Nuclear Bias in Energy Scenarios –
A Review and Results from an in-depth Analysis of Long-Term Decarbonisation Scenarios

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Overview

In the context of decarbonisation, long-term energy scenarios play an important role to provide guidance to industry and policymakers, including potential futures and pathways. However, energy scenarios are themselves subject to political and industry influence, such that assumptions – and hence results – are not "objective" but rely on specific views and perceptions on the future. The debate about the future energy systems, is often characterized by biases and belief systems rooted in broader public perceptions as opposed to expert insights and data (Midttun and Baumgartner 1986; Krey et al. 2019; Bloomfield et al. 2021). Since the beginning of long-term energy planning, nuclear power has played a particularly important role, both due to expected technical progress, and the difference between expected cost reductions and real cost developments. Thus, energy scenarios of the 1960s counted on fast breeder reactors to deliver energy "too cheap to meter" (Strauss 1954) in what Seaborg (1970) called the "plutonium economy". Another wave of technical optimism occurred in the 1980s (mainly in Europe), where the advent of a new technology generation was expected, that would lead to a significant increase in the share of nuclear power in electricity generation (Häfele 1981). At the moment, another wave of technological forecasting expecting "advanced nuclear" to play a major role in decarbonised energy systems is becoming popular (Duan et al. 2022). However, a recent paper from the Integrated Assessment Modelling (IAM) community and scenarios with updated cost assumptions of renewables, in particular for solar photovoltaics and energy system integration costs, point in the opposite direction, i.e. that due to high costs, nuclear power is phased out in the coming decades (Jacobson et al. 2019; Löffler et al. 2017; Luderer et al. 2021; Pursiheimo, Holttinen, and Koljonen 2019; Teske et al. 2021; Bogdanov et al. 2021).

Methods

We screen 409 Scenarios of 24 Integrated Assessment models based on the IAMC 1.5°C Scenario Explorer (Huppmann, Daniel et al. 2019) to their assumptions on the development of nuclear power, and other elements of the energy system, and how these translate into relative and absolute contributions of nuclear power in long-term decarbonisation scenarios. We provide an in-depth analysis of those different energy scenarios based on the IAMC 1.5°C Scenario Explorer (Huppmann, Daniel et al. 2019) and data with regards to their pathways in the share of nuclear power over time. We cluster these scenarios and compare their underlying models as well as assumptions mainly with regard to CAPEX. In addition, these results are compared with energy scenarios of major international institutions and independent research teams publishing global scenarios.

Results and Conclusions

We find that in the universe of ambitious long-term decarbonisation scenarios, two groups can be clearly identified: (1) Some models conclude a rising share of nuclear, implying a steep increase in absolute power plant capacities; this group includes international organisations (IAEA 2020), also the IPCC (2018) with its IAM scenarios and the IEA (IEA 2021a) with their Net Zero by 2050 Scenarios with the highest nuclear projection since IEA history; while (2) other models consistently find a decreasing share of nuclear power, leading to very high shares of renewables. Figure 1 shows that the former group forecasts a slightly rising relative share of nuclear, which – given steeply rising electricity demand – implies a steep increase in nuclear power plant capacities. On the contrary, the decline of nuclear in the other group is linear until 2050/2060. Interestingly, some scenarios forecast a "rebound effect" after 2060, whereas in the larger subgroup nuclear phases out by 2060.

At present, we are analysing the first group of scenarios with respect to their assumptions. In general, assumptions of cost digression for nuclear are very optimistic, whereas they are rather pessimistic on renewables costs. Nuclear is often modelled as a baseload technology because flexibility options for renewables-based systems are underestimated. Also, we find an inconsistency in the International Energy Agency`s (IEA) annual World Energy Outlook (WEO): The highest value scenario for nuclear power is estimated by the current Net Zero Emissions scenario (NZE) of the IEA, which at the same time confirms that nuclear power is the most expensive way to provide electricity (IEA 2021b), which is confirmed by independent market analysts (Lazard 2021). We conclude the need for a critical assessment of long-term scenarios, both with respect to cost assumptions of nuclear power and other variables, and the modelling of a largely decarbonised energy system.

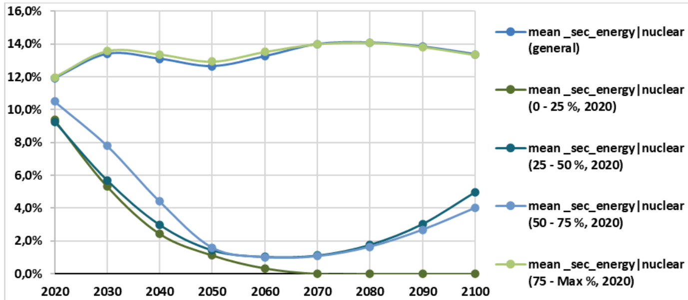

Figure 1: Preliminary explorative – analysis of the development of the share of nuclear energy in total net energy production of IAMC 1.5 scenarios (Base year 2050, 10 yr. – resolution).

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