NUCLEAR IN A DECARBONIZED EUROPEAN POWER SYSTEM: INSIGHTS FROM A CAPACITY EXPANSION AND POWER SYSTEM SIMULATION MODEL

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Overview

This paper aims to assess the role of nuclear power in a 2050 European decarbonized power system. The current states' commitment to achieve carbon neutrality calls for prospective work regarding, among others, the future optimal capacity mix and hourly economic dispatch that will meet the electric demand.

Methods

We build a two-step modeling approach to determine an optimal future power system shape and economic dispatch. The first step uses a capacity expansion model to determine the economically optimal capacities of nuclear, renewables, decarbonized gas, and interconnections. The model is run in a brownfield Western-European power system with pre-existing storage units and hydroelectricity. The second step runs a detailed hourly power system simulation spanning over one year to better evaluate the economic generation dispatch from those computed optimal capacities. This simulation includes additional dynamic generating constraints, such as start-up costs, minimum up/down durations, and plants outages. We run sensitivity analyses for each stage, with several costs scenarios for the capacity expansion model and multiple climate years for the power system simulation

Results

The first result is that the increased electric demand derived for the decarbonization of the energy sector calls for consequent investment in new capacities, whether nuclear or renewables. We find that renewables will represent a dominant share of those newly installed capacities with some nuclear reactors and interconnections lines for all of our sensitivity cases. In such capacities combination, nuclear reactors will need to operate flexibly to participate in load-following operations to accommodate renewables production's variability. Nuclear flexibility allows for better variable renewables integration and decreases the use of storage units and decarbonized gas.

Conclusions

We find that a cost-optimal decarbonized European power system will rely on a combination of renewables, new reactor builds, increased interconnections, and hydrogen use. Although each technology's relative share is dependent on cost scenarios, renewables will represent the leading low-carbon technologies in future power systems. In order to accommodate for their variability, nuclear reactors will need to operate more flexibility, which represents a consequent change for nuclear energy traditionally used as a "baseload" mean of generation. This calls for future

work regarding the economic viability of such nuclear power plants with reduced load factors, especially in the line of recents hybrid marked design developments.

References