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An assessment of the flexibility of combined heat and power plants in power systems with high shares of intermittent power sources

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Abstract

There is an urgent need to reduce anthropogenic CO_2 emissions from the power sector as a climate change mitigating strategy. Thus, the share of renewable energy sources in power systems, for example wind power, is increasing. However, the variability in wind power generation poses a challenge to conventional thermal power plants, as well as yielding volatile electricity prices. Once in place, wind power with low operating cost will replace higher-cost electricity generation units in the merit order, while during low-wind periods the need for thermal plants remains. Traditionally designed for stable base load, thermal power plants might thus face a future with new demands for flexible operation to stay competitive.

Combined heat and power (CHP) plants are thermal power plants that produce electricity and district heating simultaneously and, depending on plant type and fuel, they have different possibilities to vary the ratio between power and heat production. However, technical constraints place limitations on flexibility, including ramp rates and efficiency. The interconnection between the power and heat markets provides additional opportunities for load variation management. With the comparably slower dynamics of the heat market, and the possibility to store thermal energy, prospects of adapting to new and profitable operating strategies that can aid the balancing of the power system arise.

This study focuses on how CHP plants can provide flexibility in a scenario with fluctuating power demand and associated volatility in electricity prices. Plant and market dynamics are analyzed to estimate the need for flexibility, and what is required of CHP units in terms of operation to meet these requirements. A CHP plant is modelled in detail with a boiler, steam cycle and its link to the district heating system, both under steady state and transient conditions, using the softwares Ebsilon and Dymola, respectively. The models are validated against operational data from a Swedish CHP plant. Transient responses to load ramps are characterized, as well as the flexibility in power-to-heat ratio, and their effects on efficiency.