ELECTRICITY SECTOR TRANSFORMATION IN THE EU – HOLDING ON TO COAL AND NUCLEAR ENERGY INCREASES COSTS

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Overview

To contribute to combatting climate change, the EU member states have jointly submitted their NDC to the UNFCCC. To reduce emissions, the European electricity generation portfolio is undergoing a significant transformation. However, pathways towards a decarbonized EU electricity market remain uncertain. Although a clear trend towards renewable energies is observable, the expansion is not yet on the necessary scale to fulfill climate protection commitments and developments in different member states diverge. Two generation technologies are especially strongly debated: the role of coal and nuclear power in the coming decades (Climate Analytics 2017; IEA 2017; Kemfert et al. 2015). Keeping a fixed CO_2 budget for the EU power sector, we model four different scenarios, varying the extent to which coal and nuclear are deployed, analyzing resulting generation mixes and system costs.

The focus of the paper lies on four countries that constitute significant shares of the EU's coal and/or nuclear energy: **France, Germany, the United Kingdom,** and **Poland**. France is planning drastic short-term changes to its energy system, announcing a coal phase-out by 2022 and a reduction in nuclear energy by 50% by 2025. Critics, however, voice concerns that France cannot achieve both targets simultaneously. Germany is going to end nuclear power production by 2022. The country is still heavily reliant on coal for its electricity generation, and suggestions for a phase-out vary between 2030 and 2050. The United Kingdom will end coal consumption by 2025 but plans to construct the nuclear power plant Hinkley Point C, and debates further sites for additional nuclear capacity. In Poland, although debates about nuclear power never fully stop, the construction of a nuclear power plant seems unlikely. More than 80% of electricity is generated by coal, and limited political intention to end this dependence.

We model three different variations of nuclear and coal consumption, compared to a reference case with perfect foresight, where total EU electricity system costs are minimized by a social planner [*ref-case*]. The scenario analysis enables the comparison of resulting electricity generation mixes and costs. To do this, the large-scale electricity sector investment and dispatch model dynELMOD (Gerbaulet and Lorenz 2017) is applied. The first scenario assumes an EU-wide rapid reduction in nuclear energy, which might for example occur after another accident like in Fukushima. On the other hand, coal consumption remains high, following current trends of political and incumbent's resistance to reduce coal based electricity generation in the short to medium term [*nuc-low/coal-high*]. The second scenario keeps the assumption of a rapid nuclear decline but assumes additionally a rapid reduction in coal consumption, which might follow a global recommitment to climate protection [*nuc-low/coal-low*]. The third and last scenario represents the case that nuclear power resurges, with new-builds in France and the UK (and lifetime extensions in Sweden and Spain) and coal consumption remains high in the short- to medium-term [*nuc-high/coal-high*].

Methods

The dynELMOD framework by Gerbaulet and Lorenz (2017) is a dynamic investment and dispatch model formulated as a linear problem in GAMS. The objective is to minimize total system costs in Europe from 2015 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 five-year 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 use 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

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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 the CO_2 emission budget, 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.

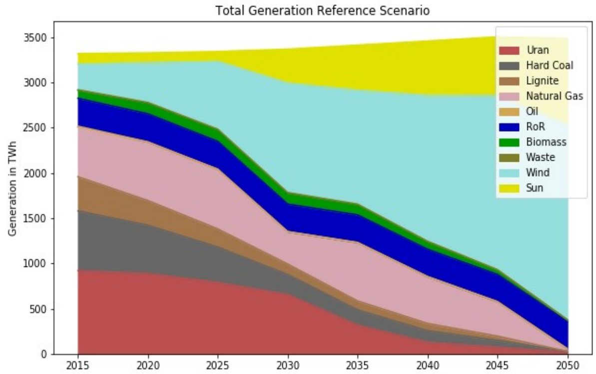

Figure 1: Electricity generation in Europe in the reference scenario.

Preliminary Results

Our preliminary results show that in the reference case, after 2025 conventional electricity generation, and especially natural gas, drops substantially (see Figure 1). In all scenarios renewables become the dominant source of electricity generation by 2040. Total investments in renewables are, apart from varying years of investment, similar, as the CO_2 budget cannot be exceeded. In all scenarios, total investment costs in new capacities are substantially higher than in the reference scenario. This is due to the timely investment in renewables and avoidance of stranded assets in the case of perfect foresight. Grid investments can be reduced when overcapacities are prevented, see Figure 2.

Total system costs are the largest in the *nuc-high/coal-high*-scenario (6.3 % higher than the reference case; *nuc-high/coal-low* +5.6%, *nuc_low_coal_high* +2.9% and *nuc_low_coal_low* +2.2%). In the further analysis we will be able to draw more conclusions on the differences between scenarios for the EU, but also for France, Germany, the UK, and Poland alone.

Conclusion

This paper is amongst the first to analyze the interplay of coal and nuclear power developments in France, Germany, the UK and Poland, as well as the EU as a whole. The extension of coal and/or nuclear power production would have major consequences for the European electricity sector. We find that our scenario with low nuclear and low coal shares has the lowest total system costs, compared to the scenarios with prolonged coal and/or nuclear energy use. In all scenarios it is possible to stay within the CO_2 budget, however, substantial stranded investments would be created in the scenarios with new investments in coal or nuclear power. The EU as a whole and countries on their own need to include the consequences of the required decarbonization in their power sector planning and regulation. Despite nuclear power seen by some as a solution for a low-carbon EU electricity system, our results show that decarbonization is possible and total system costs are lower without it. As coal cannot be part of an emission free electricity system, early phase-out plans can reduce overall costs.

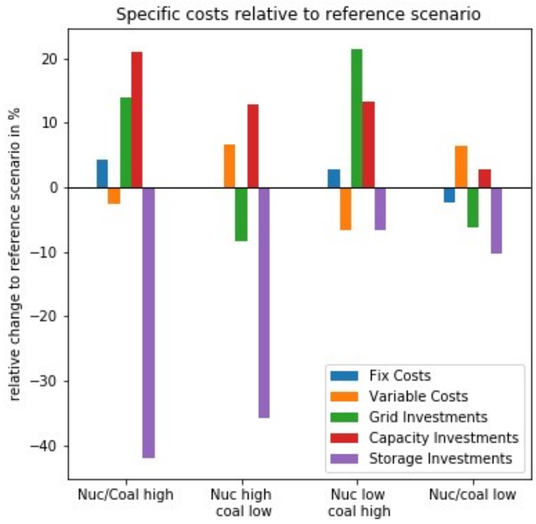

Figure 2: Total system cost comparison between scenarios and the reference case.

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