MODELING THE LOW-CARBON TRANSITION OF THE EUROPEAN ENERGY SYSTEM - A QUANTITATIVE ASSESSMENT OF THE STRANDED ASSET PROBLEM

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Overview

Increasing concerns about the adverse effects of global warming lead to an intensifying debate in both science and policy about future realizations of the global energy system, especially concerning the role of fossil fuels. Burning fossil fuels is the biggest driver for global greenhouse gas (GHG) emissions and therefore implies a fossil phase-out (IPCC 2014). The political urgency for reducing greenhouse gas-emissions is shown in the historical agreement of the 21st and 22nd Conference of the Parties in Paris and Marrakesh. As shown in the 450ppm scenario of the World Energy Outlook (IEA 2016), the effects of climate change can potentially be reduced to around two degrees compared to pre-industrial averages, but this has a tremendous effect on the future outlook of the global energy system. Given the tense global situation, Europe has to play a major role in leading the transition towards a largely decarbonized energy system. To achieve this goal, renewable energy sources (such as wind and solar power), coupled with storage technologies and other flexibility options (such as demand-side management, high-voltage grid interconnections, etc.), providing the necessary flexibility to balance intermittent renewables (Gerbaulet and Lorenz 2017) are needed. In addition, recent trends show that neither nuclear nor carbon capture technologies are likely to play a major part in decarbonizing the electricity sector (Lorenz et al. 2016; Kemfert et al. 2017). These issues, coupled with already existing overcapacities of power plants in Europe pose significant questions about the future of current and planned fossil fuel-based power plants and their economic viability.

Methods

This paper analyzes the transition of the European energy system for the sectors power, heat, and transport towards a largely decarbonized future. A special focus is placed on capacities and the eventually arising stranded-asset problem, as ambitious decarbonization goals force fossil energy sources out of the energy mix. To analyze these scenarios, an extended version of the “Global Energy System Model” (GENeSYS-MOD) by Löffler et al. (2017) is used. GENeSYS-MOD is a full-fledged, open-source energy system model, originally based on the existing “Open Source Energy Modelling System” (OSeMOSYS) created by Howells et al. (2011). The model uses a system of linear equations to search for lowest-cost solutions for a secure energy supply, given externally defined constraints on GHG emissions. In particular, it takes into account increasing interdependencies between traditionally segregated sectors, e.g., electricity, transportation, and heating. GENeSYS-MOD has been updated and expanded, featuring a more detailed time-disaggregation, an improved trading system (especially concerning the trade of electricity), and a detailed new data set for Europe, aggregated into a total of 15 geographic regions. The model then calculates energy- and resource-flows, as well as the required capacities to meet power, heat and transport demands for the years 2015 to 2050 in 5-year-steps. Multiple scenarios with varying emission constraints are analyzed, including a scenario which introduces the factor of reduced foresight into the model.

Results

The base scenario limits the global temperature rise to 2° Celsius, assuming perfect foresight from a planners perspective. The given emissions budget of 49.27 gigatons of CO_2, in addition to renewable technologies becoming more and more competitive, and cheap storages being available, leads to a drastic change in the total energy mix between 2015 and 2050. As seen in Figure 1, the resulting energy mix shifts from a strong dependence on fossil energy carriers to a system based on renewable energies such as wind, solar, and hydropower. This drastic change in utilization of fossil fuels leads to a heavy decline of fossil fuel-based power plant utilization, and therefore to unused capacities and stranded assets. Especially recently built power plant capacities face severe monetary problems, as carbon constraints and increasing market penetration of cheap renewable energy sources limit their stream of income. Reducing the amount of co-operation between European countries or introducing limited foresight to the model, and thus moving away from a planners perspective, even increases this problem, as new capacities are being constructed but become quickly obsolete.

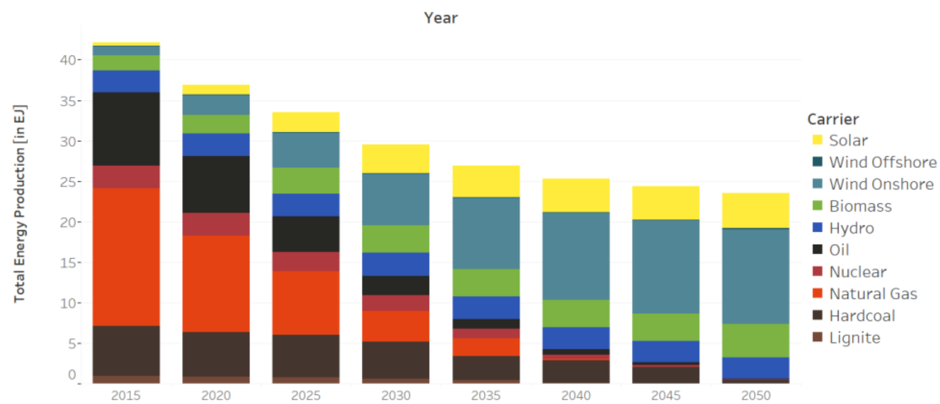

Figure 1: Development of the energy mix for Europe in the base scenario; Source: Own illustration

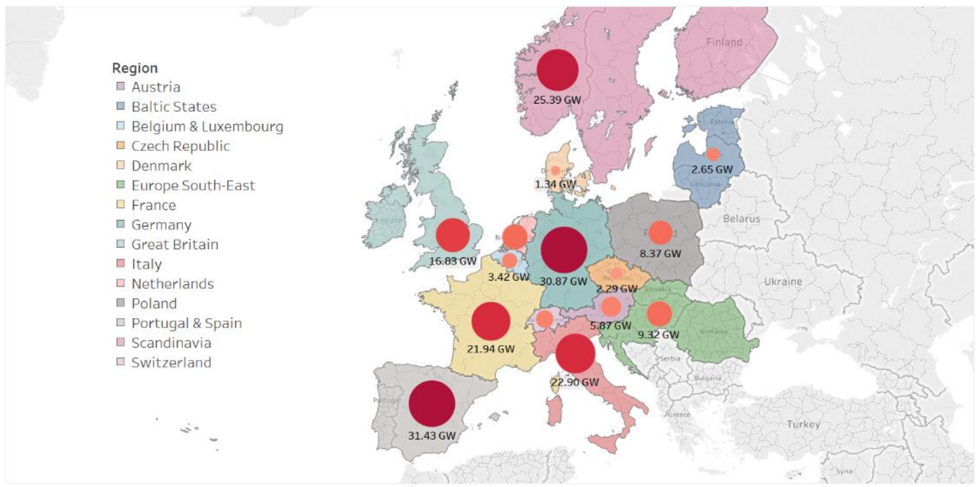

Figure 2: Unused capacities in Europe in the year 2035 for the base scenario; Source: Own illustration

Conclusions

The paper shows that to reach current climate goals, a heavy shift towards renewable energy sources will have to occur in the next 35 years. This worsens an already problematic topic in Europe: overcapacities of fossil-based power plants. It can be shown that even under perfect conditions, stranded asset problems can arise. Thus, the need for quick and determined policy decisions arises. This paper aims to give constructive input to the debate, as well as show different possible pathways towards cost-optimal solutions.

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