ELECTRICITY SECTOR TRANSFORMATION IN EUROPE – TAKING LOCAL IDIOSYNCHRASIES INTO ACCOUNT

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Overview

On the path to decarbonizing the European electricity sector the electricity generation portfolio is undergoing a significant transformation to a largely renewable and emissions free system. It is likely that the ambitious climate targets (80-95% reduction of green-house gas emissions by 2050 (basis: 1990) can only be reached when a significant share of electricity production comes from renewables such as wind and solar power, as nuclear power and CCTS technologies might not provide safe and/or feasible options of electricity supply (Kemfert et al., 2015).

While there is little dissent what the future electricity generation technologies might be, the implications of a decarbonized energy system with a possibly increased fluctuation of renewable infeed as well as a varying electricity demand are still discussed. To establish a functioning electricity system, the cooperation of numerous countries with different existing power plant portfolios and renewables is required, as well as a transmission grid connecting supply and demand centers. This can lead to large distributional effects, that need to be taken into account; furthermore, local preferences could delay certain aspects of the sector transformation.

This paper analyzes implications of the sector transformation with regards to potential local preferences of four countries: The **United Kingdom, France, Poland,** and **Germany**. For each of these countries, the effect of local preference in the context of the sector decarbonization until 2050 is analyzed. To do this, the large-scale electricity sector model dynELMOD is applied. In dynELMOD (Gerbaulet, Lorenz, 2017) France takes a role of a large exporter and transit country for flows form the Iberian Peninsula. As such a setting requires large infrastructural investments to enable the transit flows without benefiting directly, local resistance against large-scale grid expansion could hinder this development. The United Kingdom has a high potential for onshore and offshore wind expansion; at the same time a simultaneous preference for the expansion of nuclear power is expressed, e.g. by the efforts to construct the nuclear power plant Hinkley Point C. In Poland, which historically has relied on local fossil fuels such as hard coal and lignite; the existing power plant portfolio and associated infrastructure have influenced Polish energy policy to incline towards a reservation of the status-quo. Germany, the biggest electricity exporter in Europe, is unlikely to maintain this status, as renewable potentials and associated expansion costs are likely to be located further South in Europe. Thus Germany is likely to become one of the biggest importers in 2050, if local influence or policy does not guide the German renewables development towards increased expansion to maintain a certain level of “autarky.”

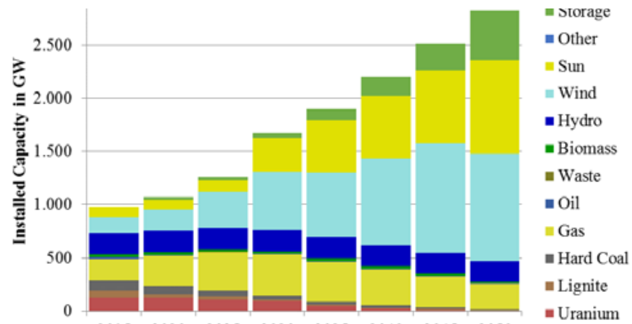
Methods

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.

Figure 1: Installed capacity in Europe in the standard scenario

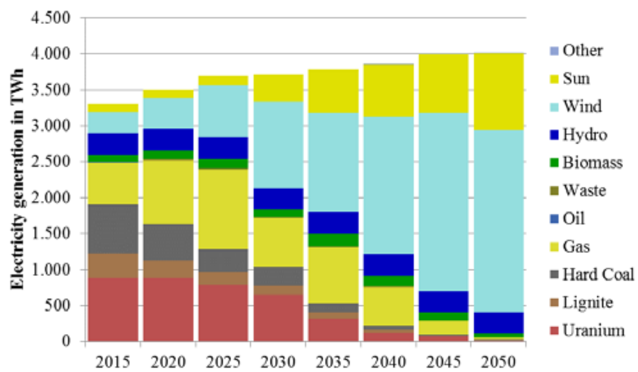


Preliminary Results

Preliminary results show, that if only a single country's local preference is implemented, the overall capacity expansion outcome remains stable compared to the "standard scenario" without any local preferences, but regional differences occur. The overall cost level remains stable as well.

The United Kingdom's preference for nuclear power expansion has the lowest impact on overall development; If France were to prevent transmission expansion, the overall capacity development shifts eastward. The combination of grid expansion targets with autarky restrictions (affecting the import and export ratios) can lead to larger disturbances in neighbouring countries as well, as here redundant infrastructure needs to be implemented, as previously "shared" transmission and storage infrastructure is not available as feely.

Figure 2: Electricity generation in Europe in the standard scenario



Conclusion

We find that local preferences can affect the overall development of the European electricity sector significantly, especially if many countries are unwilling to cooperation in the overall capacity development and prevent transmission expansion, or want to establish a high level of energy autarky. This paper is amongst the first to address these county-specific idiosyncrasies, that have major consequences for the European electricity sector.

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.

Kemfert, C., von Hirschhausen, C., Reitz, F., Gerbaulet, C. & Lorenz, C. (2015). European climate targets achievable without nuclear power. DIW Economic Bulletin, 5(47), pp. 619–625.