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Approaches to Reduce the Complexity of Mathematical Models for the Operational Optimization of Large-Scale Virtual Power Plants in Public Energy Supply

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Abstract : In context of the energy transition in Germany, the importance of so-called virtual power plants in the energy supply continues to increase. The progressive dismantling of the large power plants and the ongoing construction of many new decentralized plants result in great potential for optimization through synergies between the individual plants. These potentials can be exploited by mathematical optimization algorithms to calculate the optimal application planning of decentralized power and heat generators and storage systems. This also includes linear or linear mixed integer optimization. In this paper, procedures for reducing the number of decision variables to be calculated are explained and validated. On the one hand, this includes combining n similar installation types into one aggregated unit. This aggregated unit is described by the same constraints and target function terms as a single plant. This reduces the number of decision variables per time step and the complexity of the problem to be solved by a factor of n. The exact operating mode of the individual plants can then be calculated in a second optimization in such a way that the output of the individual plants corresponds to the calculated output of the aggregated unit. Another way to reduce the number of decision variables in an optimization problem is to reduce the number of time steps to be calculated. This is useful if a high temporal resolution is not necessary for all time steps. For example, the volatility or the forecast quality of environmental parameters may justify a high or low temporal resolution of the optimization. Both approaches are examined for the resulting calculation time as well as for optimality. Several optimization models for virtual power plants (combined heat and power plants, heat storage, power storage, gas turbine) with different numbers of plants are used as a reference for the investigation of both processes with regard to calculation duration and optimality.

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