



Future nuclear fission reactors – uncertainties, the effect of parameter choice and an application to small modular reactor concepts

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Abstract. Today, steep declines in the generation costs of renewable energy systems, particularly solar photovoltaic and wind, combined with a recent spur in storage and flexible technologies mainly driven by batteries and renewable-energy-generated hydrogen are driving a paradigm shift in energy systems across the world, and renewable energy dominates investments in installed electricity generation systems (Ram et al., 2022). In contrast, in 2022 USD 4.8 billion (ca. 21 %) of the total spending in research and development expenditures by countries within the Organisation for Economic Co-operation and Development (OECD) was still spent on nuclear development alongside the current discussion in recent literature about the role of new nuclear developments in combating the recent energy crisis and climate change (Asuega et al., 2023; Ingersoll et al., 2020; IEA, 2023).

Since predicting future costs of technologies not yet developed is a complex exercise, we start this paper with a comparison of two different approaches from production theory and show that they have a theoretically equal structure (Steigerwald et al., 2023). This we then apply to estimate a range of potential production costs for 15 so-called small modular reactor (SMR) concepts for which sufficient data are available. These include light-water, high-temperature and fast reactors. In a third step, we apply the Monte Carlo method to benchmark the cost projections assumed by the manufacturers by varying production parameters in simulations of the net present value (NPV) and the levelized cost of electricity (LCOE). Besides this, we test whether the differences between the manufacturer estimates and ours differ between technology families of SMR concepts and apply a sensitivity analysis. This contributes to an intensifying debate in the literature on the economics and finance of SMR concepts (Steigerwald et al., 2023). In a final step we compared our results with current costs of renewable energy technologies and could conclude that none of the tested concepts is able to compete economically with existing renewable technologies, not even when taking their variability and necessary system integration costs into account. We conclude that any technology foresight has to take the case specifics into account as much as possible, including technological and institutional specifics; this also holds for SMR concepts.

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