Nuclear Bias in Forecasting Energy Mix?

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Content

Is there a nuclear bias in energy scenarios?

Figure 1: Levelized Cost $/MWh of Energy Comparison by Lazard (2023)

Is there a nuclear bias in energy scenarios?

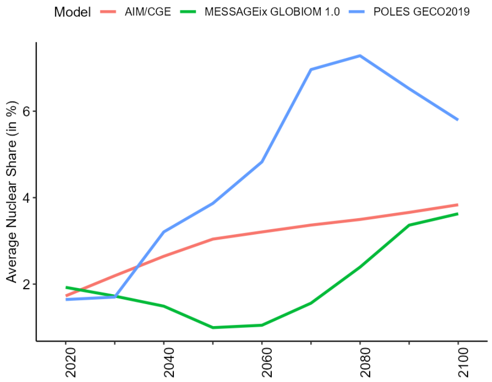


Figure 2: Average share of nuclear power in the energy sector for the AIM/CGE, MESSAGEix and POLES model. Source: COMMIT Database by van Soest et al. (2021).

Related literature

- Krey et al. (2019) compare the representation of different technologies and the associated parameters of 15 Integrated Assessment Models (IAMs)
- Breitschopf and Winkler (2019) found that the share of renewable energy in 15 IAMs varies depending on the assumptions regarding economic growth, capital constraints, discount rates and the functional form of system costs
- Weibezahn, Steigerwald, Breyer, von Hirschhausen, and Slowik (2022) point to a large discrepancy in the share of nuclear power between in 24 IAMs

AIM/CGE

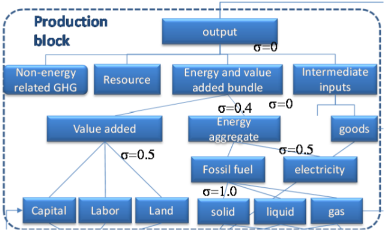


Figure 3: AIM/CGE model structure for one region. Source: Fujimori et al. (2012).

- Is a General Computational Equilibrium model developed by Fujimori et al. (2012)
- Maximizes total welfare
- The energy sector is represented as a firm that maximizes profit by using different technologies
- Perfect substitution between different technologies
- The firm responses optimal to changes in price, demand and policy
- Input costs are taken from Input-Output tables

MESSAGEix

- Is a linear programming model developed by Huppmann et al. (2019) at IIASA
- It primarily minimizes energy system cost by choosing from different technologies subject to a set of constraints like new investment, fuel availability, trade, environmental regulations
- The model optimizes at each point in time

POLES

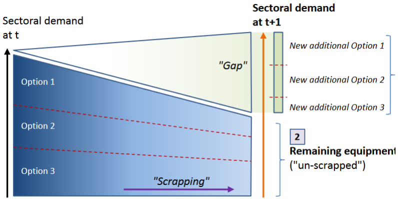


Figure 4: Capacity dynamics in POLES. Source: Després et al. (2018).

- POLES is a dynamic recursive model first developed by Criqui, Mima, and Viguier (1999) and Després et al. (2018) at JRC
- Its dynamic are described by difference equations
- New installed capacities are determined by dynamics of total demand, average lifetime and evolution of relative costs

Features

AIM/CGE

- No reactor technology specified
- Trades only in primary resources

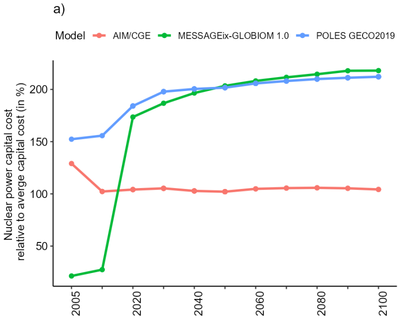
MESSAGEix

- HTR reactor
- New unspecified technology in 2050
- Trade in uranium & plutonium
- Full fuel cylce
- Social constraints

POLES

- LWR reactor
- Gen IV reactor in 2050
- Full fuel cycle
- Covers part of the base load only in competition with hydro
- Produced hydrogen
- Subsidies

Capital and fixed & O&M costs



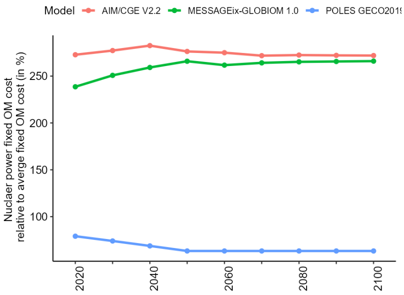


Figure 5: Capital cost of nuclear power relative to average capital cost in the electricity sector. Source: COMMIT Database by van Soest et al. (2021).

Figure 6: Fixed & operations and maintenance (O&M) cost of nuclear power relative to average capital cost in the electricity sector Source: AR6 Database by Byers et al. (2022).

Emissions & CCS

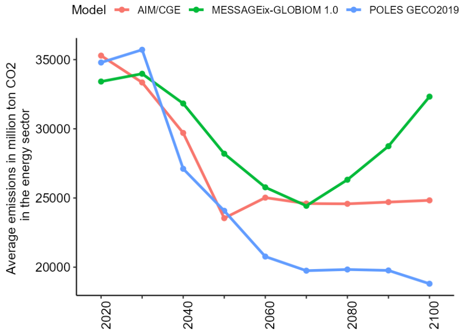


Figure 7: Emissions in the AR6 database. Source AR6 database by Byers et al. (2022).

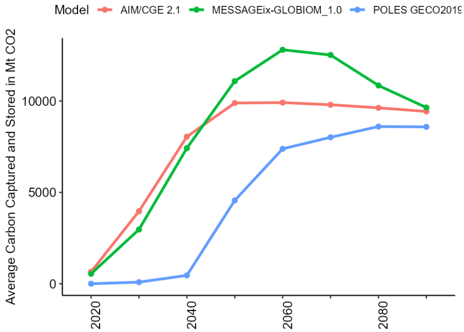


Figure 8: Carbon Capture and Storage (CCS). Source: AR6 database by Byers et al. (2022).

Conclusion

Features

- The model‘s objective function may matter
- Subsidies to the energy sector may be relevant
- Social constraints decrease the share of nuclear power
- New introduced reactor might be a "game changer"
- Secondary production of hydrogen and the placement of nuclear power in the energy system may matter

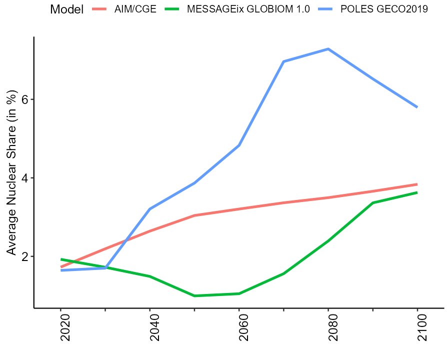


Figure 9: Average share of nuclear power in the energy sector for the AIM/CGE, MESSAGEix and POLES model. Source: COMMIT Database by van Soest et al. (2021).

Conclusion

Parameter Values

- Fixed and O&M costs may be more important than capital costs
- Stronger emission abatement may favour nuclear power

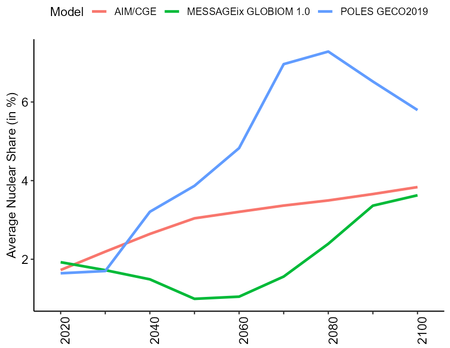


Figure 10: Average share of nuclear power in the energy sector for the AIM/CGE, MESSAGEix and POLES model. Source: COMMIT Database by van Soest et al. (2021).

Fine

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Sources

- Information on AIM/CGE is taken from by Fujimori, Hasegawa, and Masui (2017) and Fujimori et al. (2012)
- For POLES we used the the description for the POLES JRC and GECO2019 model by Després et al. (2018) and Keramidas et al. (2017)
- For MessageIX we used the documentation by Krey et al. (2020) and Huppmann et al. (2019)
- For all models used additional information from the IAMC-Documentation (2022)

Carbon Price

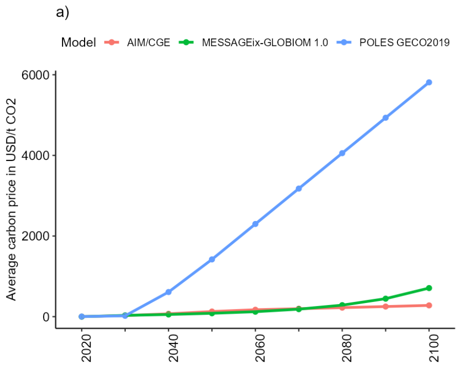

Figure 11: Emissions in the Bridge Scenario. Source COMMIT database by Baptista et al. (2022); van Soest et al. (2021).