Energy policy scenarios for the German transformation pathways of the energy system by 2030 and 2045

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Introduction

The recent energy crises of natural gas supply in Europe caused by the Russian invasion of the Ukraine have put a spotlight on the interdependence between the energy transformation towards climate neutrality and security of supply of conventional fuels from to today until 2030 or 2035. This paper therefore assesses the impact of a sustained energy crisis and resulting higher fossil resource prices, in particular for natural gas and oil, and options for dedicated measure to reduce the dependence on imports in particular of natural gas and oil. Another aspect of the paper is the results of a current policy scenario. The results are based on a common scenario approach in the ARIADNE Kopernikus project and are calculated by using the energy system REMod which was used in several important scenario studies recently. There are multiple studies analyzing the German energy transformation considering its national CO_2 reduction goals, i.e. with the target of net-zero emissions in 2045 (Brandes et al. 2021; Luderer, Kost, and Dominika 2021; Prognos, Öko-Institut, and Wuppertal-Institut 2021). However, all of them have been published before the current energy crisis in 2022.

Method

The German energy system model "REMod" was developed at the Fraunhofer Institute for Solar Energy Systems ISE to model transformation pathways of the German energy system within a given CO_2 reduction pathway (Henning and Palzer 2014; Palzer and Henning 2014; Palzer 2016; Sterchele 2019). REMod uses a mixture of simulation and optimization: it simulates the energy system on an hourly basis and optimizes the accumulated costs (CAPEX and OPEX). The focus of REMod is on the detailed description of sector coupling, i.e. the use of renewable energy in the demand sectors industry, buildings and transportation including interactions between these sectors. The simulation includes all demand sectors (industry, transportation, buildings) as well as coupling of the sectors. The optimization determines yearly additions in the available capacity for multiple power plant types and energy conversion technologies as well as exchange of technologies in the demand sectors. This approach of simultaneously optimizing all sectors of the energy system distinguishes REMod from other energy system models and enables the analysis of mutual influences of the different sectors.
By simulating the energy system on a yearly base from today to 2050 considering five years with differing meteorological conditions, the model ensures that the energy demand is always met and supply reliability is guaranteed. Moreover, the optimization of the power plant park and the technology stock in each consumption sector by REMod enables a cost optimal transformation path of the entire energy system (for a schematic overview see Figure 1).

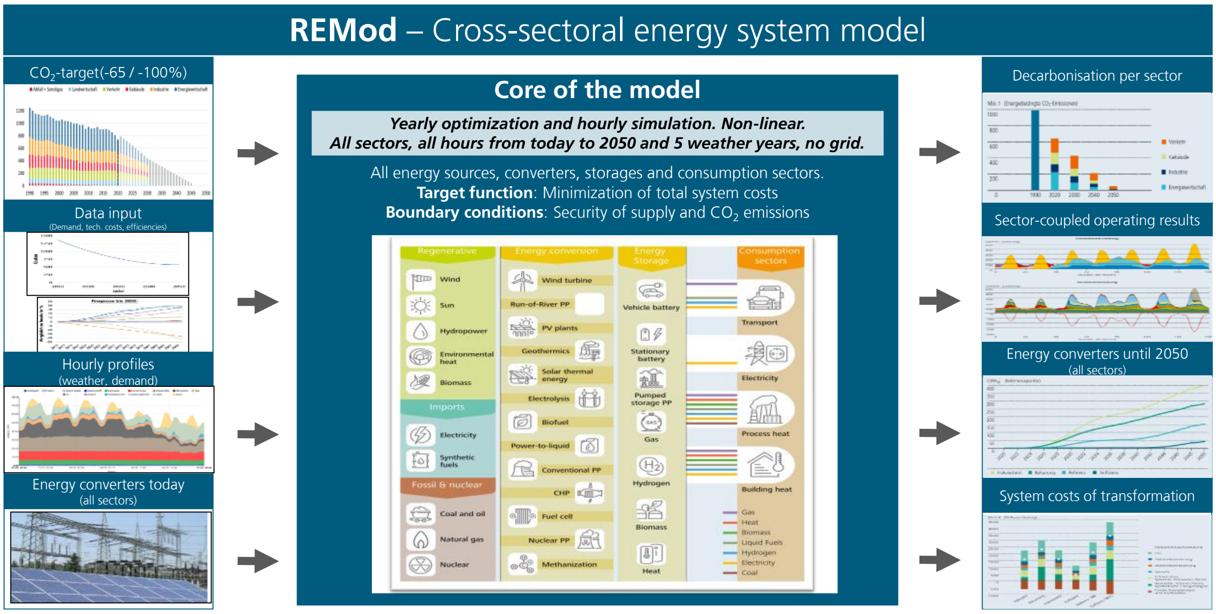

Figure 1: Schematic overview of REMod model with inputs and outputs

In this paper a scenario approach is used which considers the different constraints created by the energy crisis compared to as scenario without these constraints. Especially, the volume of consumed natural gas was given a higher price compared to previous studies. The imports (also hydrogen) are carefully assessed in this study. The two basic scenarios are named “Pre-2022 scenario” and “Energysecurity scenario”.

Results of the modeling

The results in this extended abstract show the comparison of results of the two main scenarios of this paper. Firstly, the analysis of the CO2 emissions path until 2045 is slightly changed in the scenario with lower natural gas imports due to given constraints in supply and higher prices. It can be found that some emissions are higher in the years around 2025 but they are later compensated by stronger reductions. This is required as the CO2 budget remains stable until 2045.

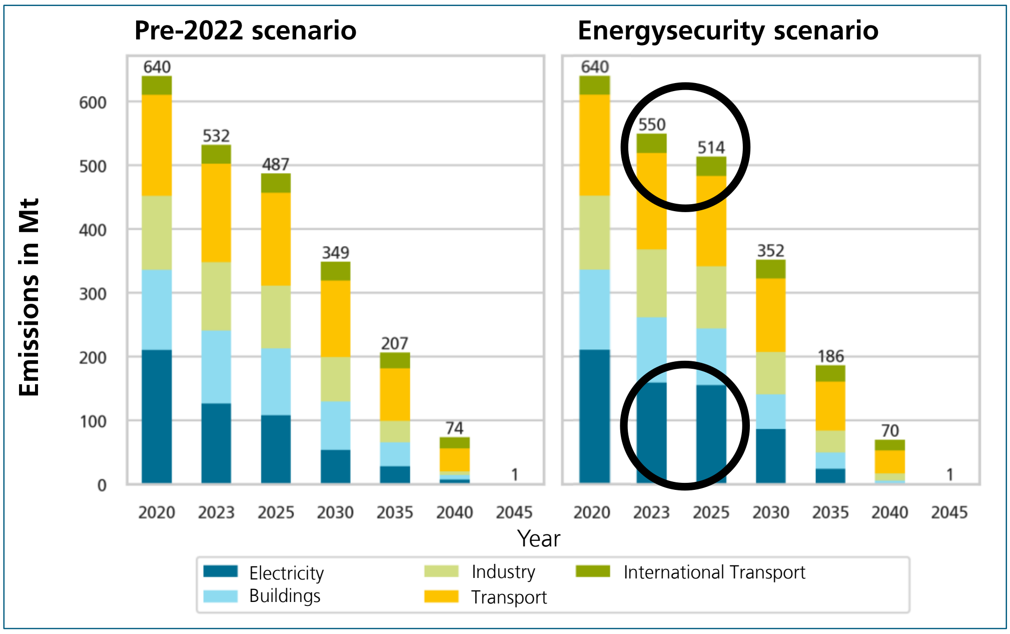

Figure 2: CO2 emissions in the scenarios by 2045

Both scenarios also show a strong difference in the use of natural gas over the time. The reduction in the Energysecurity scenario is very strong in total, but also in each sector. Especially in the years 2025 to 2030 the difference is huge, whereas the difference is reduced again in later years and almost similar in 2045. In 2045, the used gas is climate neutral and mainly consists of high shares of hydrogen.

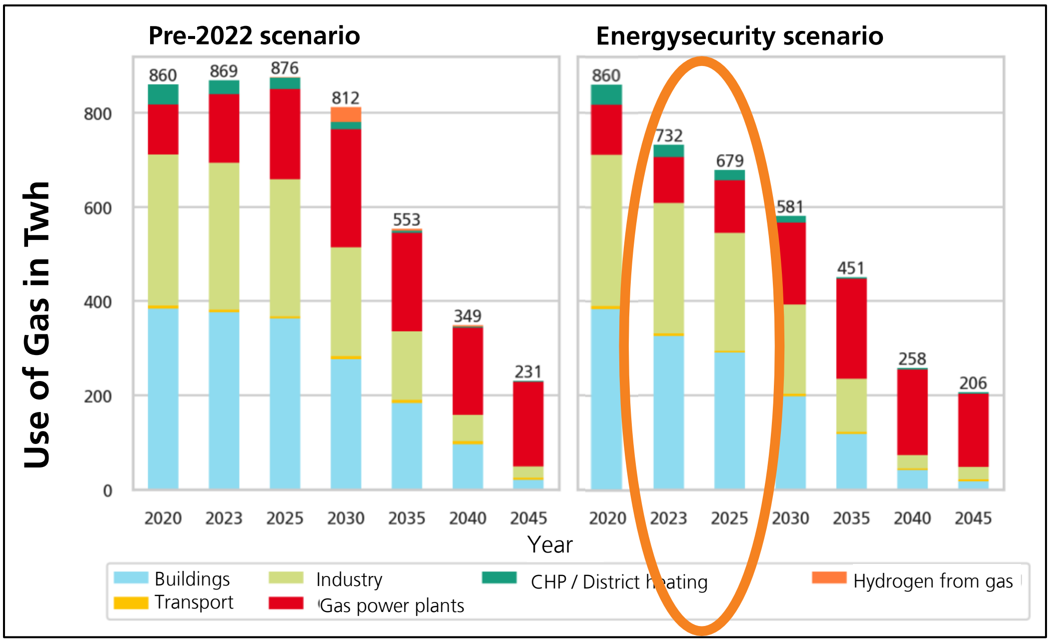

Figure 3: Consumption of natural gas in the scenarios by 2045

The following two graphs show the final energy demand development until 2045 in the case of an energy security scenario compared to a "normal" world (see Figure 4 and Figure 5). Final energy is reduced in the building sector and industrial sector by 5 to 10%.

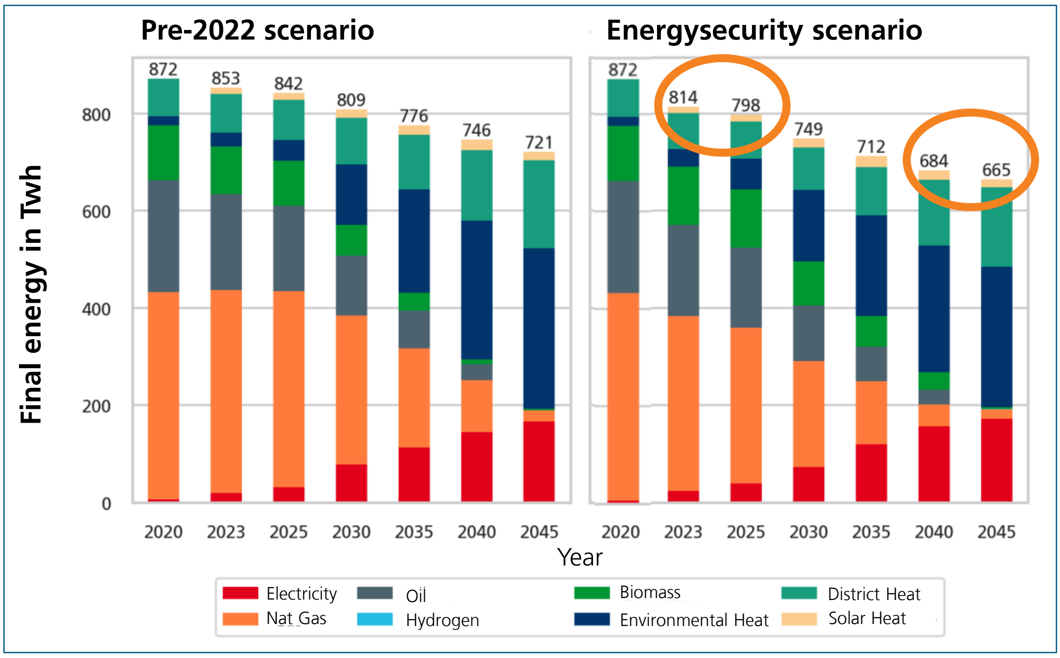

Figure 4: Final energy demand of the building sector in the balanced scenario (normal) and an energy security scenario

In the industry sector also, large changes can be found:

- Final energy demand is reduced due to higher prices.
- Use of coal is slightly higher in all years.
- Use of hydrogen is reduced as electrification remains stable, but energy demand is reduced.

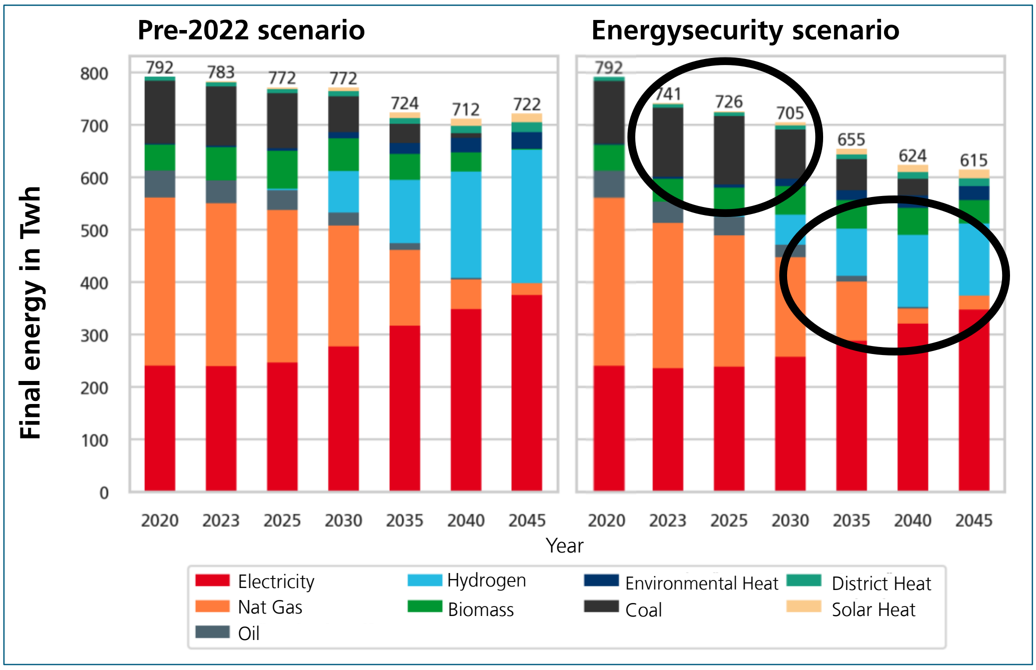

Figure 5: Final energy demand of the industry sector in the balanced scenario (normal) and an energy security scenario

One other aspect of energy sovereignty is be touched in the second part of the paper. A current policy scenario analyzes the developments in the electricity sector and heat sector as well as the discussion on the sector targets by 2030

Conclusion

The transformation path to climate neutrality is influenced by the geopolitical changes in Europe in year 2022. The modelling results show this impact on the emissions, use of technologies and the demand side. These findings should be considered to build up robust and resilient strategies with specific measures to transform the energy system in the upcoming years in the direction to climate neutrality.

Acknowledgement

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