INTEGRATING ELECTRICITY AND NATURAL GAS PLANNING: LINKING MODELS AND ASSESSMENT OF RECIPROCAL EFFECTS.

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Overview

The deployment of Renewable Energy Resources (RES) is affecting the profitability and scheduling of conventional generators (e.g. gas-fired power plants) as well as creating short-term electricity balancing problems. To manage RES variable output, additional flexible power capacity will be needed to cope with peak demand. Gas power plants ability to provide flexibility in a short time period make them especially suitable for fast balancing. Could gas power plants compensate RES fluctuations without creating instability in the gas transmission network? How investments on the gas infrastructure affects the evolution of the electricity sector and vice-versa? To answer these questions and jointly represent electricity-gas energy sectors, this paper presents 1) a methodology on combining cost based optimization models for gas and electricity and 2) the effects of long-term policy targets set to the EU electricity sector and its influence on the gas infrastructure. To address long-term (strategic investments) and short-term (operational) aspects, we model both sectors as multi-horizon stochastic programs. Models results illustrate a strong dependency of the electricity infrastructure on the short-term operations of the gas sector. Under a high RES deployment scenario, gas infrastructure investments declines slightly which increases cross-border electricity capacity needs.

Methods

This paper applies multi-horizon stochastic programing to represent long-term investment decisions under short-term operational uncertainty. We apply this methodology in the RAMONA and EMPIRE models for gas and electricity.

RAMONA (Fodstad 2016, Hellemo 2013) supports gas (strategic) infrastructure decisions such as development of new fields, construction and design of infrastructure (pipelines, compressors, and processing plants). On the operational level, RAMONA represents the relationship between pressure and flow, gas quality and processing.

EMPIRE (Skår 2016) analyzes cost-efficient decarbonization pathways for the European electricity sector. Its long-term capabilities allows to focus on the interplay between low carbon technologies (solar and wind power) and the conventional power fleet (gas, coal, hydro and nuclear power plants). EMPIRE performs country-level investments in generation capacity and inter-country exchange capacity investments. On the operational level, EMPIRE works with hourly generation dispatch by aggregate technology type in every country and cross-border flows.

To combine RAMONA and EMPIRE, this paper proposes a soft-linkage methodology. The consist of a common planning horizon until 2050, constraining gas resources for electricity generation, exchanging gas-electricity prices, and quantifying short-term usage of gas power plants for RES balancing.

Results

Spatial developments on the gas infrastructure has significant impact on the electricity cross-border flows and changes in gas prices creates relocation of plant investments.

EMPIRE results advocates for a stronger exchange on cross border flows by investment in additional transmission capacity. By linking the models, we observe that electricity demand interruptions are more likely under a high RES deployment along with limited short-term gas supply (although it does not affect the long-term gas planning).

We found that introducing “take or pay” gas contracts for short-term electricity balancing could be a viable option to promote market-based investments in gas plants.

Conclusions

The long-term EU decarbonization energy transition will affect fuel prices for electricity generation, the utilization of gas power plants and the investments in the electricity-gas nexus infrastructure. The main policy implication is the need to create market designs that reward short-term bulk units for their flexibility. The models linkage methodology developed provides a new modelling framework to assess new designs for electricity and gas markets.

References

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