Decision-making Under Uncertainty for Fuel Contracting of Combined Heat and Power Plants

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During the last years, the consumption of biomass to produce power and heat has increased due to the new carbon neutral policies. Nowadays, many district heating systems operate their combined heat and power (CHP) plants using different types of biomass instead of coal or natural gas. Besides, subsidies are given to those CHP plants that fulfill the heat demand using biomass. Nowadays, an optimal operation of a CHP plant must combine the interplay of biomass to produce heat and natural gas to generate power.

Natural gas markets have been refined throughout the last years and therefore previous works have tackled the optimization of natural gas contracts for electricity producers (e.g. [1]). On the other hand, biomass is transported from the supplier to the consumption sites and the contracts with the suppliers are negotiated months in advance. This negotiation process involves many uncertainties from the energy producer's side. The demand for biomass is uncertain at the time of negotiation, and heat demand and electricity prices vary drastically during the planning period. Furthermore, the optimal operation of combined heat and power plants has to consider the existing synergies between the power and heating systems while always fulfilling the heat demand of the system. Previous work regarding the optimization of biomass planning has been done by [2].

What we propose is a solution method using stochastic optimization to support the biomass supply planning and natural gas contracting for combined heat and power plants. Our two-phase approach combines mid-term decisions about biomass and natural gas supply contracts with the short-term decisions regarding the optimal market participation of the producer to ensure profitability and feasibility. We include flexible mechanisms in our model in the form of short-term contracts. The risk of major deficits in biomass supply is reduced by including appropriate risk measures to the models. We present numerical results and an economic analysis based on a realistic test case.

References

[1] H. Chen and R. Baldick, "Optimizing short-term natural gas supply portfolio for electric utility companies," *IEEE Transactions on Power Systems*, vol. 22, no. 1, pp. 232–239, 2007.

[2] M. Chiarandini, N. H. Kjeldsen, and N. Nepomuceno, "Integrated planning of biomass inventory and energy production.," *IEEE Trans. Computers*, vol. 63, no. 1, pp. 102–114, 2014.