Avoiding the Next Energy Crisis in Germany: Impacts of a Fuel Embargo on German Electricity Sector

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Abstract

An import embargo of Russian fuel is being increasingly discussed. We want to support the discussion by showing a way how the electricity system in Germany can manage low energy imports in the short term and which measures are necessary to still meet the climate protection targets.

Introduction

Russia is the main supplier for Germany's fossil fuel needs, with more than 50% of its primary energy consumption (Figure 1). Recent events showed, however, that this addiction led to explosive energy prices, which will at one point, the least, lead to an energy crisis. In 2020, Germany imported 94 % of its natural gas, half of which was further exported [1]. Within Germany, gas is used in four main consumption sectors. The largest share is used in the household and commercial, trade and services (CTS) sectors for space heating and hot water, and in the industry to provide process heat [2] [3]. Mineral oil in the chart includes crude oil (crude), crude gasoline, heating oil (light and heavy), liquid gas, refinery gas, gasoline, diesel and jet fuel. As of 2020, about 98 % of Germany's oil is imported, 19 % of which is re-exported [4]. One-third of oil imports comes from Russia. Oil is mainly used in the transport sector and for the provision of space heating, hot water and process heat [5]. Since 2018, Germany is importing all hard coal, the main customers being hard coal-fired power plants and the steel industry [6] [7] [8].

Scenarios Development

Four scenarios are investigated in this study. Common to all scenarios is the assumption that fuel imports from Russia will be stopped at the end of 2022. Most recently, Russian supplies of natural gas through the MEGAL and Nord Stream 1 pipelines were decreased by around 70 % of their previous daily transmission capacities before being completely shut down beginning of September [9] [10]. An import stop must reduce, above all, the demand for oil and the demand for gas in at least one of the demand sectors, therefore, we want to investigate how the electricity sector ("power sector") can compensate for a sudden abandonment of energy source imports from Russia as shown in Figure 2. With a priority given to heat supply, both oil and gas in 2023 will not be available for use in the electricity sector, and hard coal will only be available at 30% of the consumption volume in 2020.

With the establishment of new relationships and contracts for energy imports from other countries, it is assumed that hard coal and oil will have limited availability for 2 years until their availability is raised again to business as usual situation. For the import of natural gas, liquified natural gas (LNG) terminals have to be built. Here it is assumed that after 5 years the availability of natural gas also increases. The electrical demand is expected to increase rapidly in the coming years, either from the higher shares of electric mobility [11], or the potential of electrification in other consumption sectors, i.e. the industrial sector [12] [13], as well as the heating sector [14]. Therefore, an annual increase of 1 % is applied to the electrical demand so that partial electrification of other sectors is represented.

Scarcity of the energy supplies caused a historical rapid increase in the oil and gas prices. Currently, the prices spikes are more affecting in the short-term, but could also affect the long-term energy policies and sustainability goals [15]. The scenarios discussed in this study will differ in the prices for the energy sources gas and oil. Prices for hard coal remain unaffected from the price increase. Two different cost assumptions will be followed as shown in Figure 3.

With the continuous developments in Ukraine and the gas shortages in supply and storage facilities in Germany, many discussions are addressing the ability and robustness of the energy sector in Germany within the next winter, and which compensation measures will be implemented. The federal government announced at the end of 2021 a preponed phase-out date of coal and lignite fired power plants by 2030 [16]. However, recent warnings showed that the serious situation of gas supplies might lead to ramp up coal power plants again [17], especially in winter, as well as holding the ongoing phase-out by 2030 [18]. The feasibility of turning back to using coal fired power plants and prolonging their existence in the German electricity market will be studied throughout the scenarios, where the previous and new coal phase-out dates will be further analysed.

Results and Discussion

Following a scenario-based analysis [19], the studied scenarios showed some interesting aspects. Firstly, the earlier decommissioning of coal and lignite power plants by 2030 yielded higher investments in renewables, especially in offshore wind technologies, along with short and long-term storage technologies (Figure 4). The complete shut-down of power coming from gas power plants, along with the lack of adequate flexibility in the system, together incentivised the investments in renewables to nearly double the previous known

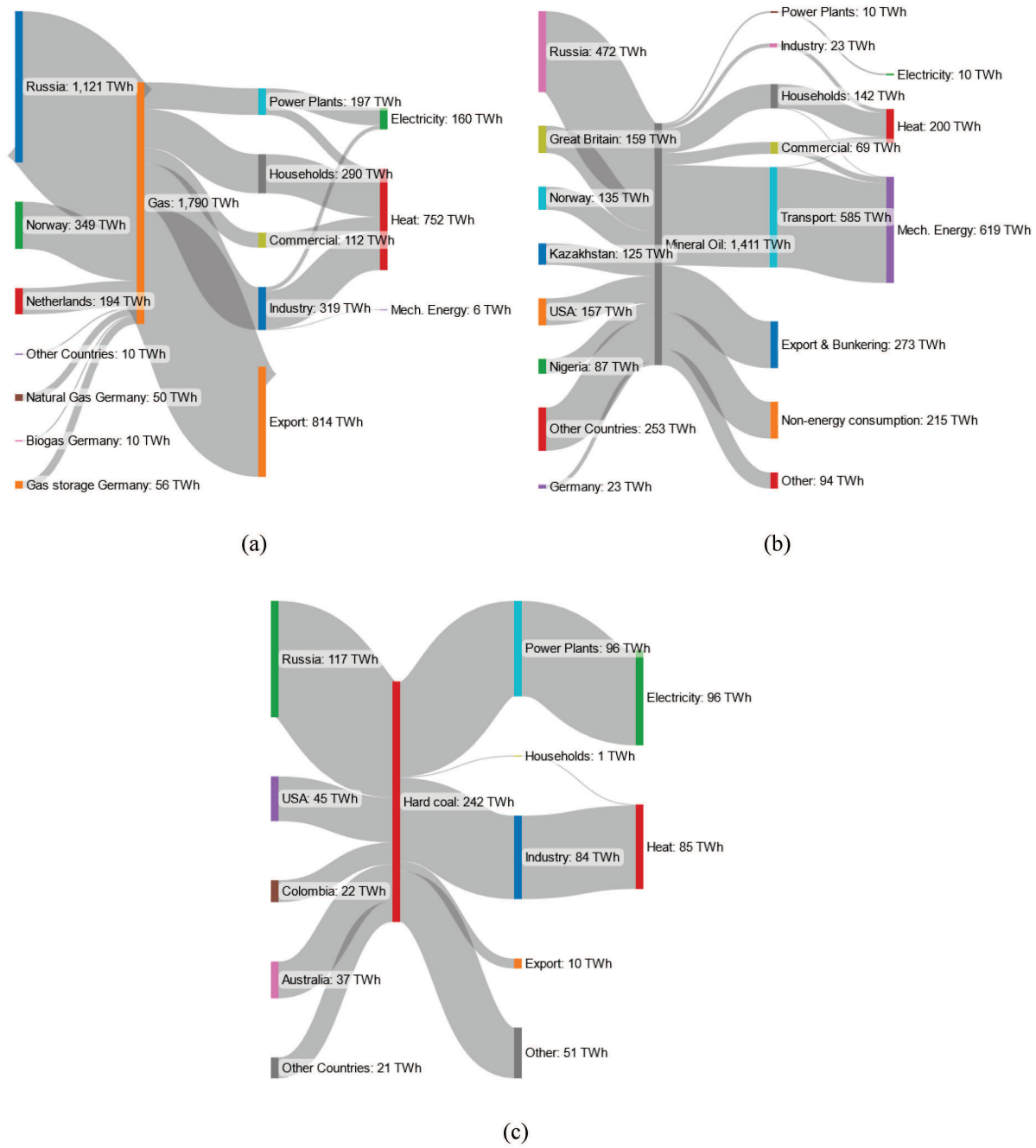

Figure 1: Imports and exports of the energy sources (a) natural gas, (b) mineral oil and (c) hard coal in 2020; the unit TWh indicates the energy content of the respective energy sources. [1-8]

installed rates in the country. With limited flexibility within the system, complete shortage of gas and oil, the system will face huge load shedding by 2023 of nearly 40 GWh if the ongoing coal phase-out by 2030 is still carried out.

After gas is reintroduced into the system, the grid will already have sufficient renewable generation capacity and enough flexible storage technologies, gas use in the energy mix experiences an almost complete decline and used to a small extent to provide flexibility and system security. If gas prices go back to normal values, the gas fired power plants utilization is higher, especially with the earlier phase-out of coal, with a share of 8 % of the energy mix (56 TWh). However, with higher gas prices, nearly 1.5% of the energy mix will come from gas-fired power plants. Oil-fired power plants are barely used in the electricity sector due to their high cost and emissions.

The huge investments in renewables and storage technologies led not only to less dependence on fuel import, but to less utilization of conventional power. This was translated into the system emissions in Figure 5, where all scenarios except the price-wave-2037 stayed in line with the 1.5 °C target of Germany.

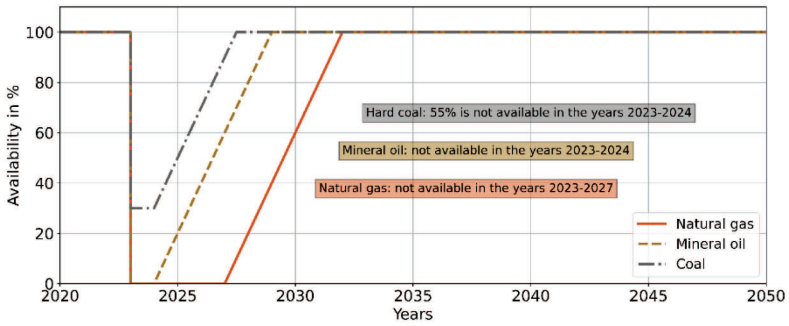

Figure 2: Scenarios availability of the energy sources hard coal, oil and gas in Germany's electricity system.

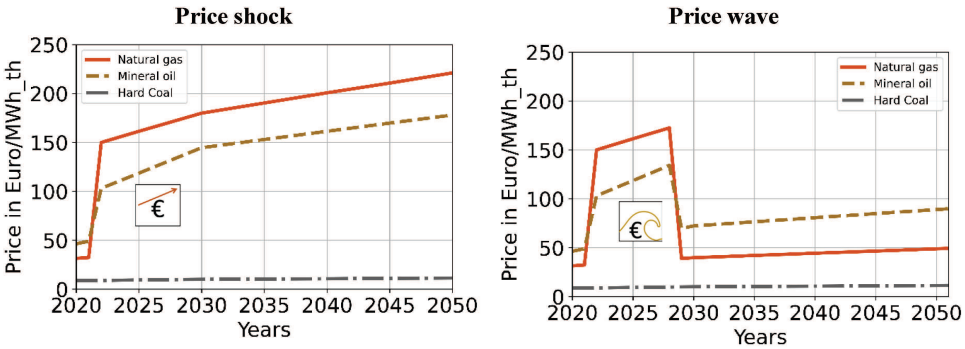

Figure 3: Model costs assumptions for the two main scenarios (a) "Price shock" and (b) "Price wave)

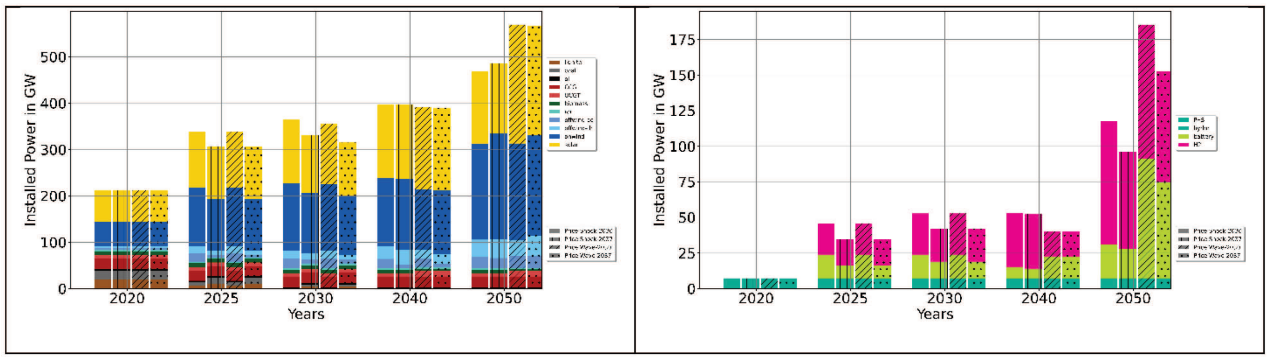

Figure 4: Scenarios Installations of Renewables and Storage Technologies.

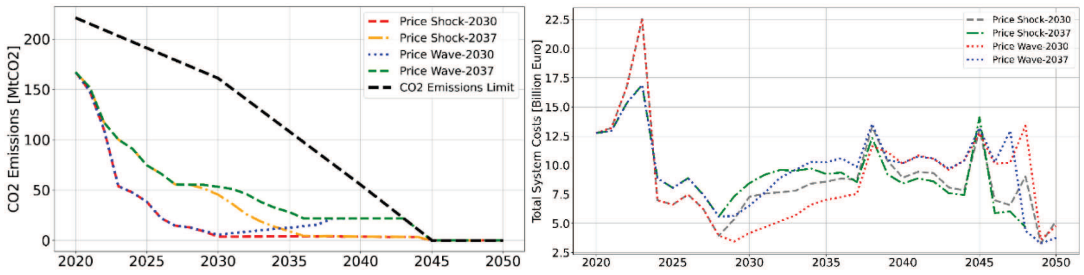

Figure 5: Scenarios emissions and total system costs.

The phase-out of coal and lignite by 2037 helped the system in terms of adequate flexibility from conventional sources, where in the 2030 scenarios these sources were compensated by using storage technologies. In terms of total transition cost, all systems had nearly close numbers. However, systems with a later coal phase-out dates were in average more expensive on the longer run, let alone the nearly-double emissions.

Conclusion

It can be summarized that an early phase-out of conventional energy sources and an expansion of renewables pave the way to a low-carbon electricity system. The short-term reduction in fossil fuel imports leads to enormous investments in renewable energy in all scenarios, almost twice as high as the investments in the previous years, in addition to enormous investments in storage. However, many positive aspects can also be taken from the scenarios. For example, the early expansion of storage facilities means that not only in the short term, but also in the medium and long term, there is no need for significant quantities of natural gas in the electricity system. Moreover, the climate targets of the German government are met and, more importantly, the available CO_2 budget in the electricity system is undercut in all scenarios and the 1.5-degree target is achieved in three of them [20]. This will most certainly have a great advantage in the long-run and will allow for a rapid transition towards a carbon-neutral electrical system.

The results showed that it would be possible after 2028 to run the electrical system without the gas-fired power plants, meaning that it is more important to focus on higher renewables and storage investments

rather than building LNG gasification stations to replace gas pipelines. Other sources of flexibility within the system can be further analysed and their potential along with the storage facilities should be adequate to run a secure system with 100 % renewables and not depend heavily on fuel imports.

Stopping the gas, coal and oil imports can be very challenging, but not necessarily impossible. Moreover, great obstacles must be resolved in order to develop and achieve a 100 % self-sufficient energy strategy. Finally, as Russia already manipulated the market once and cannot exhaust this option again, any political decision must be taken while keeping in mind that Russia cannot hurt you through energy again.

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