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DEVELOPMENT AND ASSESSMENT OF DIFFERENT ALGORITHMS FOR DISPATCHING A VIRTUAL POWER PLANT

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Overview
Linking distributed energy resources is estimated as an important step towards the future energy supply system. In a first approach this so called virtual power plant (VPP) can be dispatched in the same way like today's conventional power plants. A closer look reveals that the commonly used methods based on Mixed Integer Linear Programming (MILP) do not meet the special needs of a VPP. The mathematical problem differs from that of a conventional dispatch by the high number of individual devices, which are characterized through similar or identical technical and economic parameters. Furthermore, the local thermal load of the Combined Heat and Power (CHP) devices must be considered.

This paper deals with the development and assessment of different algorithms for day-ahead and intraday dispatching, which fulfil the requirement of a virtual power plant, consisting of individual CHP devices. This study is undertaken in the research project "Pooling of distributed energy resources", which is subsidized by the Federal Ministry for Economy and Technology and supported by two German utilities "Stadtwerke München" and "EWE".

Method
The assessment of different dispatching algorithms uses a simulation framework, which supports the individual thermal demands and their forecasts. To be able to react on forecast deviations both a day-ahead schedule and hourly rolling intraday updates are calculated. The performance of three different algorithms is investigated by applying them to VPPs of varying size and boundary conditions.

The reference algorithm is based on earlier FfE work, which implements the commonly used MILP approach. The showed results regarding solution quality and calculation time refer to that FfE implementation and may not be adapted to MILP based dispatching tools in general.

Beside this reference two alternative approaches are developed and analysed, based on heuristic and linear programming. Different aspects of the marketing (heat-lead and electricity trading) and dispatch type (day-ahead and intraday schedule) are considered in the programming.

Result
The results of the algorithms are prediction based operation schedules and intraday updates to react on forecast deviations. Assessment criteria are the operation characteristic, the revenues of electricity trading and the calculation time. It appears that none of the investigated approaches fits best to all criteria.

The MILP method leads to best solution quality and trading revenues. The disadvantages are the long calculation times and the unsteady operation characteristic. The latter can be reduced by introducing additional constraints such as minimum down time, minimum up time, start-up costs and load changing costs. Without these constraints the schedule shows many start and stop operations, especially in transition times. The calculation time is sensitive to the number of devices with similar producing prices, as they determine the flatness of the solution tree.

Applying the alternative approach based on pure heuristic algorithms yields shorter and model parameter independent calculation times. The VPP is operated steadily without additional constraints. On the other hand trading results are lower than in the MILP solution. This disadvantage is serious as the profitability of VPPs with today's German electricity market prices is marginal.

The third investigated approach combines a heuristic and a linear programming method. The steady operation schedule and the short calculation time, which is achieved by avoiding integer variables in the linear

programming, are the advantages of this concept. The day-ahead results do not reach to MILP level, but intraday trading gains satisfying results.

Conclusions

Dispatching virtual power plants makes special demands on the optimization algorithm. The common approach established for conventional power plants is usually based on MILP. The implemented reference algorithm does not perform sufficiently for productive use. A higher number of devices with similar technical and economical parameters slow down the solution process. The developed alternative algorithms lead to a faster solution, but achieve minor power trading revenues. The linear-heuristic approach is promising as it can be developed towards improved revenues in further steps.

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