

# ***Economic Aspects of Atomic Power in the 21st Century – Old Questions, but New Insights***

Hannes Weigt, Professor for Energy Economics, University of Basel, hannes.weigt@unibas.ch  
Christian von Hirschhausen, Workgroup for Infrastructure Policy (WIP), TU Berlin, cvh@wip.tu-berlin.de

## **Overview**

The future role of nuclear power in the energy mix, and in particular policies in this complex sector continue to be challenging, be it investment policy, competitiveness, incentives for efficient operation and dismantling of plants, and the regulation of the search for long-term storage of nuclear waste. Some of these topics were already discussed in the 20<sup>th</sup> century, but they are now coming back in the context of the low-carbon energy transformation going on in many countries of the world.

This objective of this paper is to provide a full-fledged review of nuclear power policy issues, in the context of global decarbonisation trends, and to identify options for particularly challenging problems. The paper thus complements Davis (2012), who provided an immediate post-Fukushima assessment, but we go beyond his analysis on issues such as economic discounting, dismantling, and waste storage.

## **Methods**

The paper relies on microeconomic and political economy analyses, the economics of regulation, risk evaluation, as well as our own numerical modelling of energy scenarios in specific countries, mainly Europe and Germany. Instead of the model-based analysis of one specific question, the paper sketches out the main policy issues related to nuclear power, as seen in the light of recent developments world-wide. Quantitative examples, in-depth case study assessments, and a full-fledged literature review complement the descriptive analysis.

## **Results**

Several decades after the introduction of commercial nuclear power, the industry is still struggling to make a case for it being an “economic” source of electricity. In fact, the gap between the per-unit costs of nuclear and other energy sources, e.g. as identified by Davis (2012) has widened over the last years, with the lower natural gas prices in the U.S., and an increasing share of renewables in some European countries, both driving down prices. Furthermore, also the investment cost increase of nuclear newbuilds identified in the U.S. and France for the period 1970-1990s (Rangel and Lévêque, 2012, Grubler, 2010), is continuing, and the specific costs for the new EPR of the 3<sup>rd</sup> generation are also much higher than anticipated. Thus, the dynamics of nuclear power newbuilds have calmed down in the Western world; an exception to this rule is China and some other emerging countries, with not less than 14 reactors currently under preparation in China alone.

Clearly there is a contradiction between the low economic competitiveness of nuclear power, and the important role it plays in many of the longer-term energy system projections, such as the Reference Scenario by the European Commission (European Commission, 2013) and the World Energy Outlook (IEA, 2015). A sensitivity analysis of our dynamic investment model, DynELMOD (Gerbaulet, et al., 2014), for the European level shows that the results are highly sensitive to the estimation of capital costs: a value between € 3,000-4,000/kW, usually adopted in international comparisons, yields a high share of nuclear power, whereas the historical and recently observed values of € 5,000-7,000 yield much lower shares. The same holds for other forecasts and scenarios involving endogenous investments. The share of nuclear strongly depends on the underlying cost assumptions. At the same time the model complexity often limits the market aspects that can be covered in investment models. This is particular relevant for short term effects of renewables and their feedback effect on conventional power plants.

A first evaluation of the policy responses, political discussions and connection between different political topics with nuclear power in different countries shows important differences (Rinscheid, 2015). A particular focus lies also on the connection of the nuclear debate to other political topics (namely the renewable debate, climate change, supply security, and industrial policy) and differences between countries on this regard.

With respect to decommissioning and dismantling old plants, we observe the emergence of an entire industry, worth several hundreds of billions of U.S.-\$, that is rapidly building up. Contrary to the status quo, where each plant is more or less responsible for the dismantling of its own infrastructure, we suggest that competition in the sector could be created, by opening up the market for dismantling to public auctions. We observe that in fact approx. 8-10 companies have sufficient technical knowledge, so competition is feasible. In Europe, we observe a gradually emerging market of incumbents and new entrants, the latter suggesting potential costs reductions of 33% (personal communication with industry representatives). The German market, with over 20 plants to be dismantled in the coming years, is particularly intense. Clearly there are economies of scale, so that national regulatory agencies have two options: Maintain the relatively expensive status quo, or bundle the dismantling of several plants and put them up for auctions. We also report about first experience and difficulties of regulatory oversight, linked to information asymmetries between the regulator and the plants to be decommissioned.

Last but not least, a “new”, old issue is currently re-emerging, with the large-scale closure of the atomic power plants of the 1970/80s: the challenges of securing final, long-term storage of radioactive waste. While this “wicked problems” (in the parlance of political scientists, see Brunnengraeber et al., 2015, 47-78), had been well known to arrive from the very first day, it has proven to be difficult to find appropriate sites to store the waste, and also to secure sufficient financial funds for this long-term process. A few projects are currently under way, that might succeed in the next decade, such as Finland, Sweden, and Switzerland; yet many countries are struggling to establish a sustainable organization model to finance this activity, lasting at least a century, and requiring safe storage for at least a million years.

## Conclusion

Nuclear power is certainly an important topic in the process of low-carbon energy transformation, but several complex policy questions remain to date, and empirical evidence on some critical issues is still scarce. This paper provides an update of the survey on nuclear power by Davis (2012), but extends the analysis to “new” issues not intensively covered in the literature, such as recent cost developments, organizing a competitive industry for the dismantling of old power stations, and securing funds for the long-term storage.

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