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ANALYSIS OF INTERDEPENDENCIES AMONG GAS, ELECTRICITY, AND EMISSION MARKETS

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Overview

With the liberalization of energy markets and the introduction of an emission trading system, the electricity production from gas (-steam) power plants increased in the last years in the European Union. Reasons for the increase can be seen in the short construction time of gas power plants and the relatively cheap specific investment costs, which result also in a short amortization time. One further advantage are the relatively low specific CO2 emissions of gas power plants. Thus, the increased use of gas for power production has been seen as a main option for reducing emission. Model calculations from various models show, that an increase of gas power production is expected, especially in the context of emission reduction targets1. In existing model calculation, the gas price is exogenously given and is varied within scenario analysis. But in general the interdependencies of the different markets (gas, electricity and CO2) as well as the country-specific gas supply options, determined by pipelines and LNG, are neglected. As the competitiveness of gas power plants mainly depends on the availability of gas and the gas price, a model development will be presented, which integrates electricity, gas and CO2-emission markets.
The objective of this paper is to analyze the long-term relevance of the gas market for the electricity sector in the European Union in the context of CO2-emission reduction targets.

Methods

The methodology of the developped model PERSEUS-EEM (Program package for emission reduction strategies in energy use and supply – European Energy Model)2 is based on a linear programming approach. The objective function requires a minimisation of the net present value of all decision-relevant expenditures (e.g. investments, fuel supply costs, etc.). The different variables used in the mathematical description of the complex decision problem comprise capacity variables that cover all (dis)investment decisions, process variables that describe plant scheduling and operation mode issues, flow variables that represent fuel supplies as well as electricity/heat flows (including interregional electricity exchanges). Technical restrictions and characteristics of the real supply system receive careful consideration with an extensive set of model constraints focusing on crucial issues such as energy and material balances, load variation constraints, capacity restrictions, etc. In the PERSEUS-EEM model, market prices of electricity, gas and CO2-certificates are assumed to be set by the marginal costs in an open and fully competitive market and are thus a model result. The marginal costs of the mathematical model are therefore often used to indicate electricity, gas and certificate prices.
The model consists of 17 core model regions covering the 25 countries of the EU. The core regions represent predominantly net gas importing countries (e.g. Germany and France). Each of these core regions consists of a specific sector for the electricity and natural gas markets. The electricity sector is bottum-up modelled by different sets of power and heat

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[1] See [Fichtner 2004]
[2] See [Perlwitz et al. 2006]

utilities described by techno-economic data. Apart from the core regions all other European gas demand countries and other non-European natural gas export and transit countries (e.g. Ukraine, Turkey) are included. For these regions, only the natural gas sector is modelled.The exporting regions considered are the North Sea region (Norway, UK, Denmark and the Netherlands), North Africa (Algeria, Egypt, Libya), Russia, the Caspian region (Azerbaijan, Kazakhstan and Turkmenistan), the Gulf (including Iran), West Africa (Nigeria) and South America (Trinidad and Tobago, Venezuela). Thus, countries which are only LNG (Liquefied Natural Gas) suppliers (e.g. countries in South America) for the European market are also taken into account.

Results

Different scenario calculations are done with the developped model within the paper. Within the reference scenario a business-as-usual development is assumed for the supply of gas, the emission reduction targets, the renewable energies targets, and the transmission network capacities. Within this reference scenario, the established gas producing countries Russia, Algeria and Norway keep their dominant standing. Russia extracts until the year 2020 up to 708 Mrd. m3/a, followed by Algeria with approx. 172 Mrd. m3/a and Norway with approx. 118 Mrd. m3/a. Furthermore, new gas producing countries enter the market: these are countries from North-Africa (e.g. Egypt and Lybia), Middle-East and the Caspian region. The additional gas supply from these countries is mainly provided via pipelines for the European market. Beside the extension of existing and the preparation of new gas conveyor (e.g. Jamal and Barents Sea), different investments in the pipeline system and the LNG-infrastructure are realized.

Without CO2-emission reduction obligations, the electricity production from gas power plants is much lower as in other scenarios. This has also a significant influence on the endogenous modelled gas prices. In the scenario without emission reduction obligations, the gas price is between a corridor of 8 EUR/MWhtherm and 12 EUR/MWhtherm. Within the scenario with actual CO2-emission reduction obligations, the gas price is slightly higher and is between 8,7 EUR/MWhtherm and 16 EUR/MWhtherm. It has to be mentioned that these prices are based on system marginal costs (under the assumption of a perfect market) and that transport costs (and taxes) have to be added on top.

Within further scenarios analysis in this paper, the influence of higher gas exploitation rates, of higher emission reduction targets and of network congestions in transit countries on the electricity sector, the gas price as well as the CO2-emission price is quantified. Within the paper crucial interdependencies among the natural gas, the electricity and CO2-certificate market are taken into account. The analysis options of the described model thus cover most important aspects that decision makers may need in order to get an indication of how interdependencies can influence technologies, energy system structures, prices and exchange of energy.

References

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