Cost estimates and economics of nuclear power plant newbuild: Literature survey and some modelling analysis

Ben Wealer, Research Associate, TU Berlin & DIW, +49-(0)30-314-75837, bw@wip.tu-berlin.de
Clemens Gerbaulet, Research Associate,TU Berlin & DIW, Tel. +49-(0)30-314-25377, cfg@ wip.tu-berlin.de
Claudia Kemfert, Head of Department, DIW Berlin, +49-(0)30-89789-663, ckemfert@diw.de
Christian von Hirschhausen, Professor, TU Berlin & DIW, +49-(0)30-314-25048, cvh@wip.tu-berlin.de

Overview

The perspectives of nuclear power deployment in the long-term depend very much on the development of costs, in relation to other low-carbon options, and the economics of investments into new capacities. Currently, these perspectives are discussed quite controversially, see the discussion between (Lovering et al., 2016) and (Koomey et al., 2017). While there is a consensus in the literature that nuclear power is not competitive under regular market economy, competitive conditions (Davis, 2012), at least three issues need to be considered going forward. First, the evolution of future technologies (e.g., SMR and Generation IV reactors). Second, the treatment of "costs" in other, non-market institutional contexts, such as indigenous suppliers or "home suppliers" (Thomas, 2010) or the new—subsidized—export models of countries like China (Thomas, 2017) or Russia (Hirschhausen, 2017). Third, the development of the nuclear nuclear energy market, e.g. the filing for bankruptcy of the major reactor vendor Westinghouse, the much needed investments into the civil nuclear supply chain (Energy Futures Initiative, 2017). The objective of this paper is to provide insights into the economics of nuclear power for electricity generation.

Methods

We focus on the perspective of a (private or public) investor, and thus leave aside the public policy perspective, such as externalities, cost-benefit analysis, proliferation issues, etc. Instead, we apply a conventional economic perspective, such as proposed by Rothwell (2016), to decompose the costs into different technical components, to take into account the institutional context (capital costs, etc.), and to estimate values that are not readily available, or need to be aggregated, such as the costs for decommissioning at the end of a plant's lifetime, and long-term waste storage.

In a first step, a brief recap on the private economics of nuclear power is given. The different approaches to break down the costs and the differentiation between the concepts of "overnight costs" and "levelized costs of electricity" are introduced. We decompose the costs into different technical components or systems with different input and output variables, e.g. the balance-of-the-plant, the cooling system, or the nuclear steam supply system. The next section summarizes the state of scientific literature, as well as the grey literature that has not undergone peer review. While the literature on the costs of nuclear power is vast, especially on the issue of construction costs for the major nuclear countries U.S. and France, topics to which much less attention has been paid to are the issues of decommissioning and long-term radioactive waste management and storage. We then present an update of our own cost estimates, lay out the critical parameters, and perform some Monte Carlo and sensitivity analyses.

Preliminary Results

Based on the analysis of the levelized cost for electricity generation by Davis (2012), where the total cost of electricity production includes construction costs, fuel costs, and operations and maintenance over the lifetime of the power plant, resulting in an average value of electricity generation costs. Davis concludes, that under the then-current circumstances, nuclear power is not competitive compared to natural gas- and coal-fueled electricity generation. This kind of analysis has been conducted in 2016 by DIW Berlin, using a similar methodology, but in a European context, and taking the 2016 boundary conditions into account. The calculation shows, that nuclear power remains uncompetitive, even when the CO_2-price is set to 100€/t CO_2 (See Table 1).

	Levelized costs in €cents/kWh		
	Nuclear	Coal	Natural Gas
Baseline (2016) (no CO_2-price)	11.0	5.1	5.0
CO_2-price: 25 €/t	11.0	6.3	5.7
CO_2-price: 100 €/t	11.0	10.0	7.9

Table 1: Levelized costs of conventional electricity (€cents/kWh)

Source: own calculations

The breakdown of a nuclear power plant into different systems lets us identify some system costs, which are more sensible to future increases. For example, there is currently worldwide only one large-scale supplier for reactor pressure vessels for boiling water reactors – this also applies for the newer generations of reactors. This kind of analysis is informative to predict cost estimates of newbuild projects.

Conclusion

We confirm the consensus of the literature that, even under very optimistic assumptions about critical parameters, nuclear power is far from being competitive. Current newbuild projects are still subsidizied (see Hinkley Point C) or the construction is financed by low-interest loans, e.g. by the Russian or Chinese state. Comparing the generation costs of nuclear power to the costs of coal and natural gas, even with a CO_2-price of 100€/t, there is no profitable investment to be expected where nuclear becomes competitive.

References

Davis, L.W. (2012). Prospects for Nuclear Power. *Journal of Economic Perspectives*, 26(1), pp. 49–66.

Energy Futures Initiative (2017). The U.S. Nuclear Energy Enterprise: A Key National Security Enabler.

Hirschhausen, C. von (2017). Nuclear Power in the 21st Century – An Assessment (Part I). *DIW Berlin Discussion Paper 1700*.

Koomey, J., Hultman, N.E. & Grubler, A. (2017). A reply to "Historical construction costs of global nuclear power reactors". *Energy Policy*, 102, pp. 640–643.

Lovering, J.R., Yip, A. & Nordhaus, T. (2016). Historical construction costs of global nuclear power reactors. *Energy Policy*, 91, pp. 371–382.

Rothwell, G. (2016). Economics of Nuclear Power. London, UK: Routledge.

Thomas, S. (2010). The Economics of nuclear power: An update. *Heinrich Böll Foundation Ecology*, Brussels.

Thomas, S. (2017). China's nuclear export drive: Trojan Horse or Marshall Plan? *Energy Policy*, 101Supplement C, pp. 683–691.