IAEA
International Atomic Energy Agency
Atoms for Peace and Development

IAEA Support to Advanced Reactors Development and Deployment

Aline des Cloizeaux
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Short bio – A. des Cloizeaux

- Since 2022 Director, Division of Nuclear Power, in the Department of Nuclear Energy of the International Atomic Energy Agency.
- Before joining the Agency, I worked as Director, Civil Nuclear and Equipment Business Line at Naval Group, as Program Director at Framatome, and for Large Investment Projects SVP at Orano, and held various positions at Areva and Cegelec, in Paris, France.
- Vice-President of Women in Nuclear IAEA, after being President of WiN France
- Holding two Master's degrees and MBA

Advanced reactors & fusion

IAEA

- Innovation
- Non-electric applications
- Fast reactors
- SMRs & MRs

Nuclear Fusion

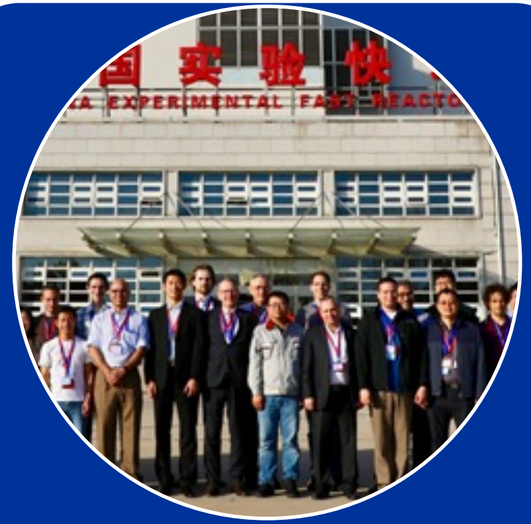
Main IAEA Activities on Advanced Reactor Technology

Knowledge Sharing

Publications

Conferences

Technical Meetings



Technology Development

Coordinated Research Projects (CRPs)

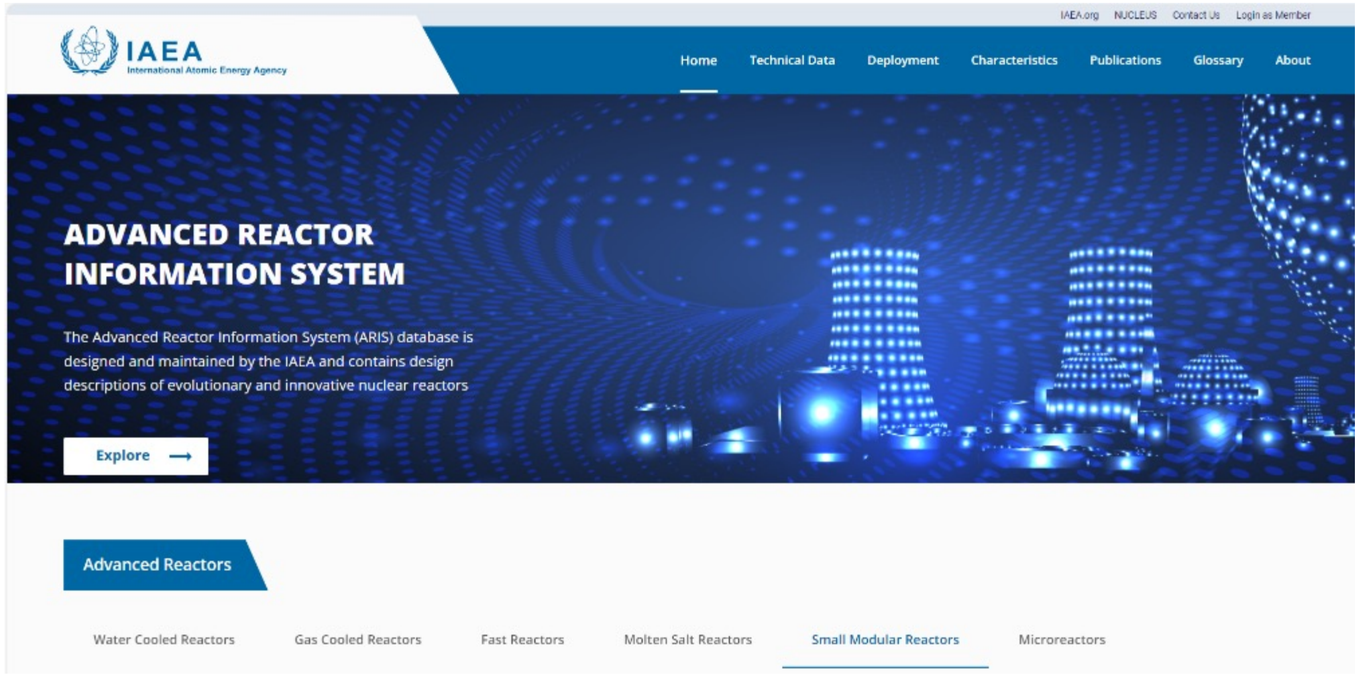
Capacity Building

Training Courses

Workshops

TECDOCs (Documents)

IAEA Advanced Reactors Information System (ARIS)

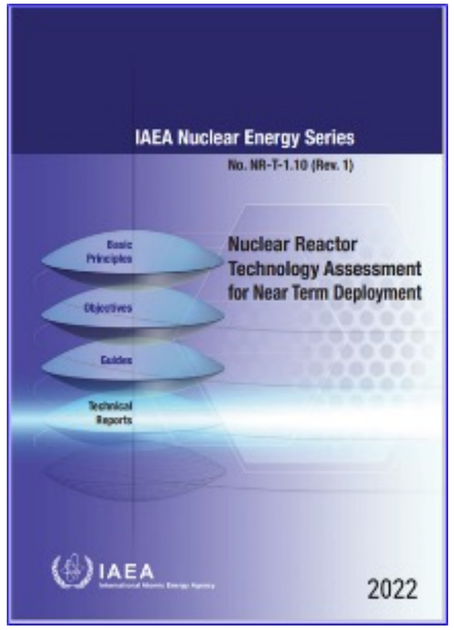


- New User Interface
- Display Contents
  - More Organized Way
  - More Filters
- Comparison of Several Designs
- Dynamic Graphs/Maps for Plant Sites
- Dashboard for Vendor and Admins
- New Reporting System

IAEA Reactor Technology Assessment: Methodology and Tools

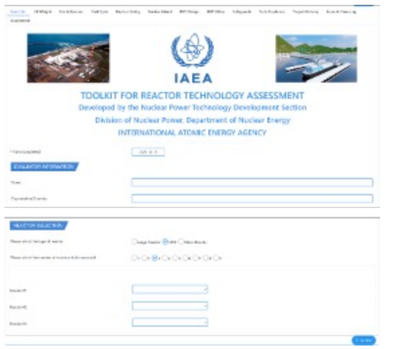
- **Design selection process for the most suitable reactor technology** to meet the objectives of a Member State's nuclear power programme
- User defines its own **degree of importance** among different Key Elements of the decision
- **Self assessment tool** revised in 2022 after 10 years of practice by MSs
- RTA in Practice- General Conference Side event, organized by the SMR Platform, on sharing the applicability of the RTA to SMRs and Ghana's experience of use

Methodology Publication



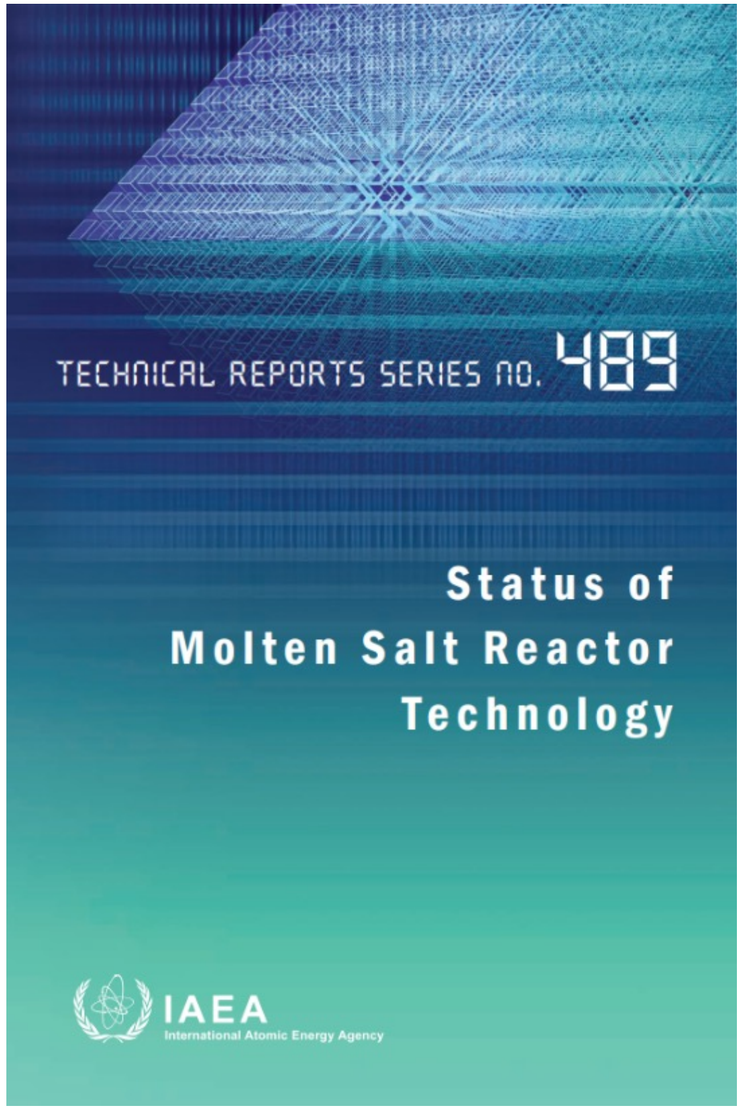
eLearning Module

IT-Toolkit



Keystone publication on MSR Technology

EXAMPLE OF PUBLICATION



- Published November 2023 - Status of Molten Salt Reactor Technology | IAEA
- The aim of this publication is to share information on programmes and projects on molten salt reactors in Member States which will shape future collaborative efforts.

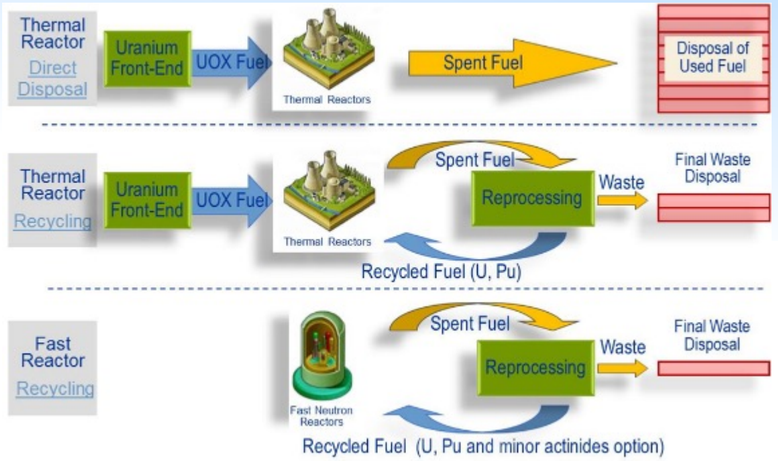
IAEA and Innovative Nuclear Power Technologies

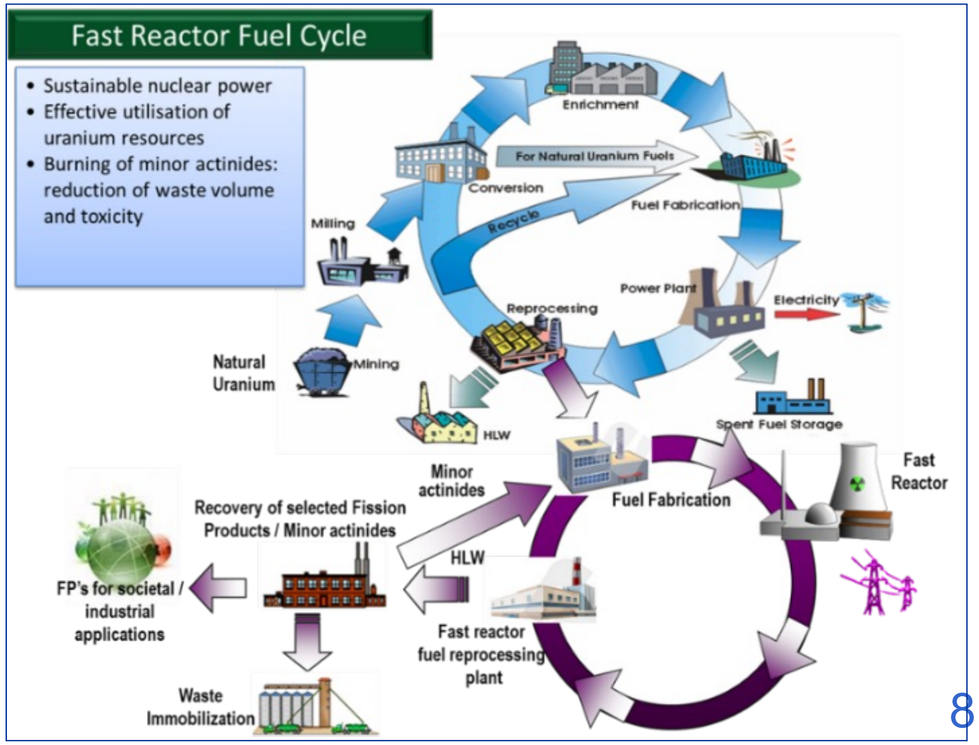
In parallel with technical activities in area of Advanced / Innovative Nuclear Reactors:

- **Activities on Advanced Fuel Cycles** – technical advances and innovations
- **INPRO** (International Project on Innovative reactors and Fuel Cycles) Project – strategic studies, international, regional and national scenarios, role of innovations

Some INPRO studies or services:

- Cooperative approaches to Back End of fuel cycle
- NESA (Nuclear Energy System Assessment) Wastes from Innovative Types of Reactors and Fuel Cycles
- Scenarios to Support Multi-recycling of Fuel in a Nuclear Energy System – STEP FORWARD
- H2 study (on-going)
- Collaborative Project on Fossil Fuel – to – Nuclear Power Plants (on-going)





SMR Platform

- Continuous support to MSs: Expert Missions, Interregional Workshops, Training Courses, Technical and Consultancy meetings.
- **SMR Portal (https://smr.iaea.org)** provides latest news, IAEA events, and publications on SMRs
- Successfully organized the IAEA's first Symposium on Floating Nuclear Power Plants (FNPPs)

SMR Platform Annual Report for 2023 Published on the Portal.

Report highlights key collaborative efforts, major activities on SMRs, and outlines the progress on the NHSI through 2023

FNPP Symposium - Outcomes

- Attended by 168 participants from 44 MSs and four International Organizations.
- Key players in FNPP development and deployment both speaking and in attendance:
  - Industry: nuclear (developers and vendors) and maritime (ship builders)
  - Regulators: nuclear and maritime (national and international)
  - Ship classification societies
  - Legal experts

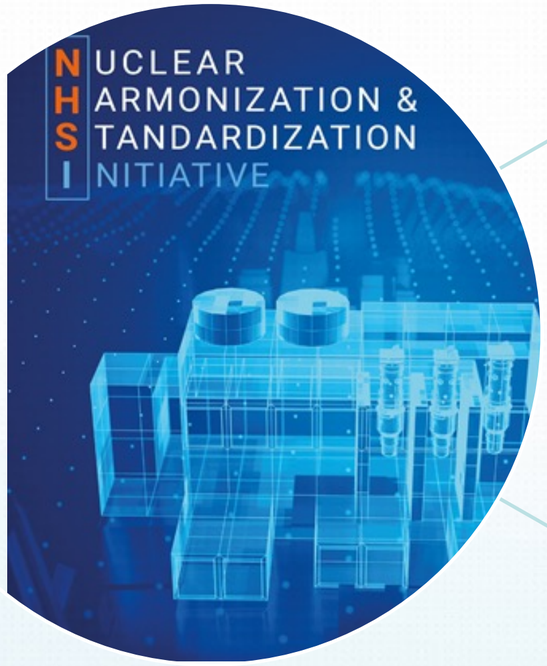
- **Improved awareness** about who the main players are, their limitations and the importance of more coordination and awareness building.
- **Recognition that action is needed** soon to bring the main players together under some form of coordination/cooperation platform.

The main areas for future work:

Industry cooperation: need for nuclear and maritime (incl shipbuilding) industries to work together
Regulatory cooperation: IAEA, IMO, national nuclear and maritime regulators, ship classification societies need to work together
Industry/regulatory coordination: regulators need early engagement from vendors
Safety, Security and Safeguards (3S): some unique challenges for FNPPs

NHSI initiative 2022-24

Effective Global Deployment of **Safe and Secure** Advanced Nuclear Reactors



Harmonization of Regulatory Approaches Track

- WG1: Framework for information exchange
- WG2: Multilateral pre-licensing regulatory reviews
- WG3: Leveraging other regulatory reviews AND working together

IAEA as facilitator
within and between the tracks

Standardization of Industrial Approaches Track

- TG1: Harmonization of high-level user requirements
- TG2: Common approaches to Codes & Standards
- TG3: Experiments and simulation codes validation
- TG4: Acceleration of nuclear infrastructure implementation for SMR

- Regulators
- Governments
- Technology Holders
- Operators and other end-users
- International Organisations and Associations

NHSI past 2024– Ideas for the Regulatory Track

1. Implementation of pilot review projects

Multinational pre-licensing regulatory reviews of specific SMR design, upon vendor request, for interested regulators (closed review service)

Support to leveraging of reviews

Small scope reviews of targeted technical topics could be launched

2A. Capturing experiences from pilots

Capturing feedback on cooperations, supplier/importer countries and joint regulatory reviews: lessons learned, good practices, impediments

Restricted area on experience with regards to the oversight of SMR, particularly Long Lead Items (LLIs)

2. Virtual exchange of good practice for a standardized nuclear reactor deployment

(Integrating industry and regulatory efforts)

2B. Mapping regulatory commonalities and differences

- Capturing areas of commonality and differences in regulatory approaches based on pilot projects and past cooperations
- Potential pilot compare regulatory frameworks if sufficient countries interested
- Sets up a strategy for work on harmonization

3. Practical guidelines on key aspects of implementation of NHSI RT framework

In collaboration with SMR RF

Approaches for dealing with areas of regulatory differences

Practical guidelines for leveraging reviews

Support to building embarking countries regulatory competences using leveraging approaches

4. SMR Toolkit for Embarking Countries

Key information on completed regulatory reviews of SMR designs

In collaboration with RCF

5. Task Force on international collaboration on security of advanced reactors

Advancing harmonization of security regulatory approaches

Led by IAEA NSNS

NHSI past 2024– Ideas for the Industry Track

Topic 1 – Harmonization of High-level User Requirements

Develop Generic User Requirements for HTGRs and then other near deployment non-WCR

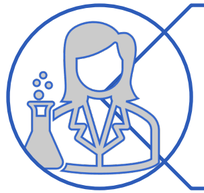
Topic 2 – Common Approaches to Codes and Standards

Continue to enhance platform on common approaches to C&S (eg non-nuclear codes and standards) that can impact SMR Designs

--In cooperation with the SMR Regulators Forum MCCO WG --

1.Develop a product on how to engage regulators when utilizing serially produced items for safety functions

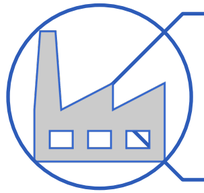
2. Develop a product on the serial manufacturing, and approval process, for long-lead, high integrity items



Topic 3 – Experimental Testing and Validation for Design and Safety Analysis Computer Codes

First NEXSHARE Workshop (18-21 June 2024):

Continue to enhance NEXSHARE database and implement activities based on member and participating TSOs recommendations



Topic 4 - Accelerating the implementation of nuclear infrastructure for SMRs

Integrate NHSI Community into efforts that shape infrastructure programs, collect lessons learned from industry & Member States to support the Regulatory Track's efforts and, potentially, a future revision of the Milestones Approach

Beyond

1. As interface with nuclear security, integrate recent work on advanced operations (e.g. remote operations) to facilitate collecting additional industry feedback, harmonizing user requirements.

2. A new project on how to pivot the NPP "project licensing" to "product licensing", e.g., to prepare for the deployment for microreactors .

Vision

Let's make nuclear simpler

Near Term Goal(s)

1) Reduce timelines and costs to both vendor and customer, and facilitate common approaches for regulatory approvals (eg component level)

2) Gather lessons learned from SMR deployment models

Long Term Goal

Prepare industry, end-users and MSs for large-scale SMRs deployment

Continuous Engagement

Strong and consistent interface mechanism with industry

NHSI next Plenary and the 2024 International Conference on SMRs

NHSI Plenary to be held on 21 October 2024 morning (tentatively 9.30-13.00), prior to the SMR conference opening (planned at 14.00)

Prospective Plenaries:

1) Discussion with Industry CEO's
2) SMR Regulatory Collaboration
3) **Non-water cooled and Gen-IV SMRs**
4) Human Resource Development Perspectives for SMR Deployment
5) Innovative Industrial Involvement for SMRs: from concept to manufacturing

Evening Events:

- Industry Night - Give the opportunity to all SMR developers present at the SMR Conference to present their concept in an informal manner to the interested audience

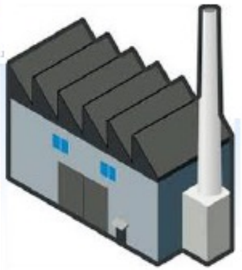
- Young Generation Event – led by the International Youth Nuclear Congress (IYNC), the focus will be in inter-generational discussions and role of nuclear to address climate change

Exhibition proposals still open

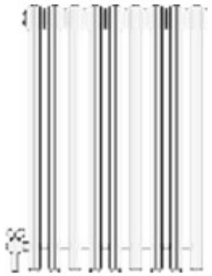
Reactor Technologies for Non-electric Applications

Image courtesy of KAERI and K.A.CARE

Electricity Generation



Process Heat



H_2

Desalinated Water

Integrated with Renewables

Replace Aging Fossil Plants

Hydrogen Production

Image courtesy of www.energypost.eu

A viable option to contribute to Climate Change Mitigation

Non-Electrical Applications – IAEA Projects going forward

- **New <u>CRP</u>** (2022-2025) - Role of Nuclear Cogeneration for Sustainable Development, entering 2nd year with 11 participants from 11 countries.
- Completed CRP - Assessing Technical and Economic Aspects of Nuclear Hydrogen Production for Near-Term Deployment (2018-2022)

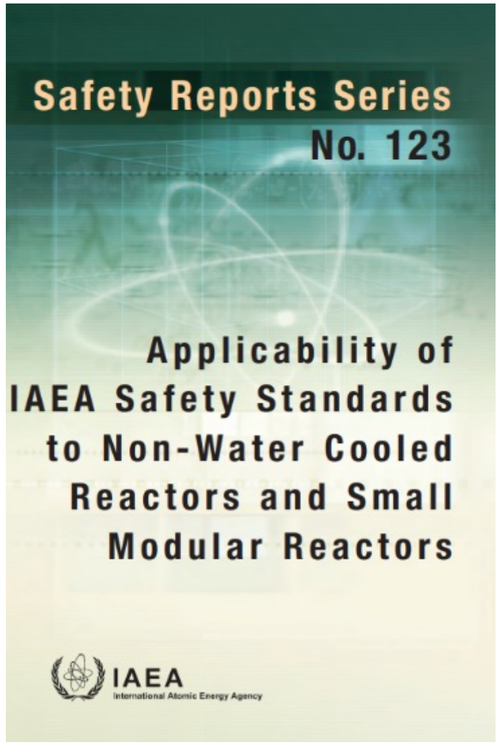
- **Incorporate heat models in <u>FRAMES</u>** - To support modelling of large systems with heat demand (district heating, desalination, H_2 production with/without heat, direct heat for industry etc.)

- **<u>Hydrogen</u>**
  - **Roadmap for deployment of nuclear H2** (finalizing publication)
  - **(NEW) Updating NES: Hydrogen Production Using Nuclear Energy,** with an emphasis on High Temperature Water Splitting Processes for nuclear hydrogen production.

- **<u>Cogeneration</u>**
  - **Safety & Regulation** for Coupling of Nuclear Cogeneration Facilities (TM planned for May, 2025).
  - Support Member States through **engagement with specific sectors** (e.g. oil/gas, steel, chemicals, cement etc).
  - **Technical Meeting on Recent Developments in Cogeneration Processes in Member States Meeting with oil/gas sector,** TM planned for 12-16, Nov 2024.

- **<u>Nuclear Desalination</u>**
  - **Support newcomers countries interested in nuclear desalination** (e.g. Jordan) with workshops, expert missions etc.
  - Update DEEP tool with newest correlations, and benchmarking against commercial desalination engineering software.
  - Collect & summarize advances in desalination technologies and uses for optimal coupling with nuclear plants, including SMR (emphasis on heat).
  - Advised by the TWG on Nuclear Desalination (next meeting scheduled for September 2024)

Review and Update of Safety Standards



Safety Reports Series No. 123

Applicability of IAEA Safety Standards to Non-Water Cooled Reactors and Small Modular Reactors

Published in December 2023

In view of the findings of the review, the IAEA is planning to enhance the applicability of safety standards to SMRs and non-water-cooled reactors as part of planned updates of safety standards:

- Capture practical examples of application of safety standards for specific technologies
- Develop a repository of technology specific knowledge

17

Review and Update of Safety Standards

Documents under development:

- Safety Guide DS537 Safety Demonstration of Innovative Technology in Power Reactors Designs
- TECDOCs
    - Analysis and Modelling of Severe Accidents for LMFRs: Report of a Technical Meeting
    - Considerations on the safety of Liquid Metal Cooled Fast Reactors
    - Considerations on the safety of High Temperature Gas Cooled Reactors
    - Considerations on the safety of Molten Salt Cooled Reactors
    - Safety Considerations in Non-Water-Cooled Reactor Core Design

Upcoming meetings:

- CM on **Safety Considerations in Non-Water-Cooled Reactor Core Design**, 10-13 June, 1-4 October 2024
- CM on **Considerations on the Safety of Molten Salt Cooled Reactors**, 8-12 July 2024, Vienna
- TM on **Severe Accident Analysis and Management for Non-Water-Cooled Reactors**, 14-17 Oct 2024, Vienna
- TM on **Advanced Manufacturing and Qualification Programmes for New Materials for Small Modular Reactors and Non-Water-Cooled Reactors: Safety Considerations**, 18-22 Nov 2024, Vienna
- **Joint IAEA-GIF Workshop on the Safety of NWCR**, May 2025

18

Thank You!

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Do you have any questions?