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Increased power export from Sweden to Germany due to nuclear phase out policy:

Transmission network considerations

This paper presents the future outlook on the electricity supply system in Germany with the newly effective policy on nuclear power phase out. Nuclear phase-out not only affects the generation mix in the supply system and the trade balance with other countries, but also has a potential impact on the power transmission system. The effects are found to be most severe in the North-South transmission corridors. Furthermore, the strain on the transmission grid is increased in the Western part and reduced in the Eastern part. This would show clearly the needs for internal grid management strategies, both in short-term and long-term in order to minimize the transmission system effects without having to curtail loads and generation. Increased electricity export from the Nordic countries to Germany is possible up to several GW, but will cause bottlenecks in more than 10% of the German transmission lines.

German nuclear phase-out and Nordic electricity export

As a direct consequence of the Fukushima nuclear reactor accident in Japan, the German government agreed in June 2011 on a decision to finalize a complete nuclear phase out by the end of 2022 (BMU 2011). Furthermore, eight of the 17 operational reactors were shut down immediately in March 2011. This had a direct impact on cross-border electricity trade between Germany and the neighbouring countries, where the prevailing net export immediately was turned into a German net import (VGB Powertech 2012). Also in a longer perspective, it is reasonable to assume that Germany has to rely more on imported electricity due to the phase-out. The Nordic countries may supply a certain share of that electricity. Besides phasing-out nuclear power in Germany, ambitious European climate and renewable policies are likely to spur a significant increase in Nordic electricity export to Continental Europe (see e.g. “Increase in Nordic electricity export towards 2030” in this report). The question is, thus, whether the Continental grid is ready for such a significant increase in Nordic electricity export, or not?

The electricity supply scenarios

Taking into account the plans for nuclear phase out in Germany, the ELIN/EPOD of the integrated model tool box has been run for two cases, i.e., a ”Reference” case and a ”Nordic import” case. In the ”Nordic import” case, the Nordic net export is increased by 50 TWh annually as compared to the ”Reference” case. The description of the Nordic export scenarios can be found in “Increase in Nordic electricity export towards 2030” in this report These 50 TWh are considered as base-load export which is constant throughout the year. Out of these 50 TWh, two third is exported to Germany and the rest goes to Poland. This corresponds to 3.76 GW to Germany and 1.9 GW to Poland. Needless to say, the large amount of power import would have an effect on the supply scenario of Germany and Poland.

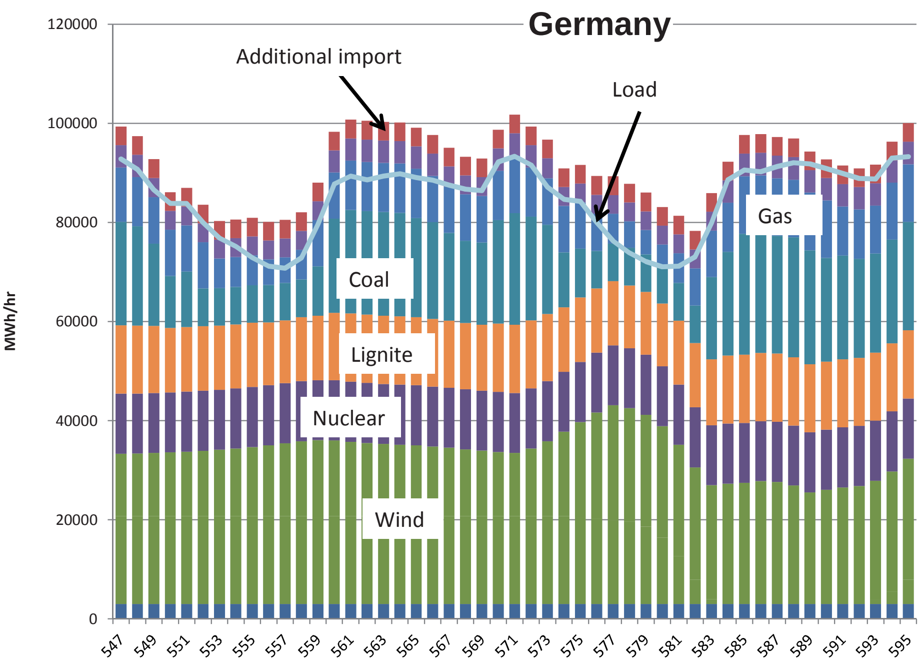

Figure 1: The generation mix for the Nordic import case, model year 2015.

Figure 1 shows the supply scenario of the ”Nordic import” case mentioned above. The case also belongs to the overall “Climate Market” scenario as defined within the framework of the Pathways project.

Implications of the nuclear phase out policy in Germany’s transmission network

In this part, selected results of power flow calculation performed for the transmission network in Germany using DC Power Flow model to evaluate the effects of the generation supply scenarios for different cases as described above. Due to space limit, only the results of the two cases are shown.

Figure 2 shows the results of one case for Germany with the peak load data taken from ENTSO-E statistics for the third Wednesday in January 2011. This case is referred to as ” ENTSO-E Reference”. The generation power outputs from power plants are scaled up from original data of the approximate European transmission network model for the year 2011. Several loading limits of transmission lines are found to be violated. However, to represent a normal operating hour case, the transmission capacity of transmission lines in this system has been adjusted such that no big congestion would occur during this hour. This should be done due to the fact that the network should be managed by one way or another in order not to violate the transmission loading limits of the lines during operating hour. This adjustment corresponds to either operations of power flow control devices in the system or adding new transmission capacity on the lines. Where to put new transmission capacity is a question of transmission investment planning and this is however not the focus of this paper.

To evaluate the effects of the new policy based on our models’ runs, the generation power output of the ”Nordic import” case has been utilized in the power flow model. The results from the model is shown in Figure 3. As can be seen in the figures, about 12% of the total number of transmission lines in the systems get overloaded (as shown with the red circles) with the highest overload area being experienced in the North part of the system where there are power injections from the Nordic imports. The power has to be transferred from North to South direction which gets congested. Also, as compared to the original case with ENTSO-E data, there are more wind power off-shore in this case, which also contribute to the overloading of the network. It is also interesting to note that the power flow from East to West side have been decreased in the Eastern part of the system due to power flow redistribution in the system.

It is noted that the power flow calculation was done for a single hour (i.e., a ”snapshot”) with the intention to show the possible problems in the network in the future generation and load plan. In order to give a complete picture about how often internal bottlenecks would occur in the system, it is important to examine the system more extensively, i.e., using multi-period power flow calculation where the effects of variations in power generation, power exchanges between countries, and the load on the line flows can be captured. This will be further investigated.

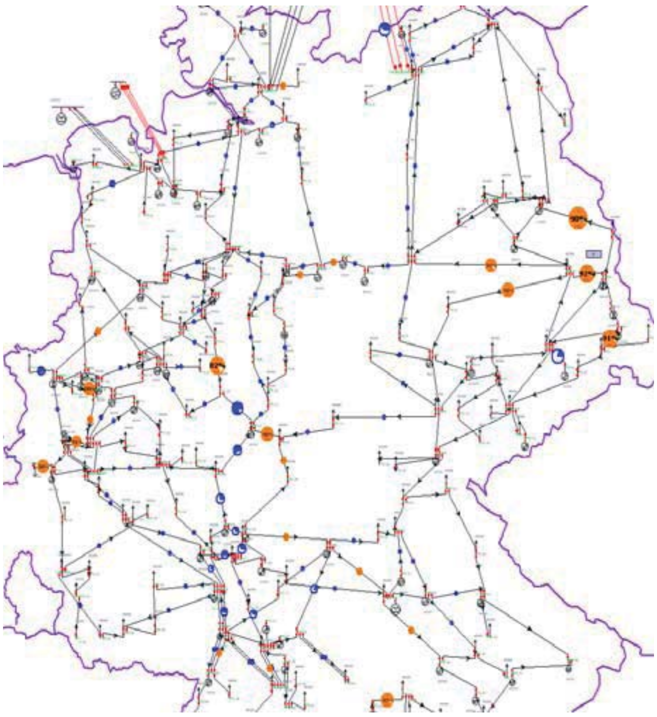

Figure 2: Results of ENTSO-E Reference Case, model year 2015

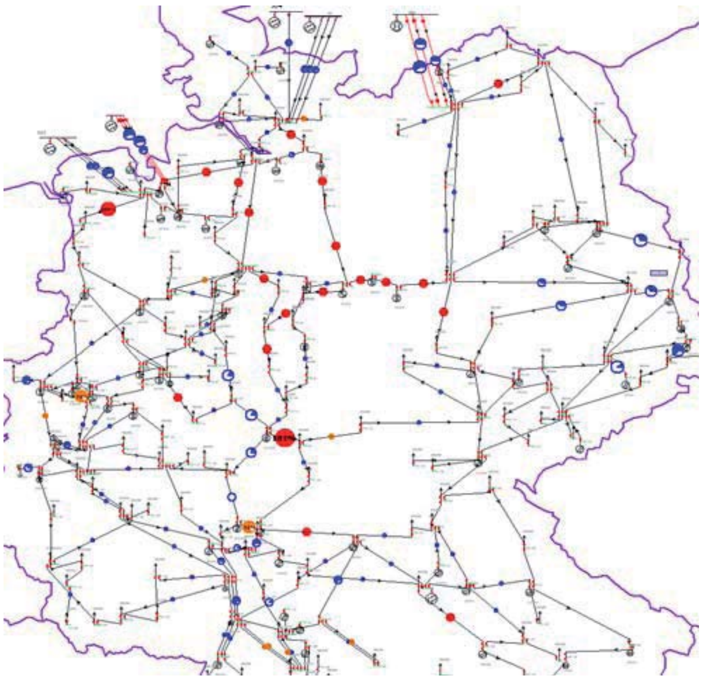

Figure 3: Results of Nordic Import Case, model year 2015

For further information: Tuan Le, Chalmers, Mikael Odenberger, Chalmers, Thomas Unger, Profu