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LONG-TERM INVESTMENT STRATEGIES FOR POWER AND HEAT GENERATION PORTFOLIOS WITH MINIMAL COSTS

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Overview

Many European energy service companies face the problem of finding long-term investment strategies for power and heat generation to meet new political and economic tasks including CO_2 emission targets as well as rising economic inefficiency of gas power plants. In this paper a mathematical framework is developed to find cost minimal strategies for power and heat generation portfolio including different types of power plants. The time horizons of the investments strategies are from twenty up to fifty years. The proposed model builds on the existing literature on the short-term portfolio optimization for power plant dispatching. A suitable adaptation of the models is used and combined with long-term effects to find portfolio strategies with minimal costs for future power and heat generation including investment costs that meet political targets.

Method

The cost-optimal strategies can be found as a solution of a mixed-integer linear optimization problem (MILP). The objective function contains the discounted costs of power and heat generation for the planning periods and all discounted investment costs of new power plants. The input arguments include in particular different paths of energy demand, spot electricity and heat prices and feed-in-tariffs, fuel costs, investment costs and carbon costs. Technological advancement is considered via learning curves for the investment and reinvestment costs. The modeling will allow for different types of power plants, e.g. plants with combined heat and power generation as well as renewables. The control variables are the investments (or alternative no investments) in the new possible power plants and the reinvestments in existing power plants. Thus the investment and reinvestment decision for every period are made such that the overall costs of investments and power and heat generations of every (future) period are minimal. This framework differs from the common portfolio management approach based on the Markowitz paradigm developed for financial portfolios and used in energy economics [1]: With the approach of the paper an individual optimal investment strategy is based on an existing generation portfolio and not a global optimal solution for a completely new portfolio. As the problem is formulated as MILP different scenarios (e.g. scenario trees) can be calculate to incorporate the stochastic behavior of the input arguments and to consider costs of risks for the optimal solution.

Results

The proposed mathematical optimization model allows for finding long-term investment strategies for power and heat generation portfolios with minimal costs for the energy service company. When using different scenarios also uncertainty of the input arguments can be incorporated. Representative data for a central European energy service company will be used to illustrate the parameterization and outcomes of the model. The result of this paper should highlight the importance of choosing the right point in time for investment decisions in the field of power and heat generation Moreover, based on different scenarios, the sensitivity of the investment decisions to different price developments is studied. These sensitivity results can be the foundation for stochastic optimization problems within this field.

Conclusions

The mathematical model developed in this paper allows for giving a quantitative support of long-term investment decisions for a power and heat generation portfolio simultaneously. As the approach is suitable for generation portfolios with various types of power plants it can be widely used by energy service companies. The integration of different scenarios copes with the uncertainty of future development.

References

[1] Florian Kienzle and Göran Andersson: “Efficient multi-energy generation portfolios for the future”, 4th Annual Carnegie Mellon Conference on the Electricity Industry, 2008