COMBINED HEAT AND POWER PRODUCTION - VALUING FLEXIBLE OPERATION IN AN UNCERTAIN ENVIRONMENT

Christoph Weber, HEMF – University of Duisburg-Essen, +49 201 183 2966, christoph.weber@uni-due.de

Overview

CHP provides an efficient means of converting fuels into power and heat. At the same time operation of CHP units is restricted by thermodynamical and technical constraints and subject to the double uncertainty of power prices and heat demand. The contribution explores the impact of operational flexibility both in the CHP unit (extraction condensing vs. backpressure turbines) and in the system configuration (back-up heat boiler). Analytical results are derived and a numerical application is presented.

Methods

The contribution extends a real option model of a thermal power plant by the heat generation part to consider CHP production. Thereby both CHP units with one degree of freedom (backpressure plants) and with two degrees of freedom (extraction condensing plants) are modelled. Furthermore a heating boiler is considered as back-up facility. The optimal operation mode of the system is determined analytically as a function of electricity prices and heat demand. Then formulas for the value of the real option are derived based on the expected operation margin over one year, taking into consideration fluctuations both in heat demand and in prices.

The approach is applied to a large-scale gas-fired CHP plant both for a historical year (2015) and scenarios for a future year (2030).

Results

As long as no further operational restrictions beyond the heat demand are introduced, analytical formulations for the value function containing integrals may be derived for all CHP system configurations considered. However a fully analytical solution is only possible for particular specifications of the deterministic and stochastic components of the electricity price and heat demand.

In the application case, the operational flexibility provided by an extraction-condensing turbine is shown to be much more valuable in the year 2015 than the flexibility provided by a heatboiler. For future scenarios this is also confirmed, although the flexibility value of an additional heat boiler may be considerably higher.

Conclusions

CHP systems have a long-standing tradition in efficient energy use and sector coupling. Yet the additional heat constraints makes CHP plants less flexible than conventional power plants when it comes to act as complement to intermittent renewables. By introducing additional degrees of freedom in the system through condensing-extraction turbines and back-up heat boilers, the benefits of CHP may also prove useful in a future energy system context – and this is also reflected in higher flexibility values of these configurations.