COUPLING OF ELECTRICITY AND GAS MARKET MODELS

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Introduction

Natural gas as a fossil energy source continues to be important across sectors, as low emission factors, an existing infrastructure and the possibility of synthetic production will still make the energy source gas attractive in the future. For example for the electricity sector, there is a need for quickly adjustable gas power plants to maintain the security of supply[1]. Further, there may be a closer coupling of the electricity sector and the gas sector. This results from the use of new technologies, such as power-to-gas, that converts electrical power to a gas fuel, as well as the more intensive use of gas power plants as a natural partner for electricity generation from sources of renewable energies. Therefore an analysis of the combination of electricity and gas market models is carried out. Problems are highlighted and first exemplary studies are performed to link an existing electricity market model with a model of the European gas market.

Method

The analysis of a coupling of two models first requires the separate consideration of these. The energy system model "ISAaR" describes the energy system using linear optimization and can determine electricity prices for the period of one year in hourly resolution[2]. The regional resolution of the electricity sector is regarded through the mapping of the European transmission network. The gas market model, on the other hand, shows the daily marginal costs per market area for one year[3]. The considered geographical range will be extended to the neighboring states of the continental European network, as the gas market with global imports requires a more global view. The largest pipelines of the German transport network are modeled so that gas consumption in Germany can be shown more regionalized. Both models can perform an operational planning of all variable plants by minimizing overall economic costs. The temporal and geographic resolution of both models must be considered during the coupling in order to allow consistent modeling.

In a next step, the coupling points are identified. Obviously, there are coupling points for gas-fired power plants, which represent gas consumption for the gas market model and a production of electrical energy for the electricity market model. Further, the gas consumption of the heating sector, which is included in the energy system model "ISAaR", can serve as input for the gas market model. The generation of hydrogen or methane by the use of excessive electricity of renewable energy sources, the power-to-gas technology, is also a coupling point. The process is simulated as consumption of gas for the electricity market model and generation of gas within the gas market model. These many coupling points between the gas and electricity sectors require the consideration of the reactions that the results of the models have to each other.

Result

The output from the energy system model "ISAaR" results in a regionalized gas consumption, which is transferred to the gas market model. In a reaction, this results in marginal costs for each modelled market area in the gas market model, so that an iterative process can be used to adjust the gas price and make adjustments to gas consumption until a termination criterion is realized. A decreased gas demand will imply a change for the gas price, which in turn has an effect on the demand of the gas. The termination criterion of the iterative process is achieved when the modification of the gas consumption implied by the adjusted gas price is sufficiently small. The developed methodology for the coupling of a power model and a gas market model can be analyzed in exemplary tests. Based on a considered basic scenario for the year 2030, a daily gas price for each market area is determined, which is transferred to the energy system model. Initially there can be noticed high gas prices that lead to a reduced gas consumption. The average reduction in gas consumption is returned to the gas market model, resulting in an adjustment of the gas price. An iterative development of the gas price

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and the gas consumption of a “market area A” for an exemplary day is displayed in the following figure.

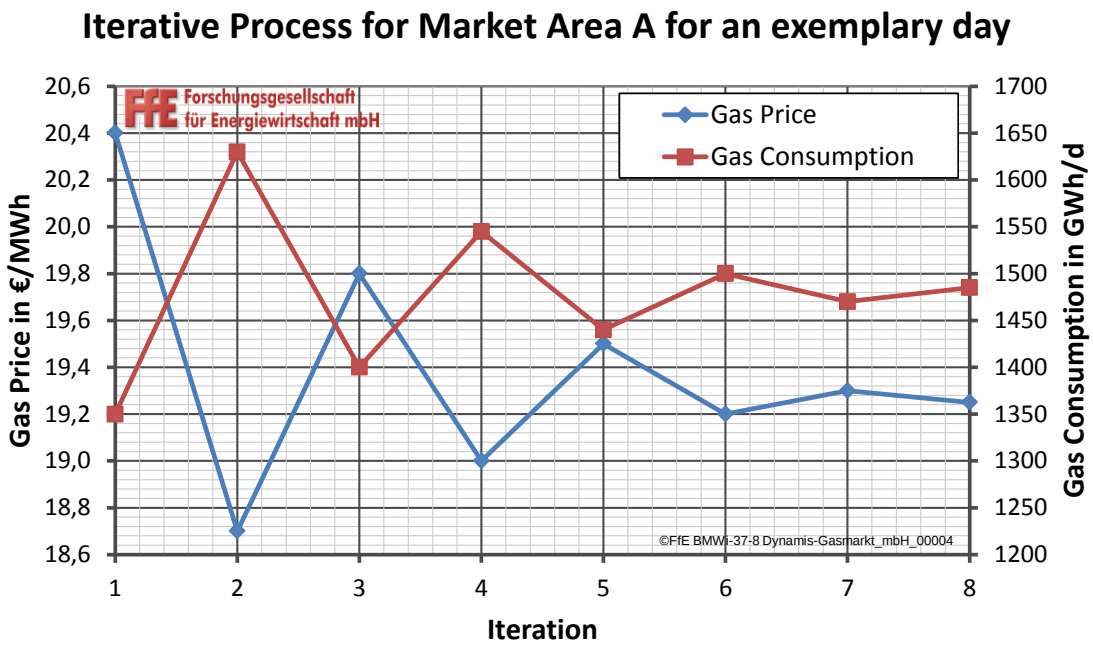

Figure 1: *Iterative Process of Market Area A for an exemplary day*

References

[1]: Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit; „Klimaschutzplan 2050 – Kabinettbeschluss vom 14. November 2016“

[2]: Marc Gallet, Tobias Schmid, Jochen Conrad, Dr. Roger Corradini; „Energiesystemmodell: Globale Herausforderungen regionale Lösungen“

[3]: Benedikt Eberl, Julius Ott, Dr. Serafin von Roon; „Entwicklung eines Dispatchmodells im Gasmarkt“