



INTERNATIONAL ATOMIC ENERGY AGENCY
ASIAN NUCLEAR SAFETY NETWORK (ANSN)

MEETING REPORT

Training Course on Safety Aspects of Small Modular
Reactors and Other Innovative Reactor Technologies

Hosted by the
Government of Japan

through the
Fukui Int'l Human Resources Development Center for Atomic Energy,
The Wakasa Wan Energy Research Center

Fukui, Japan

04 – 08 November 2024

Ref. No.: EVT2402354

Introduction

The training course on the “Safety Aspects of Small Modular Reactors and Other Innovative Reactor Technologies” was hosted by Government of Japan through Fukui International Human Resources Development Center for Atomic Energy (FIHRDC) and The Wakasa Wan Energy Research Center (WERC) during the period from 04 to 08 November 2024.

To meet the growing demand for energy and to mitigate global climate change challenges, the interest in advanced reactor technologies, including Small Modular Reactors (SMRs), for electric and non-electric applications is growing.

While advances in technologies continue to evolve worldwide, new opportunities and challenges emerge, necessitating enhanced cooperation and timely efforts to provide Member States with adequate guidance on the implementation of the Agency’s safety standards and their applicability to different advanced reactor technologies.

Recognizing this need, the IAEA has developed this training course as part of a series of capacity-building activities dedicated to enhancing the competence levels of personnel in Member States concerning the requirements and recommendations of the Agency safety standards and their applicability to advanced reactor technologies. This training course also aims to raise awareness of the key safety characteristics associated with different types of advanced reactor technologies.

The purpose of the event was to train participants in key safety aspects of small modular reactors (SMRs) and other innovative reactor technology types, namely water cooled SMRs, high temperature gas cooled reactors, sodium cooled fast reactors, lead cooled fast reactors and molten salt reactors.

This event helped enhance the participants’ understanding of the IAEA’s programme on advanced reactor technologies, including SMRs; as well as increase their knowledge, and awareness of the key aspects related to the safety of the five different advanced reactor technology types. The event also provided a forum for exchanging experiences with peers and experts and advanced participants’ knowledge.

The topics under the scope of the training course included 1) Introduction to the IAEA Organisational Framework and IAEA Safety Standards, 2) Overview of the Specific Safety Requirements on Nuclear Power Plant: Design, No. SSR-2/1, Rev. 1, 3) Overview of the General Safety Requirements on Safety Assessment for Facilities and Activities, No. GSR Part 4, Rev. 1, 4) Overview of the Specific Safety Guide on Format and Contents of Safety Analysis Report, No. SSG-61, 5) Water Cooled SMRs - Technology Aspects and Safety Considerations, 6) High Temperature Gas Cooled Reactors - Technology Aspects and Safety Considerations, 7) Sodium Cooled Fast Reactors - Technology Aspects and Safety Considerations, 8) Lead Cooled Fast Reactors - Technology Aspects and Safety Considerations, and 9) Molten Salt Reactors - Technology Aspects and Safety Considerations. The agenda of the training course is provided as Annex 1 of this report.

Work done

The training course was attended by 29 participants from 18 Member States of the IAEA and the Asia Nuclear Safety Network (Australia, Bangladesh, China, Indonesia, Kazakhstan, Korea, Malaysia, Philippines, Thailand and Viet Nam). Most participants were from either from the utilities or the regulatory bodies, while some participants were from ministries or nuclear training institutes.

The training course was opened with introductory remarks by Mr Hiroshi Sakuramoto, Chairman of the Wakasa Wan Energy Research Center, who represented the host and welcomed participants to the training course. In the brief opening session, Ms Ana Gomez Cobo (Section Head Safety Assessment Section) welcomed the participants and made a presentation on the IAEA organisational structure and introduction to the IAEA Safety Standards as well as the objectives of the training course. Mr Waseem Bukhari (SAS, NSNI, IAEA) presented the training course agenda and expected results. The full list of participants is provided as Annex 2 of this report.

The IAEA presentations included:

- IAEA efforts to support MS on Design Safety and Safety Assessment of SMRs – Introduction (IAEA Staff);
- IAEA Specific Safety Requirements on the Safety of Nuclear Power Plant: Design, No. SSR-2/1, Rev. 1 (IAEA Staff);
- IAEA General Safety Requirements on the Safety Assessment for Facilities and Activities, No. GSR Part 4, Rev. 1 (IAEA Staff);
- Specific Safety Guide on Format and Content of the Safety Analysis Report, No. SSG-61 (IAEA Staff); and
- IAEA efforts to support MS on Design Safety and Safety Assessment of SMRs – Work Programme (IAEA Staff);

The presentations of the experts were focused on the technology aspects and safety considerations for five different types of reactors including water cooled SMRs, high temperature gas cooled reactors, sodium cooled fast reactors, lead cooled fast reactors and molten salt reactors.

A tour of the Tsuruga training center was provided by the host (WERC) to the training course participants, where they observed the full scope training simulator of Tsuruga Nuclear Power Plant Unit 2 and the training facilities for the electrical, mechanical and I&C operator and maintenance personnel.

Working group sessions were also organized during the training course, where the experts provided few questions related to each reactor technology. The participants were divided into five groups to work on the questions provided by the experts and prepare short presentations including their answers and the relevant justifications. From each working group, one member of the group presented their answers, and the experts provided their feedback on the participants' work.

Working group sessions

The agenda of the training course included four working group sessions, where participants were expected to demonstrate their understanding of the technology and safety aspects of the innovative reactor technologies. For the working group sessions, the participants were divided into five working groups of 5 or 6 participants each to work together on the question provided by the experts. The experts provided following questions for each of the reactor types:

1. Water Cooled SMRs
 - i. Name the three main types of WC-SMRs.
 - ii. Name three differences between iPWRs and existing large LWRs that introduce challenges for designers, operators, and regulators.
 - iii. Name three physical barriers relied on by iPWRs for defence-in-depth.
 - iv. Name three typical postulated initiating events for LWRs
2. High Temperature Gas Cooled Reactors
 - i. Please mention at least 2 advantages and 2 disadvantages of the Gas Cooled Reactor Technology?
 - ii. What are the main neutronic feedback of Gas Cooled Reactor? And what's the value (order of magnitude) of the related reactivity coefficients?
 - iii. During a Depressurized Loss of Forced Cooling in a Gas Cooled Reactor, how the residual heat is removed from the core?
3. Liquid Metal (Sodium) Cooled Fast Reactors
 - i. Quote three SFR design features that mitigate the consequences of core meltdown accident.
 - ii. Is it possible to operate the decay heat removal (DHR) circuits in natural convection mode right after a station blackout (SBO)?
4. Liquid Metal (Lead) Cooled Fast Reactors
 - i. To which level of defence in depth can the protection of key structures against lead corrosion be associated?
 - ii. Name the three inherent features typically advocated by LFR designers as ultimate safety measures for the three main safety functions (as per IAEA's SSR-2/1 Rev. 1).
 - iii. Indicate the main safety challenges for an LFR in an ULOF and in an UTOP.
5. Molten Salt Reactors
 - i. What are the main safety-relevant phenomena unique to liquid-fueled molten salt reactors (MSRs)?
 - ii. What challenges to the fulfilment of fundamental safety functions (FSFs) do they represent?
 - iii. What are some design choices that can be implemented to fulfil fundamental safety functions (FSFs)?

Main conclusions and recommendations

The training course achieved all stated objectives of training the participants in key safety aspects of small modular reactors (SMRs) and other innovative reactor technology types and enhanced the participants' understanding of the IAEA's programme on advanced reactor technologies, including SMRs; as well as increased their knowledge, and awareness of the key aspects related to the safety of the five different advanced reactor technology types. The event also provided a forum for exchanging experiences with peers and experts and advanced participants' knowledge.

Based on the presentations provided by the IAEA staff members, the presentations of the experts and the results of the working group activities and the discussions, following are the conclusion and recommendations of the training course:

- i. The training course was successful in achieving its stated objectives.
- ii. For the presentations on IAEA safety standards, it was proposed that the presentations should be more focused on explaining the key safety concepts like application of defence in depth, practical elimination, design basis accident, and design extension conditions etc.
- iii. For the experts' presentations, it was suggested that while presenting Member States concepts which are different from the concepts in the IAEA Safety Standards, the link with relevant concepts from the IAEA Safety Standards should be included to provide a better overview to the participants.
- iv. Some of the participants provided feedback that as the training course covered a wide range of topics in a short time, the duration of the training course should be increased to two weeks, so that more discussion could be held on technological aspects and safety considerations of these innovative reactor technologies.
- v. It was suggested by some participants that experts from regulatory bodies may be involved in future courses to have more elaborate discussion on the regulatory aspects like licensing process, regulatory review and inspects etc.

Annex 1

IAEA Training Course on Safety Aspects of SMRs and other Innovative Reactor Technologies

Hosted by the Govt. of Japan through Fukui Int'l Human Resources Development Center for Atomic Energy,
The Wakasa wan Energy Research Center (WERC), Fukui Japan, 4-8 November 2024

Agenda

Time	Monday 04 Nov.	Tuesday 05 Nov.	Wednesday 06 Nov.	Thursday 07 Nov.	Friday 08 Nov.
09:00 - 10:30	9:15 Start – Opening Ceremony: IAEA & Fukui Welcome Session, Self-Introduction, Group Photo Training Course Agenda (5 min) WASEEM Bukhari (IAEA) Introductory Presentation Ana Gomez COBO (IAEA)	08:30-09:30 – TSURUGA Training Center Tour (stay there for the day) 09:30-10:30 – Water Cooled SMRs: Technology Aspects and Safety Considerations	High Temperature Gas Cooled Reactors: Technology Aspects	Liquid Metal Cooled Fast Reactors - SFRs: Safety Consideration (Online)	Molten Salt Reactors: Safety considerations and Wrap Up Work Group Assignment
10:30 - 11:00	Coffee Break	Coffee Break	Coffee Break	Coffee Break	Coffee Break
11:00 - 12:30	Overview of the IAEA Safety Standards SSR-2/1 (30 min) WASEEM Bukhari (IAEA) Overview of the IAEA Safety Standard GSR Part 4 (30 min) WASEEM Bukhari (IAEA) Overview of IAEA Safety Standard SSG-61 (30 min) Ana Gomez COBO (IAEA)	Water Cooled SMRs: Technology Aspects and Safety Considerations	High Temperature Gas Cooled Reactors: Safety Considerations	Liquid Metal Cooled Fast Reactors - LFRs: Safety Considerations (Online)	11:30-11:45 - Overview of IAEA Activities on SMRs (Ana) 11:45-12:00 – Closing Ceremony
12:30 - 13:30	Lunch	Lunch	Lunch	Lunch	Adjourn (12:00)

Time	Monday 04 Nov.	Tuesday 05 Nov.	Wednesday 06 Nov.	Thursday 07 Nov.	Friday 08 Nov.
13:30 - 15:00	Water Cooled SMRs: Technology Aspects and Safety Considerations	Water Cooled SMRs: Wrap Up Work Group Assignment	High Temperature Gas Cooled Reactors: Wrap Up Work Group Assignments	Liquid Metal Cooled Fast Reactors - SFRs and LFRs: Wrap Up (Online) Work Group Assignment	
15:00 - 15:30	Coffee Break	Coffee Break	Coffee Break	Coffee Break	
15:30 - 17:00	15:30-16:30 – Water Cooled SMRs: Technology Aspects and Safety Considerations 16:30-17:00 - Working Groups Arrangements for the Week	16:00-17:00 – High Temperature Gas Cooled Reactors: Technology Aspects	Liquid Metal Cooled Fast Reactors - SFRs and LFRs: Technology Aspects (Online)	Molten Salt Reactors: Technology Considerations	
18:30 - 19:30	Welcome Reception				

Annex 2. List of Participants

No.	Last Name	First Name	Organization	E-mail
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