EVALUATION OF THE DEVELOPMENT OF NON-GHG EMISSIONS FROM THE EUROPEAN ELECTRICTY SECTOR

Rupert Hartel, Dogan Keles, Wolf Fichtner
Chair of Energy Economics, Institute of Industrial Production, Karlsruhe Institute of Technology
Hertzstrasse 16, 76187 Karlsruhe, Germany
Rupert.Hartel@kit.edu

Overview

The transformation of the European Energy system is driven by efforts to limit the global temperature change to no more than 2 degrees above the pre-industrial level. This implies a greenhouse gas (GHG) emissions reduction goal of 80 to 95 % below the 1990 level by the year 2050. Major reduction potential is seen in the electricity sector and the most promising measure for achieving the goal are renewable energies (RES), especially fluctuating wind power and photovoltaic. Contrary to the GHG emissions, pollutant emissions are of minor interest and seem to be well controlled through different laws like the EU DIRECTIVE 2010/75/EU (EU 2010). Pollutant emissions are reduced through threshold values for each production unit depending mainly on the type and size of the production unit. The threshold values for different production units are guided by (EU 2010) on a European level. So the way of reducing pollutant emissions is different from GHG emission reduction mechanisms. Due to these different reduction approaches it is not a necessity that a reduction in GHG emissions leads to a similar reduction in pollutant emissions. This accounts especially for cases where the transformation of the energy system is pushed on:

1. From a low emission fuel to a higher emission fuel (e.g. when natural gas power plants are substituted by biomass fired power plants the particle matter (PM) emissions are likely to rise while the calculative CO_2 emissions are brought to zero).
2. By the preference of a different plant size or technology and therefore a probably higher threshold value (e.g. a smaller production unit is likely to have a higher threshold value).
3. When the operation regime of conventional power plants is forced out of the optimal generation point (e.g. more often occurring part load situations because of fluctuating RES).

This paper analyses these three possible pathways which are hardly addressed in the actual literature. Point 1 and 2 are analysed on a European level, whereas the third point is studied in detail for the German electricity sector due to the large deployment of fluctuating RES.

Methodology

The development of the NON-GHG emissions on the European level is analysed by applying the electricity system model PERSEUS-EU28[1]. PERSEUS-EU28 is a bottom up optimisation model. It includes the existing conventional power plant as well as renewable capacities of the 28 European member states. The power plants are aggregated by plant size and used fuel, according to the threshold values suggested by (EU 2010). With PERSEUS-EU28 the long term development of the European electricity system can be calculated in terms of optimised investment planning of new power plant capacities and an optimal power plant dispatch until the year 2050. A general model description of the PERSEUS model can be found in (Rosen 2007).

The according pollutant emissions are calculated via emissions factors which are derived from (EC 2012). (EC 2012) includes plant by plant specific emissions quantities for the pollutants sulphur oxide (SO_x), nitrous oxide (NO_x) and particle matter (PM) as well as used fuel values. With these values an emission factor for the corresponding plant size can be calculated and can be included in the PERSEUS-EU28 model.

Based on the calculation of the European model a second optimisation model, the regional dispatch PERSEUS-ReDi[2], is applied. PERSEUS-ReDi takes the capacities which were calculated by the European model and recalculates the dispatch with a much higher temporal and technical resolution for one country. PERSEUS-ReDi is a linear, mixed integer optimisation model which calculates the plant dispatch for one year in an hourly resolution for a timeframe of two weeks. The dispatch model considers the high integration of fluctuating RES into the electricity system. The resulting cycling of the dispatch of conventional power plants might be underestimated or not represented adequately in the European model.

The target function of both models is the minimisation of the annual system costs.

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[1] Programme Package for Emission Reduction Strategies in Energy Use and Supply- European Union 28
[2] PERSEUS- Regional Dispatch

Preliminary Results

Figure 1 shows the development of the NO_x emissions of the German electricity sector for two different scenarios. The first one is represented by the year-bars and can be seen as reference scenario. The second scenario is called "GAS" and is represented by the "GAS" bars. The main difference between these scenarios is the way the technology potentials are implemented. In the scenario "GAS" it is assumed that the potential for building new big conventional power plants in Germany is limited due to public acceptance. Because of this restriction the investment model is installing more smaller power plants especially gas turbines. In the long term this leads to increasing NO_x emissions in the "GAS" scenario compared to the reference scenario. Further, one can see that the overall NO_x emissions are reduced because of the high diffusion of renewable energies.

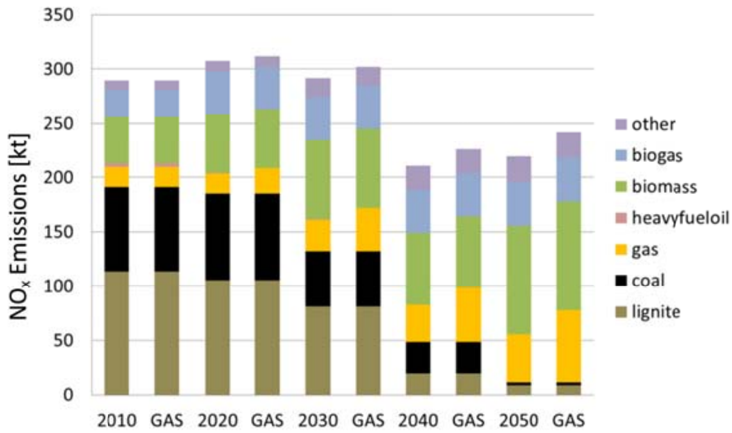

Figure 1: Comparison of the NO_x emissions in Germany with and without a restriction in power plant size

Conclusion

A new model was developed and applied to the European and in detail to the German electricity sector to analyse the effects of increasing share of renewables on pollutant emissions from the electricity sector. It can be shown that the consideration of the three pathways described in the overview can lead to different pollutant emission amounts. The PERSEUS-ReDi further shows that the pollutant emissions are higher due to the higher technical and temporal resolution.

The results show that electricity production technologies which have low or zero CO_2 emissions can influence the pollutant emissions in a negative way.

References

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