THE EUROPEAN ELECTRICITY SYSTEM COUGHT BETWEEN AUTARKY ENDEVOURS AND DECARBONIZATION TARGETS

Casimir Lorenz, TU Berlin and DIW Berlin, cl@wip.tu-berlin.de (corresponding)
Clemens Gerbaulet, TU Berlin and DIW Berlin, cfg@wip.tu-berlin.de

Overview

The European member states agreed on ambitious climate targets of 80-95% reduction of green-house gas emissions by 2050. Next to these ambitious goals, the European member states agreed on the target of a joint market for electricity spanning over the whole of Europe. In contrast to those earlier commitment the member states are striving for autarky of their electricity system, neglecting the interconnected nature of the European electricity grid. At the same time, we see more and more countries which are in serious danger of failing their own green-house gas emission and renewable targets for the upcoming years of 2020 and 2030.

In this paper we want to address the question how the endeavours for autarky and the step by step reduction of green-house gas emission targets are interlinked and influence the under these conditions cost minimal generation portfolio. We therefore formulate a scenario matrix with axis one *degree of autarky* and axis two *degree of GHG Emission reductions.* We test the interplay with three expressions for autarky and GHG emission reductions which results in 9 different scenarios. We apply those scenarios to the large-scale electricity sector model dynELMOD (Gerbaulet, Lorenz, 2017) to determine the cost optimal power plant portfolio depended on the boundary conditions defined by each scenario. We therefor vary the maximum import share a country is allowed to have in average over the year. This allows us to gradually analyze the effects autarky and search for turning points.

Methods

This paper presents different scenarios for the decarbonization of the European electricity sector in 2050 relying on a detailed model of electricity generation, transmission, and consumption, called dynELMOD.

The dynELMOD framework by Gerbaulet and Lorenz (2017), is a dynamic investment and dispatch model for entire Europe formulated as a linear problem in GAMS. The objective is to minimize total system costs in Europe until 2050. To do so, the model can decide endogenously upon investments into conventional and renewable power plants, different storages including Demand Side Management (DSM) and the electricity grid. While for the investment decisions a reduced time frame is considered, the dispatch calculations are done in a subsequent step with a full year and checked for system adequacy. The time frame reduction technique is unique and allows to represent the general and seasonal characteristics of an entire year but also to achieve a continuous time series of a day for renewables feed-in and electricity demand. dynELMOD determines investments into electricity generation capacities in 5 years steps with a variable foresight length. The underlying electricity grid and cross-border interaction between countries is approximated using a flow-based market coupling approach.

In dynELMOD local preference of certain countries is implemented by the used of constraints or increased/decreased cost of investments in grid or generation and storage capacities. We develop multiple generation capacity scenarios in Europe using a detailed representation of generation as well as multiple storage technologies and demand flexibility options in an electricity sector model for Europe. Furthermore, we take into account the total level of electricity demand, which depends on many influencing factors. Given a set of boundary conditions such as yearly CO_2 emission budgets, technological parameters and technical availability and cost assumptions the model determines the cost-minimal generation portfolio, cross-border transmission expansion as well as the underlying generation and storage dispatch with an hourly resolution.

Preliminary Results

In the *default scenario* no autarky should be simulated and therefore no restrictions on import shares is set. Furthermore, an ambitioned green-house gas emission of up to 95% is assumed in the electricity sector. The results show, that no new nuclear capacity is necessary and variable renewables are the main source of electricity supply. These capacities are accompanied by storages which are necessary to balance out short and long term fluctuations.

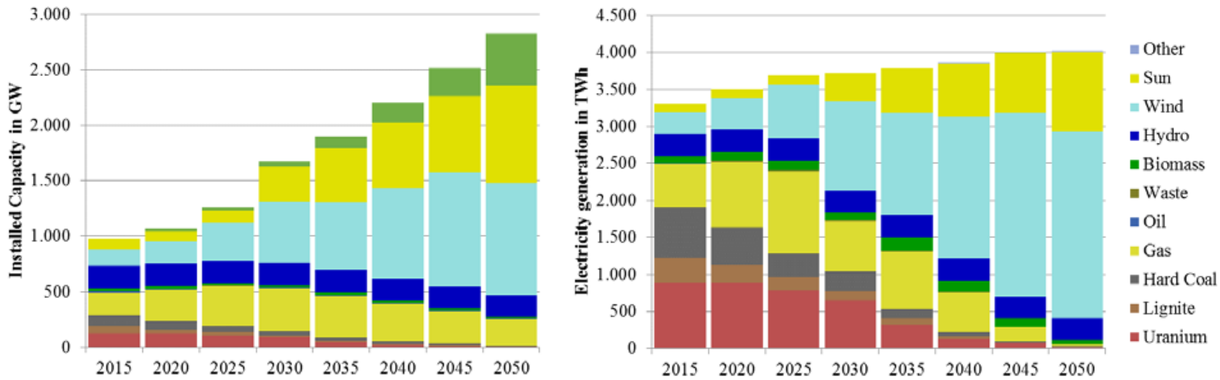

Figure 1: Installed capacity and electricity generation in the *default scenario*

Preliminary results show, that increased autarky of countries lead to a large increase of necessary generation capacities all over Europe. Depending on the level of autarky necessary generation capacity could double. Especially for countries with low potentials for renewables, which are large net importers in the *default scenario* need to increase their capacities even more.
If the necessary level of green-house gas emissions reductions in order to reach the Paris agreements must be reached the situation is getting even more dramatic. For high green-house gas emission reductions large amounts of electricity must be transferred between countries in order to use the full potential of regions with high renewable potentials. Every constraint on that transports increase the total system cost.

Conclusion

We find that in order to reach the Paris agreement, the full cooperation potential of the European electricity system is necessary and that there is no options for autarky endeavors. Limiting the possibilities of countries to rely on electricity imports will directly increase the cost of electricity generation and hence could limit the chances of reducing green-house gas emissions in time to prevent climate change.

References

Gerbaulet, C. & Lorenz, C. (2017). dynELMOD: A Dynamic Investment and Dispatch Model for the Future European Electricity Market. DIW Berlin, Data Documentation 88, Berlin, Germany.