UNCERTAINTY IN INTEGRATED ELECTRICITY AND GAS MARKETS – ANALYSING THE ECONOMIC IMPACT

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Overview

A considerable amount of research has been oriented to economic modelling of European energy markets. To date, several studies have highlighted interdependencies between power generation and gas markets (Lienert and Lochner (2012), Abrell and Weigt (2016) and Deane et al. (2017)). The authors demonstrated that modelling practices that do not consider linkages between the markets lead to results with systematic deviations from integrated modelling approach.

Markets and in particular energy markets underlie significant uncertainties. When analysing the impact that uncertainty has on these markets, accounting for cross-sectoral interdependencies significantly improves the solution adequacy. Aiming to capture these cross-sectoral interdependencies, we develop a stochastic two-stage cost-minimization model of an integrated European power and gas system. The model accounts for uncertainty on both the electricity and gas sector. The main contribution of our paper is a systematic comparison of the economic impact that uncertain economic, technological, and regulatory key drivers have.

Methods

Our methodology follows the modelling techniques used in the literature utilizing linear programming formulation (LP) of a global cost-minimization problem to determine optimal investment decisions. We create and apply a fundamental investment model, which accounts for uncertainty and interdependencies between European electricity and gas markets. The model includes all relevant infrastructure elements and cost estimators for energy production and transport within Europe.

We combine the two markets via the fuel linkage: both the gas demand for power sector and the price for gas-fired generation are modelled as endogenous variables. This approach exploits the following methodologic advantages: (i) the LP allows for handling large datasets while keeping computation time reasonable, (ii) the model is suitable for simulation of commodity (electricity and gas) dispatch decisions on a short-run perspective, as well as market changes on a long-run perspective, and (iii) the integrated modelling approach ensures reliable marginal costs estimators on both products, electricity and natural gas.

Aiming to account for uncertainty, we develop a two-stage stochastic programming model with recourse. In the first stage the investments decision has to be made before the information on uncertain factors is revealed in the second stage. We determine key uncertainty factors and evaluate possible uncertainty ranges. In addition, we are able to track the effects caused by uncertainty, which allows us explaining to what extent decision variables are affected by different uncertainty levels.

Results

We investigate and explain the impact of uncertainty drivers. First, we model uncertainty of economic key drivers, such as fuel and CO_2 prices, electricity and gas demand etc. For each particular driver, we receive a set of uncertainty ranges. Second, we apply these uncertainty ranges in our integrated stochastic market model. We sequentially run the

model for each particular uncertainty driver and systematically compare them according to the value of the stochastic solution and the effect on the decision variables. As a result, we are able sorting them according their economic impact.

For each particular driver, we further provide a comparison to a deterministic benchmark solution (i.e. ignoring uncertainty). With varying the magnitude of the uncertainty levels, we also perform a sensitivity analysis.

Conclusions

We create and apply a fully integrated investment model that accounts for interdependencies between the electricity and natural gas sector. Hence, feedback effects across the energy sectors are included in our model results.

As a main contribution, we create a methodological approach to model uncertainty for economic key drivers on the electricity and gas sector. We systematically compare their economic impact and in addition, provide a better understanding regarding the impact of uncertainty in a system.

References

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