THE GEMINI+ SYSTEM for polygeneration of power, process heat and hydrogen

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GEMINI 4.0 is a project initiated by the Nuclear Cogeneration Industrial Initiative (NC2I), the last one of a series of Euratom funded projects dedicated to nuclear high temperature process heat supply to industry. Industrial heat needs represent indeed a new quite large market for nuclear energy of the same order of magnitude as the market of electricity generation. In a previous project, the design of a small Modular High Temperature Gas-cooled Reactor (HTGR), GEMINI+, for cogeneration of electricity and high temperature heat has been developed. Compared to other advanced modular reactors that could supply high temperature heat, being based on mature HTGR technology already developed in Europe, it has the merit to be ready for deployment and therefore to be able to provide an effective contribution to European 2050 net zero objective. On the other hand, the chosen configuration of the nuclear system allows addressing versatile heat and power needs of industry with the same standard design. In the present project, it has been shown that the GEMINI+ reactor is also suitable for competitive CO_2 free hydrogen production preferably through high temperature Solid Oxide Electrolysis with electricity and high temperature heat supplied by the reactor. Other processes, like the copper-chloride process, were assessed as longer-term options that may offer an economic advantage. Based on the work of previous projects, European TSOs continued their efforts in interaction with regulators to build a licensing approach for such a nuclear system, focusing in particular on new questions raised by the interaction of the coupled nuclear plant and industrial non-nuclear production facilities. In addition, the licensing acceptability of the safety demonstration based on the inherent safety design of the nuclear system has been addressed, as well as common issues for innovative SMR licensing. Safety studies resulted in improved reactor and core design. It provides enlarged margins to design and safety limits in operation and accident conditions. Finally, the project also analyses the conditions for establishing a TRISO fuel supply chain and a fuel cycle for the GEMINI+ reactor in Europe. In particular, it shows that the HTGR fuel cycle of the GEMINI+ system is flexible enough to allow the use of different fissile resources and to adapt to different fuel back-end strategies, from direct disposal to recycling. Achieved results of the project allow beginning works on commercial design and deployment for industrial application.

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