

THE HORIZON-EURATOM ESFR-SIMPLE PROJECT: MID-TERM ACHIEVEMENTS

P. Sciora^{1*}, V. Dupont¹, J.J. Gil Quijano², E. Fridman³, S. Eckert³, B. Farges⁴, K. Mikityuk⁵, E. Bubelis⁶, A. Rineiski⁶, X. Gaus-Liu⁶, A. Dubey⁷

¹CEA, DES, IRESNE, DER, Cadarache, 13108 Saint Paul Les Durance, France

²CEA, DRT, CEATECH, Cadarache, 13108 Saint Paul Les Durance, France

³Helmholtz-Zentrum Dresden-Rossendorf (HZDR), Dresden, Germany

⁴FRAMATOME, Courbevoie, France

⁵Paul Scherrer Institut (PSI), Villigen PSI, Switzerland

⁶Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany

⁷University of Cambridge (UCAM), Cambridge, United Kingdom

* Corresponding author email: P. Sciora*: pierre.sciora@cea.fr ; J.J. Gil Quijano : Jesus-Javier.GILQUIJANO@cea.fr ; E. Fridman e.fridman@hzdr.de ; S. Eckert s.eckert@hzdr.de ; B. Farges benjamin.farges@framtome.com ; K. Mikityuk konstantin.mikityuk@psi.ch ; E. Bubelis evaldas.bubelis@kit.edu ; A. Rineiski andrei.rineiski@kit.edu ; X. Gaus-Liu xiaoyang.gaus-liu@kit.edu ; V. Dupont Vincent Vincent.DUPONT@cea.fr ; A. Dubey ad2221@cam.ac.uk

Following several previous European projects on sodium-cooled fast reactors, the ESFR-SIMPLE project was launched in 2022 and is scheduled to run until October 2026. Its main objectives, in line with the HORIZON-EURATOM call on “Safety of advanced and innovative nuclear designs and fuels”, are to reassess the Generation IV ESFR (European Sodium Fast Reactor) design proposed in the previous ESFR-SMART project. After two and a half years of work, several achievements can be highlighted.

Starting from the large power ESFR design, a preliminary downscaled system has been proposed to meet the key constraints for factory production and transportation. Subsequently, a core optimisation has been carried out, leading to a complete system design that fits the required core power and vessel size constraints. The first 360 MWth version has been developed and novel solutions are proposed to maximise the power while minimizing the impact on the vessel.

Safety assessments on this reactor have started, focusing on accident prevention and mitigation. Concurrently, an alternative system design is being explored to enhance flexibility for electrical grid load-following. In parallel, the secondary loops are being optimized to reduce costs and improve safety. The installation of sodium expansion bellows is being studied to shorten pipe length by eliminating most of the elbows: this work is being carried out both analytically and experimentally.

Meanwhile, the steam generators are being replaced by compact designs instead of the very large modular ones previously envisaged. The pumps, dedicated to the decay heat removal system, installed in the secondary circuit, are optimised: a new design is being proposed and tested, before being incorporated into the overall system design.

To further increase the core safety, specific tests are being carried out on the behaviour of the core catcher, on the impact of corium jet impingements, and on low-porosity fuel pellets. The initial results are already available and are being analysed.

Finally, the work on safety includes the detection of sodium bubbles: tests are ongoing with newly developed sensors feed AI; parallel modelling is also in progress. Regarding social acceptance, a public survey is underway in two different countries - France and the United Kingdom - to gauge public expectations.

159_abstract