Phasing Out Nuclear Power in Europe

By Rolf Golombek, Finn Roar Aune and Hilde Hallre Le Tissier

INTRODUCTION

Until the Fukushima accident in Japan in February 2011, nuclear power was by many seen as an important part of a low-carbon future. The accident sparked security concerns and anti-nuclear sentiments in many European countries causing three EU member states – Belgium, Germany and Switzerland - to phase out nuclear power over time. For other EU countries, the response to the Fukushima accident was more mixed. For example, in France a European Pressurized Reactor is under construction but the President has pledged to reduce the share of nuclear electricity production to 50 percent by 2025. In some East-European countries, there are plans to either extend the lifetime of current reactors (for example Bulgaria) or build new reactors (for example Romania), but currently plans are on hold because of lack of financing. Hence, the future of nuclear power in Europe is uncertain.

In this note (see Aune et al. (2015) for the complete version of the paper) we examine the outcome if all EU member states follow the long-run strategy of Belgium, Germany and Switzerland to phase out nuclear power. We focus on two questions. First, to what extent will a phase-out of nuclear power be replaced by supply from other electricity technologies? Second, how will a phase-out change the composition of electricity technologies?

We make three contributions to the literature. First, we believe we are the first to examine the imapct of an EU-wide nuclear phase out. Second, we offer a strategy to model profitable investment in solar power and wind power taking into account that i) the production sites of these technologies differ, that is, the number of solar and wind hours differ between sites, and ii) access to sites is regulated. Both wind power and solar power will in general use surface area that has an opportunity cost; we therefore make assumptions on how much land that may be available for this type of electricity production in each country. The endogenous determination of investment in solar power and wind power is based on a combination of technical factors – the degree to which production sites differ – political factors – the degree to which actors get access to production sites – and economic factors – the profitability of investment given access to a set of production sites.

Third, we present an overview of costs of producing electricity by comparing total cost of electricity, as well as different cost elements, between different electricity technologies. These cost elements have consistent assumptions about factors like duration of a new plant, rate of interest, operational hours throughout the year, and fossil fuel prices. We also compare our cost assumptions to other studies.

MODELING THE EUOPEAN ENERGY MARKETS

We use the numerical multi-good, multi-period model LIBEMOD to analyze impacts of a nuclear phase-out by 2030, see Aunet et al. (2008) and LIBEMOD (2014). This model covers the entire energy industry in 30 European countries (EU-27 plus Iceland, Norway and Switzerland). In the model, eight energy goods, that is, three types of coal, oil, natural gas, two types of bioenergy and electricity, are extracted, produced, traded and consumed in *each* of the 30 European countries. In each country, electricity can be produced by a number of technologies; nuclear, fuel based technologies (using either steam coal, lignite, oil, natural gas or biomass as an input), fossil-fuel based CCS (using either steam coal or natural gas), hydro (reservoir hydro, run-of-river hydro and pumped storage hydro), wind power and solar. We make a distinction between plants with pre-existing capacities in the data year of the model (2009) and new plants; the latter are built if such investments are profitable.

All markets for energy goods are assumed to be competitive in 2030. While steam coal, coking coal and biofuel are traded in global markets in LIBEMOD, natural gas, electricity and biomass are traded in European markets, although there is import of these goods from non-European countries. For the latter group of energy goods, trade takes place between pairs of countries, and such trade requires electricity transmission lines and gas pipelines. These networks have pre-existing capacities in the data year of the model, but through profitable investments capacities can be expanded.

LIBEMOD determines all prices and quantities in the European energy industry, as well as prices and quantities of energy goods traded globally. In addition, the model determines emissions of CO_2 by country and sectors (households; services and the public sector; manufacturing; transport; electricity generation).

Rolf Golombek is Senior researcher, at Frisch Centre, Norway; Finn Roar Aune is a Researcher at Statistics Norway; and Hilde Hallre Le Tissier is a research assistant at Frisch Centre, Norway. Golombeck may be reached at rolf.golombek@frisch.uio.no

RESULTS

In our reference scenario, nuclear capacity in 2030 is according the present plans, that is, about 20 percent lower than in 2009. Moreover, the 2030 EU policy to reduce GHG emissions by 40 percent relative to 1990 and to reach a renewable share in final energy consumption of (at least) 27 percent is implemented. These goals are achieved by imposing EU-wide prices on emissions in the ETS and non-ETS sector, as well as renewable subsidies.

We then study the impact of a complete nuclear phase-out in EU-30 by 2030, that is, the planned nucleaer capacity in 2030 is replaced by no nuclear capacity. We find that there is a moderate impact on total production of electricity (4 percent reduction) and only a tiny impact on total consumption of energy (1 percent reduction). A nuclear phase-out is to a large extent replaced by more natural gas power and renewable electricity. After the phase-out, the aggregate market share in electricity production of bio power, hydro, wind and solar is 78 percent. There is a tiny production of coal power, and no Carbon Capture and Storage in the electricity industry.

We find that the annual cost of a nuclear phase-out is around 60 billion euro, which corresponds to 0.5 percent of GDP in EU-30 (in 2009). End users lose, mainly due to higher end-user prices of energy. Higher electricity prices benefit several electricity plants, but the group of electricity producers lose due the lost profit from nuclear power. The government sector gains, mainly because a nuclear phase out promotes more renewables such that less subsidies (than in the reference scenario) is paid to renewable electricity plants.

We have run a number of other scenarios to examine how the equilibrium with a complete phase-out of nuclear power changes if one of the main assumptions of the reference scenario is changed, that is, we vary factors like i) the GHG emissions target, ii) the policy instruments imposed by the EU, and iii) cost of electricity production, for example, cost of investment in CCS power stations. We find that typically the impact on production of electricity and consumption of energy of a complete nuclear phase is minor. On the other hand, the equilibrium composition of electricity technologies reflects the stringency of the climate target and whether some technologies are being promoted through subsidies.

We have also examined a case in which the rate of energy efficiency is so high that end-user demand for energy does not increase over time, that is, demand for energy in 2030 is equal to demand in 2009. Then production of electricity is as much as 18 percent lower than in the complete phase-out scenario. Lower demand for energy decreases the ETS price of emissions, and hence strengthen the competitive position of coal power (relative to the complete phase-out scenario).

CONCLUSIONS

We explore the impact of an EU-wide nuclear phase-out by 2030 provided the EU energy and climate policy for 2030 is implemented. Using a numerical simulation model of the European energy industry (LIBEMOD), we find that a complete nuclear phase-out in Europe by 2030 has a moderate impact on total production of electricity (4 percent reduction). Lower nuclear production is to a large extent replaced by more gas power and renewables.

In all scenarios, we have assumed all markets to be competitive; this is in line with the EU policy to transform the European electricity and natural gas markets into efficient ("internal") markets. However, the transition has been partial and incremental. This suggests to run LIBEMOD under different assumptions about market structure; the market structure in LIBEMOD can be represented by a number of parameters that reflect the degree of deviation from the competitive outcome in different parts of the European energy industry, see Golombek et al. (2013).

Finally, we have assumed no uncertainty. Needless to say, actors in the energy market face a number of uncertainties, for example, future growth rates and prices. In the stochastic version of LIBEMOD, see Brekke et al. (2013), different sources of uncertainties can be imposed. The stochastic LIBEMOD can be used to study the impact of a nuclear phase-out when actors face uncertainty in, for example, future growth rates, or nuclear policy is uncertain.