



IAEA

International Atomic Energy Agency

Atoms for Peace and Development

Workshop on Core and Plant Simulation with an Emphasis on Fuel Behaviour in Light Water Reactor Based Small Modular Reactors

IAEA Headquarters, Vienna, Austria
and virtual participation via Cisco Webex
27 February – 29 February 2024

Background

To meet the growing demand for energy and to mitigate global climate challenge, the use of Small Modular Reactors (SMRs) has raised an increasing interest in Member States, especially for regions inaccessible to large electricity grids or requiring technology options deployed incrementally. SMRs are also viable options for users that need more than just a supply of electricity, e.g., district heating, desalination, industrial process heat, as well as hydrogen.

SMR development is a topic of high interest in MSs' nuclear R&D activities, and significant progress has been made in many countries, including in innovative fuel design for SMRs. R&D is underway on UO₂ fuels and ATFs for light-water-cooled SMRs (e.g., CAREM, SMART, BWRX-300, NuScale, NUWARD™, Rolls-Royce SMR, SMR-160, LUTHER, LDR-50, and mPower). However, the new small core design, the integral concept, the innovative heat exchangers, and passive heat removal systems as well as the novel containment designs represent new challenges for the safety demonstration in the frame of licensing processes. The design peculiarities of SMR-cores, along with the potential use of enhanced accident tolerant fuel materials, are challenging the prediction capability and accuracy of currently used analysis tools.

The IAEA Technical Working Group on Fuel Performance and Technology (TWG-FPT) during its 21st meeting, in April 2023, recommended to organize a Workshop on LWR SMR fuel behaviour simulation, jointly with the Euratom project McSAFER, to compare the results of SMR fuel behaviour simulation using common analysis tools, taking advantage of the fact that the McSAFER project is ending and its results already available.

The aim of the Euratom Horizon 2020's project McSAFER (High-Performance Advanced Methods and Experimental Investigations for the Safety Evaluation of Generic Small Modular Reactors) was to advance the safety research for water-cooled SMRs, with:

- a) Key experiments relevant to SMR safety (e.g., heat transfer, boiling, critical heat flux (CHF) and cross-flow in the core, system behaviour under natural and forced convection, and heat transfer and pressure drop in helical heat exchangers) performed at EU facilities (e.g., COSMOS-H, MOTEL and HWAT);
- b) The development, improvement, and validation of simulation tools (thermal-hydraulics codes, neutronics codes and fuel performance codes) for safety evaluations of SMRs; and
- c) The application of simulation tools to four SMR designs (i.e., NUWARD™, CAREM, NuScale and SMART).

The IAEA is therefore organizing a joint workshop with the EU McSAFER Project and the support of the US Oak-Ridge National Laboratory (ORNL), to foster the exchange of information on approaches, challenges and specific experiences related to multi-physics and multi-scale simulations of SMR-cores.

Objectives

The purpose of the event is to bring together experts in the field of fuel behaviour simulation, to foster the exchange of information on multi-physics and multi-scale simulations of SMR-cores (loaded with ATF fuels or without) and integral plant behaviour, using different computation approaches, to compare results of SMR fuel behaviour simulation and to perform common analyses.

Target Audience

The event is intended for participants from research organizations, nuclear fuel design organizations, nuclear power plants and regulatory bodies, technical support organizations, universities, and other organizations engaged in fuel behaviour simulation of SMR-cores, and in SMR nuclear fuel design, as appropriate.

Expected Outputs

The event will provide the basis for an IAEA publication on multi-physics core and fuel behaviour simulation in Light Water Reactor Based Small Modular Reactors.

Structure and topics

The programme will mainly consist of sessions dedicated to invited oral talks and discussions. A Programme Committee made up of international representatives will be responsible for selecting the invited oral presentations and for arranging the technical and discussion sessions,

as well as their scientific content. The topical area of focus will be the current situation in MSs in multi-physics and multi-scale simulations of the SMR-cores (loaded with ATF-fuels or without) and integral plant behaviour using different computational approaches.

This event will comprise 4 main technical sessions as follows:

- Multi-physics analysis of SMR-cores with different simulation approaches (includes neutronic and thermal hydraulics) applied to cores loaded **with ATFs** or without (**e.g., nodal and pin level solutions**)
 - o Traditional approach
 - o Industrial approach
 - o Emerging approaches (e.g., neutron diffusion solvers coupled with subchannel solvers for nodal level core analysis, Monte Carlo codes coupled with subchannel codes for pin/subchannel level simulations).
- Multi-physics analysis of SMR-cores with different simulation approaches (includes neutronic and thermal hydraulics and **thermo-mechanics**) applied to cores loaded **with ATFs** or without:
 - o Traditional approach
 - o Industrial approach
 - o Emerging approaches (e.g., neutron diffusion solvers coupled with subchannel and thermo-mechanic solvers for nodal level core analysis, Monte Carlo codes coupled with subchannel codes and thermo-mechanic solvers for pin/subchannel level simulations).
- Transient analysis of water-cooled SMRs with different computational approaches:
 - o Traditional approach using 1D thermal hydraulics and 3D nodal diffusion core solvers
 - o Industrial approaches
 - o Emerging approaches (e.g., multiscale coupling of thermal hydraulic system codes coupled with subchannel codes and 3d nodal diffusion, and thermal hydraulic system codes coupled with CFD codes and 3D nodal diffusion).
- National and International Programms on Fuel Behaviour in Light Water Reactor Based Small Modular Reactors.

Programme Committee

The International Programme Advisory Committee is composed of the following members:

V.H. Sanchez-Espinoza, (Chair)	Germany, KIT, Coordinator McSAFER
S. Kliem	Germany, HZDR, McSAFER
C. Queral	Spain, UPM, McSAFER
P. Van Uffelen	Germany, European Commission (DG JRC), McSAFER
M. Bencik,	Czech Republic, UJV, McSAFER

H. Suikkanen	Finland, LUT, McSAFER
A. Iorizzo	Belgium, European Commission (DG RTD) Project Officer for McSAFER
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