying mathematical problems of network planning boil down to NP-hard problems, an approach based on heuristics and the use of deep reinforcement learning was developed in order to provide a feasible solution. As basis for the project, data from an existing electricity grid from a distribution system operator (DSO) in the Netherlands was used, consisting of a graph representation of the network and the electricity demand of the individual consumer nodes. This allows to benchmark the solution against a real-world grid, as well as other network optimization tools and libraries. After modelling the grid as a regular grid with arbitrary granularity, the network planning problem was split into two problems – first – finding an optimal positioning of transformers and producers based on an electricity consumption distribution and second – finding optimal connections between consumers and producers. Based on the recent developments in deep reinforcement learning methods for combinatorial optimization, a metaheuristic approach was developed to tackle simultaneously a combination of NP-hard problems. Another heuristic algorithm is then used to subsequently find feasible solutions for the resulting subgrid problems. The proposed solution operates on two levels by connecting microgrids in a tree fashion optimizing for the min cost max flow target. The center of mass of each microgrid is connected to the higher level network in a ring topology using a generated approximative solution to the traveling salesman problem. The reinforcement learning neural network architecture was based on a pointer network with attention models for time series for the encoder and decoder parts. The tool was deployed as a REST-API in the Google Cloud Platform. This allows easy scaling of computational resources required for grids of different sizes.

Result

The solution developed by Reasonance offers an extremely fast way for network operators to evaluate new network infrastructure, by taking into account construction cost, transmission losses and expected demand across the network. We were able to achieve a cost saving of up to 30% compared to real-world electricity networks and comparable and in some cases better results to existing tools and libraries. The proof-of-concept solution could be a useful basis for tackling the challenges of network expansion and grid design for energy companies, whereby applications for gas or heat networks are also possible.

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