GLOBAL OUTLOOK FOR THE NUCLEAR INDUSTRY: THE ROLE OF ADVANCED NUCLEAR TECHNOLOGIES IN THE ENERGY TRANSITION

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Overview

Past decades witnessed the development of energy sectors, renewables and low-carbon technologies becoming steadily prominent within national energy mixes at a worldwide scale. Transition towards such decarbonised mixes currently mainly revolves around political ambition, apposite policies and suitable partnerships in order to reach climate goals, such as set by the Paris agreement in 2015. Thus, being currently on the political agenda in many countries, the role of the nuclear industry needs to be adressed: what part can it play within these energy issues? Technologies such as Small Modular Reactors (SMRs), Generation IV reactors, nuclear fusion being heavily developed among both scientific and political spheres, are likely set to occupy a notable space, as well as representing a major shift in the nuclear sector. The increasing number of experimental projects and global scientific collaborations highlights the growing focus on advanced nuclear reactor designs: particular attention is being given to light-water, sodium, molten-salt based advanced modular reactors (AMRs, but also SMRs) and fast neutron reactors among many others. We seek to analyse late technologic trends, political and strategic schemes to shed light on the nuclear functions in the energy transition – in a global perspective – and associated questions such as materials or water needs using the TIAM model.

Methods

This study is firstly based on a state of the art of an updated representation of nuclear power particularly including advanced nuclear technologies ranging from fusion and SMRs to nuclear fuels and waste management (Liu et al. 2021). Major research projects are currently underway around the world to develop breakthrough innovations with technologies designed to be safer and reduce waste production.
Then, long-term scenarios for different regions (such as Europe, China and India, the United States of America) and, more generally, for the world as a whole, are analysed using TIAM-FR, a bottom-up model describing the world energy system in great detail of current and future technologies expressed by region and sector. TIAM-FR, of the ETSAP-TIMES family model, is a geographically integrated model, with 15 world regions, on the time horizon from 2018 to 2100. Sensitivity analysed are then carried out on the basis of distinct technical and economic parameters, such as cost, construction time and technology availability, performance, regulations, and waste management.

Results

In view of the objective of carbon neutrality, the study will discuss the potential role of the various nuclear technologies in the energy transition, taking particular account of issues relating to water availability and the materials footprint. A study of the prospects for the nucleay industry is being carried out, including not only electricity production, but also possible developments in the sector in terms of its orientations (heat, hydrogen) (IAEA, 2021; IAEA, 2021) and its costs, not forgetting social and environmental considerations.
Once completed this model development work, various scenarios are explored on different geographical and temporal scales. Firstly, a study of the decarbonisation of regional and then global energy mixes over the 2050-2070-2100 timeframe, in line with carbon neutrality objectives and international guidelines, could be carried out in order to discuss the potential role of nuclear power (Liu et al., 2023). An analysis of possible tensions over access to critical fuels and metals could also be a point for discussion, as could those relating to water resources.

Conclusions

This study highlights the specific regional technico-economic path of international advanced nuclear energy technology. It presents the current status and future trends in the development of nuclear industry, and points out their future evolution, and development roadmap, taking into account impact on materials and the environmental.

References

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