Germany's Nuclear Phase Out -

A Survey of the Impact since 2011 and Outlook to 2023

Friedrich Kunz[1] and Hannes Weigt[2]

Executive Summary

The moratorium and final approval of the nuclear phase out in Germany in 2011, following Japan's Fukushima nuclear accident, ends the rollercoaster like path of Germany's nuclear policy. The phase out is an essential ingredient of Germany's *Energiewende*, and is being observed with great interest by a global audience. Consequently its progress is of general interest and its success or failure can influence energy policy decisions worldwide.

Looking back to the immediate aftermath of the "moratorium", i.e. the decision to immediately close the seven oldest plants in March 2011, a number of analyses were carried out to assess the consequences of the phase out decision on prices, generation patterns, trade flows with neighboring countries, and supply security. We provide an *ex-post* assessment of model analysis on the impact of the nuclear moratorium presented by the modelling community, in 2011 or shortly after. These are then compared with the real-world developments over 2011-2013. We also provide recent modelling results on the final phase out of all German nuclear power plants by 2023.

Following the moratorium of nuclear capacities a number of analyses examining the direct consequences of the moratorium or forecasting market developments after the full

1 DIW Berlin, fkunz@diw.de.

2 University of Basel, hannes.weigt@unibas.ch.

nuclear phase out were carried out. Albeit they differed in methodology and their impact forecasts all these studies stated that the phase out was possible. They showed a clear short-term impact on market outcomes with increased fossil fuel generation, reduced exports, and price increases in the range up to 10 EUR/MWh. The increased fossil generation also led to modest increases of emission prices. The studies including network details showed that changed power flow patterns would result in some grid congestion. However, this is mainly due to the development of renewable energies. Finally, investment evaluations showed the largest divergence ranging from increased gas shares, new lignite and coal plants, to no additional investments and even reduced investments.

Examining the real market developments after the phase out decision shows that the overall impact of the moratorium and following nuclear decommissioning was rather modest. The moratorium led to a short-term shift from nuclear to fossil fuel generation along with a decrease of German electricity exports. Furthermore, the generation shift implied increasing electricity market prices due to replacing nuclear generation with more expensive generation technologies, basically shifting the merit order to the left. However, the import effect persisted for only a couple of months during summer. Thus, the nuclear moratorium caused a short-term generation shift, but no underlying structural change in the generation and import patterns can be identified both for Germany and its neighboring countries. The same holds for the price developments. This is mainly due to a strong increase of renewable generation, in particular from solar (i.e. between 2010 and 2012, solar capacity increased by roughly 7 GW per year). The reduction of nuclear generation capacity is overcompensated by renewable capacity additions yielding an overall increase of installed generation capacity in Germany. However, the strong increase of renewable capacities, in combination with the moratorium, increases transmission needs along the north-south axis leading to higher redispatch costs and the contracting of additional reserve capacities.

Between 2015 and 2022, nine additional nuclear power plants with a capacity of about 12.7 GW will be closed. Scenario analyses show that the complete phase out will increase the import dependency in extreme situations, but will pose no threat to resource adequacy given considered capacity expansion projections. A particular challenge will be the secure supply of electricity to southern Germany, where most of the nuclear power plants, which will be taken offline, are located and where demand is high. However, a node-based analysis shows that following the phase out, electricity supply to southern Germany is assured given that network infrastructure is extended as described in the national network expansion plan.

Summing up, the March 2011 nuclear moratorium and the subsequent nuclear capacity reductions did not cause a structural change to the German power system, thus confirming the studies of 2011. Although the models do not provide perfect forecasts, their general insights regarding the ability of the European electricity market to cope with the German phase out match the observed developments. The studies on the moratorium indicate that the reduced nuclear generation could be compensated by increased domestic and imported generation. This matches with the actual 2011 market results. From 2012 onwards, this trend is overshadowed by the large increase in renewable generation, leading to an overall increase in exports from Germany.

Faced with the political determination and broad societal consensus, the nuclear industry has given up its resistance against the phase out and changed its strategy: its proposal to hand over the entire nuclear installations to the government, including open issues such as decommissioning and storage, is a clear sign that the phase out is accepted and the remaining strategy is to reduce the private costs thereof. It is likely that the “phase out debate” will phase out rapidly: the question of whether nuclear plants are needed or not is no longer on the political agenda. The relevant topic now has become the integration of large quantities of

renewables including the subordinate aspects of network congestion and extension, system stability, and the capacity market debate.