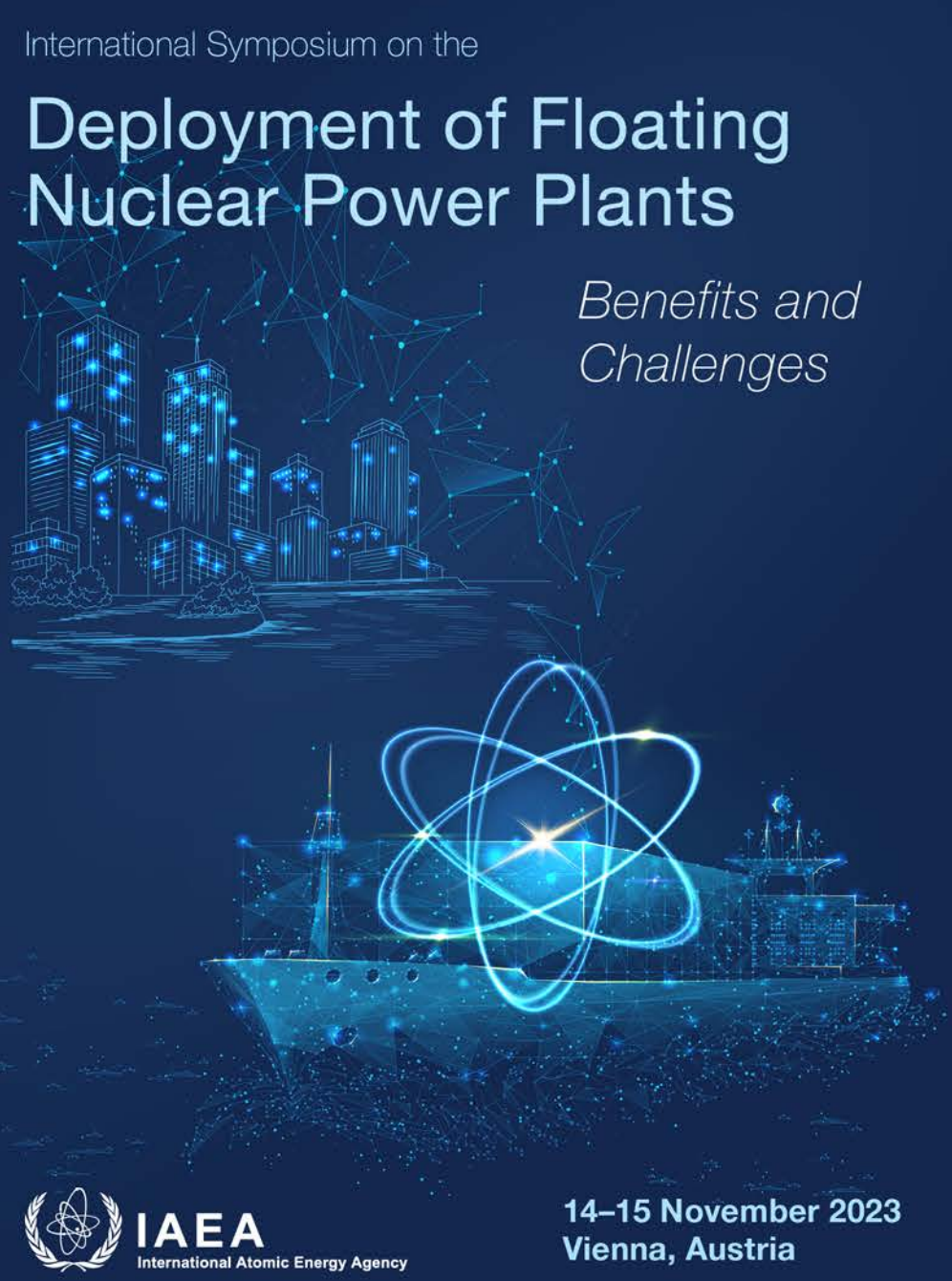
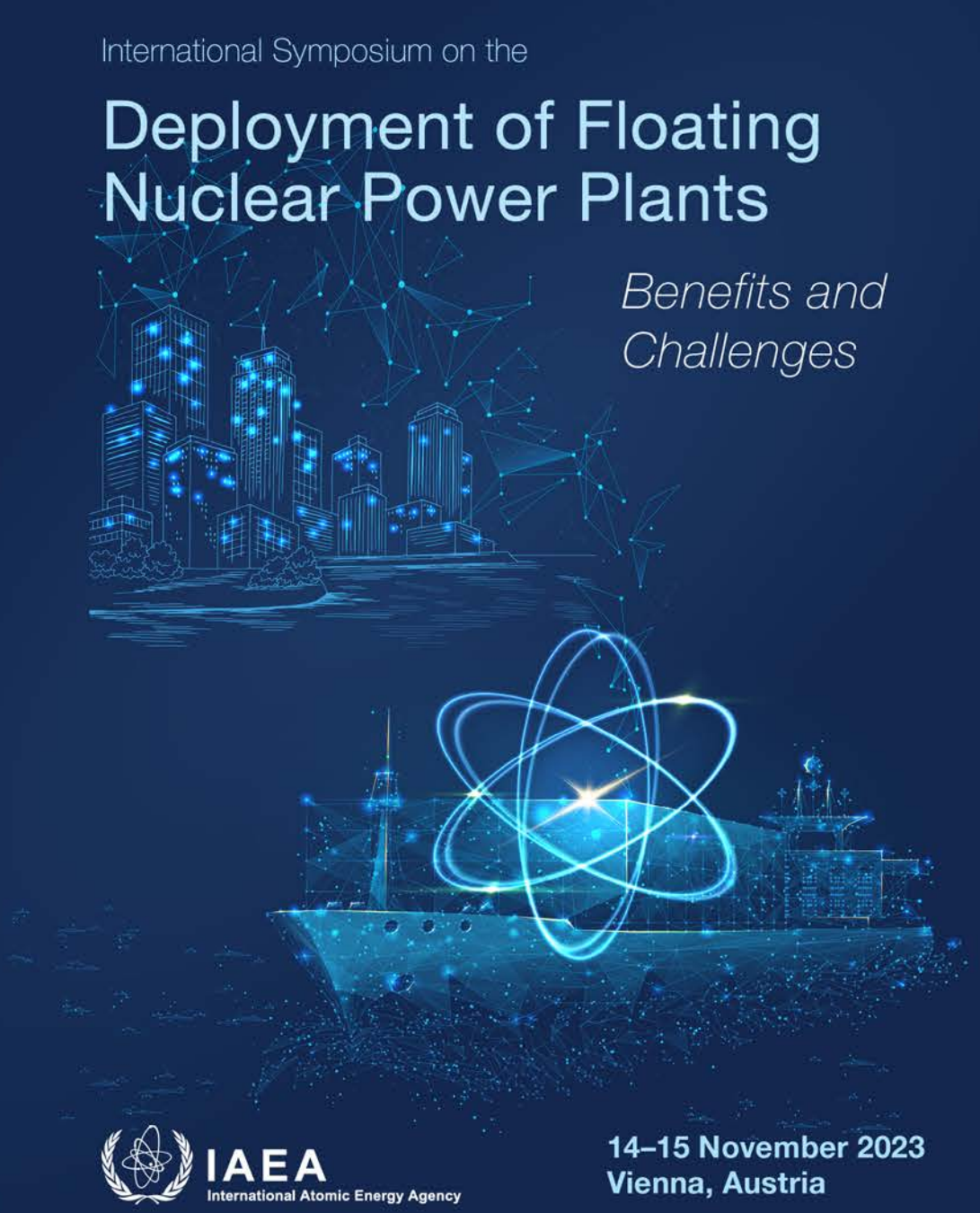
IAEA FLOATING NUCLEAR POWER PLANTS ACTIVITIES: HIGH-LEVEL OVERVIEW

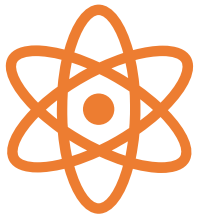


IAEA Department of Nuclear Energy

Activities supporting floating nuclear power plants



Department of Nuclear Energy (NE)



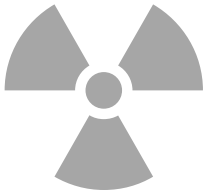
Division of Nuclear Power

Nuclear Power Engineering Section

Nuclear Power Technology Development Section

Nuclear Infrastructure Development Section

International Project on Innovative Nuclear Reactors and Fuel Cycles Section (INPRO)



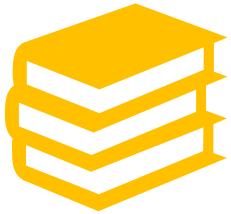
Division of Nuclear Fuel Cycle and Waste Technology

Nuclear Fuel Cycle and Materials Section

Research Reactor Section

Decommissioning and Environmental Remediation Section

Waste Technology Section



Division of Planning, Information and Knowledge Management

Planning and Economic Studies Section

Nuclear Information Section

Nuclear Knowledge Management Section

Key FNPP Related Activities

INPRO Studies

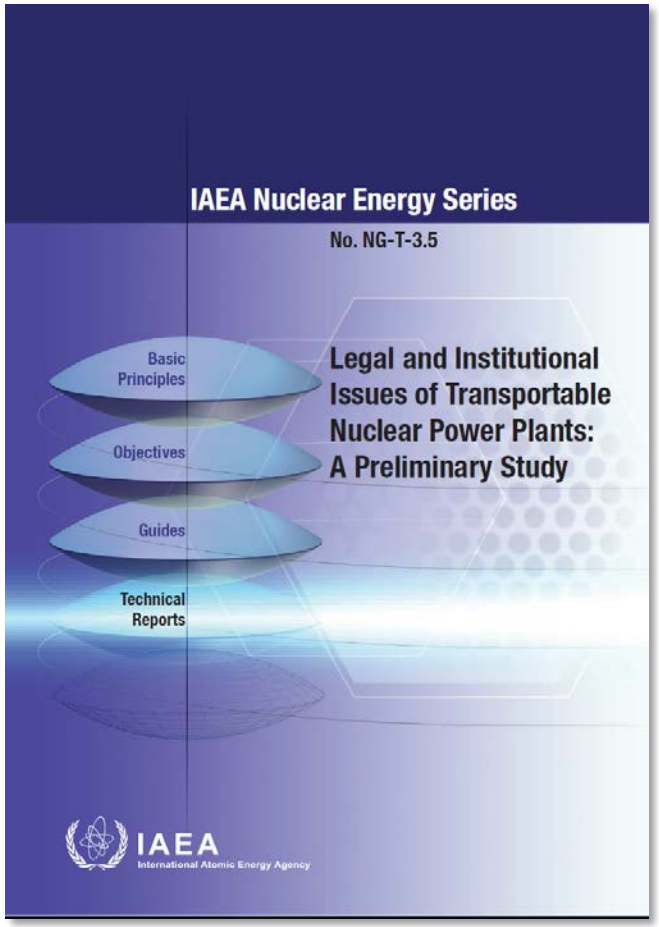
SMR Platform

Nuclear Harmonization and Standardization Initiative (NHSI)

Advanced Reactors Information System (ARIS)

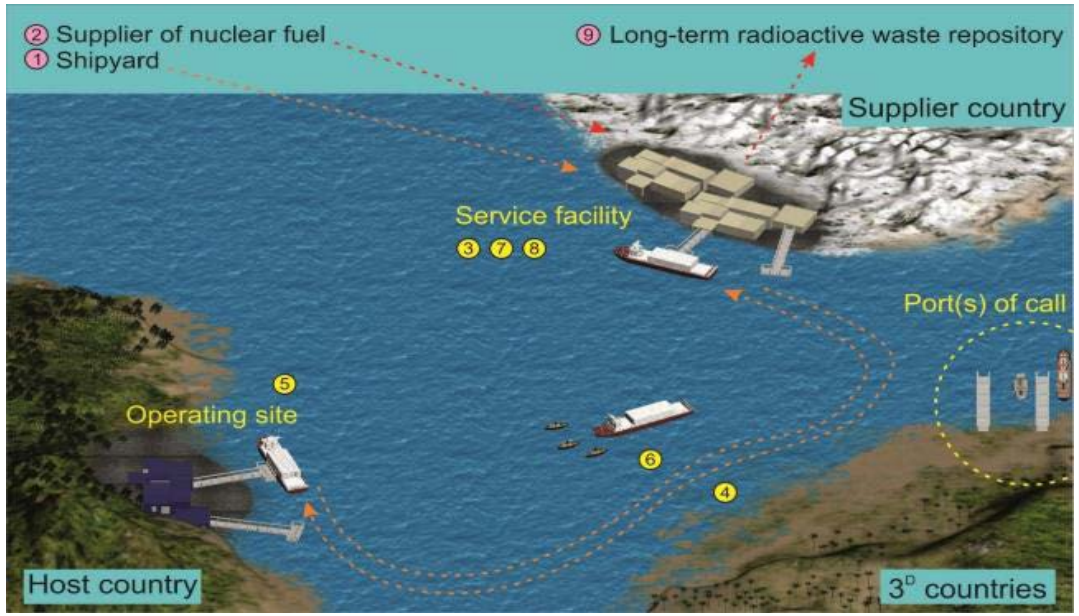
INPRO Studies on Transportable Nuclear Power Plants (TNPPs)

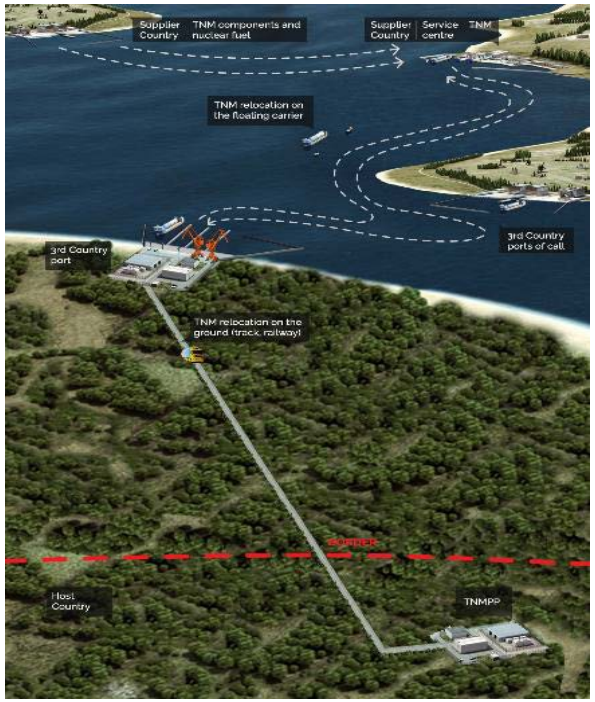
- Preliminary study (2008-2013): TNPP-1
- Two cases were considered
  - Factory assembled, fuelled, tested, maintained, refuelled or decommissioned
  - Factory assembled, pre-tested (non-nuclear), maintained, fuelled and refuelled on-site
- And two scenarios:
  - Supplier is operator/host State is regulator
  - Host State is operator and regulator
- Legal and infrastructure issues considered
- For factory fueled reactors, there are gaps/insufficient coverage in the international nuclear law and in the non-binding international norms



INPRO Studies on Transportable Nuclear Power Plants (TNPPs), cont.

- Follow-up study (TNPP-2) - ongoing
  - INPRO Case study for the Deployment of a Factory Fuelled Small Modular Reactors (SMR)
  - 3 case studies: floating, land based, submersible





IAEA International Atomic Energy Agency

Sign In

The Platform on Small Modular Reactors and their Applications

Services | Resources | IAEA SMR News | IAEA SMR Events | Working Groups | NHSI

Functions of the SMR Platform

- Coordinate the Agency's activities in the field of SMRs
- Offers expertise from the entire Agency, encompassing all aspects relevant to the development, early deployment, and oversight of SMRs and their applications.
- Serves as the mechanism by which the IAEA responds to requests from Member States related to SMRs.
- Provides a focal point for Member States and other stakeholders to request assistance on general issues related to SMRs and their applications via official channels. Additional information on this process can be made by contacting us at SMR.Platform@iaea.org

Basis Documents for the SMR Platform


IAEA Medium Term Strategy on SMRs and their Applications

IAEA SMR Platform Annual Report 2021-2022


Small Modular Reactors: A new nuclear energy paradigm


IAEA SMR ARIS Booklet 2022

The NHSI

https://smr.iaea.org

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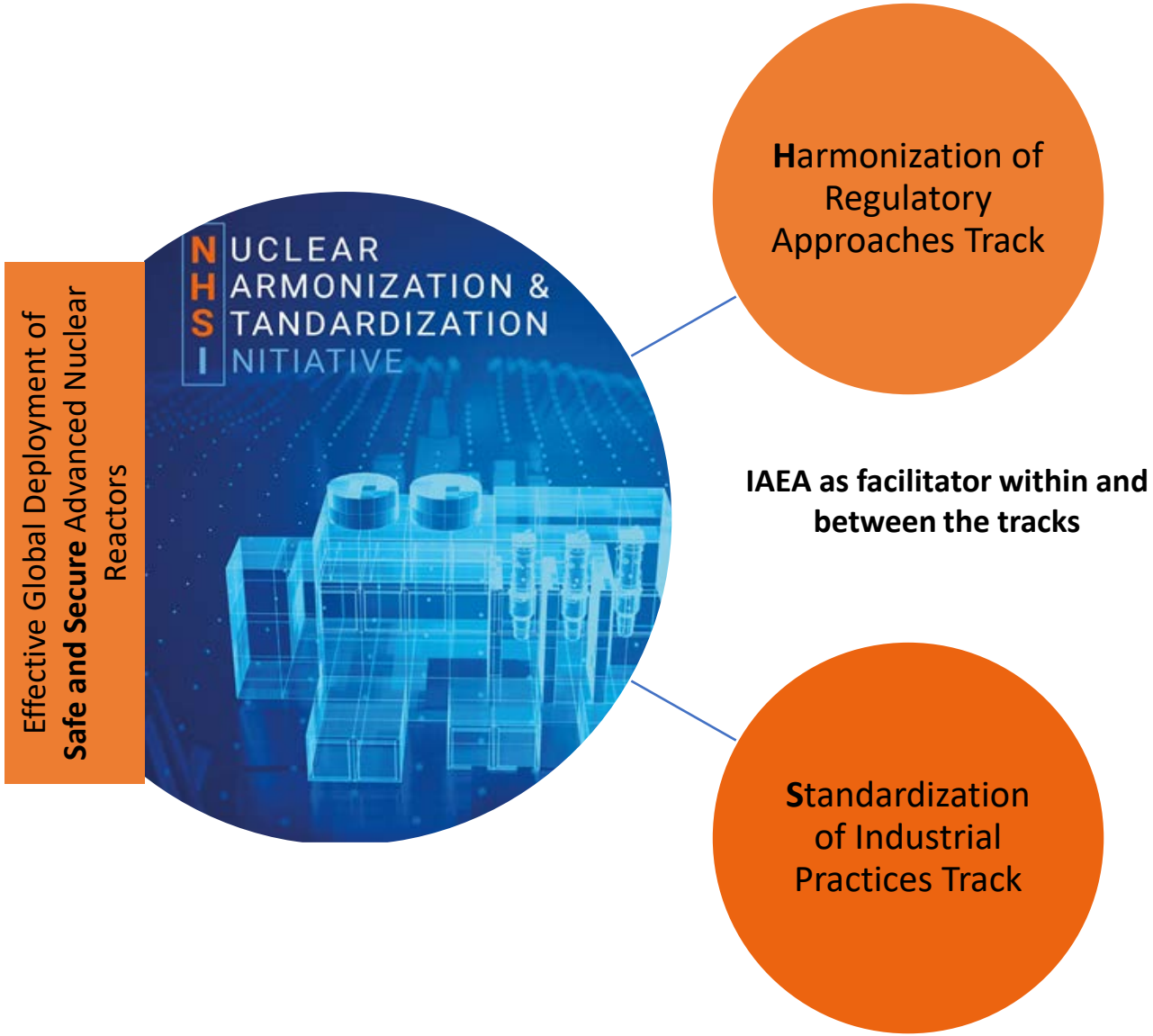
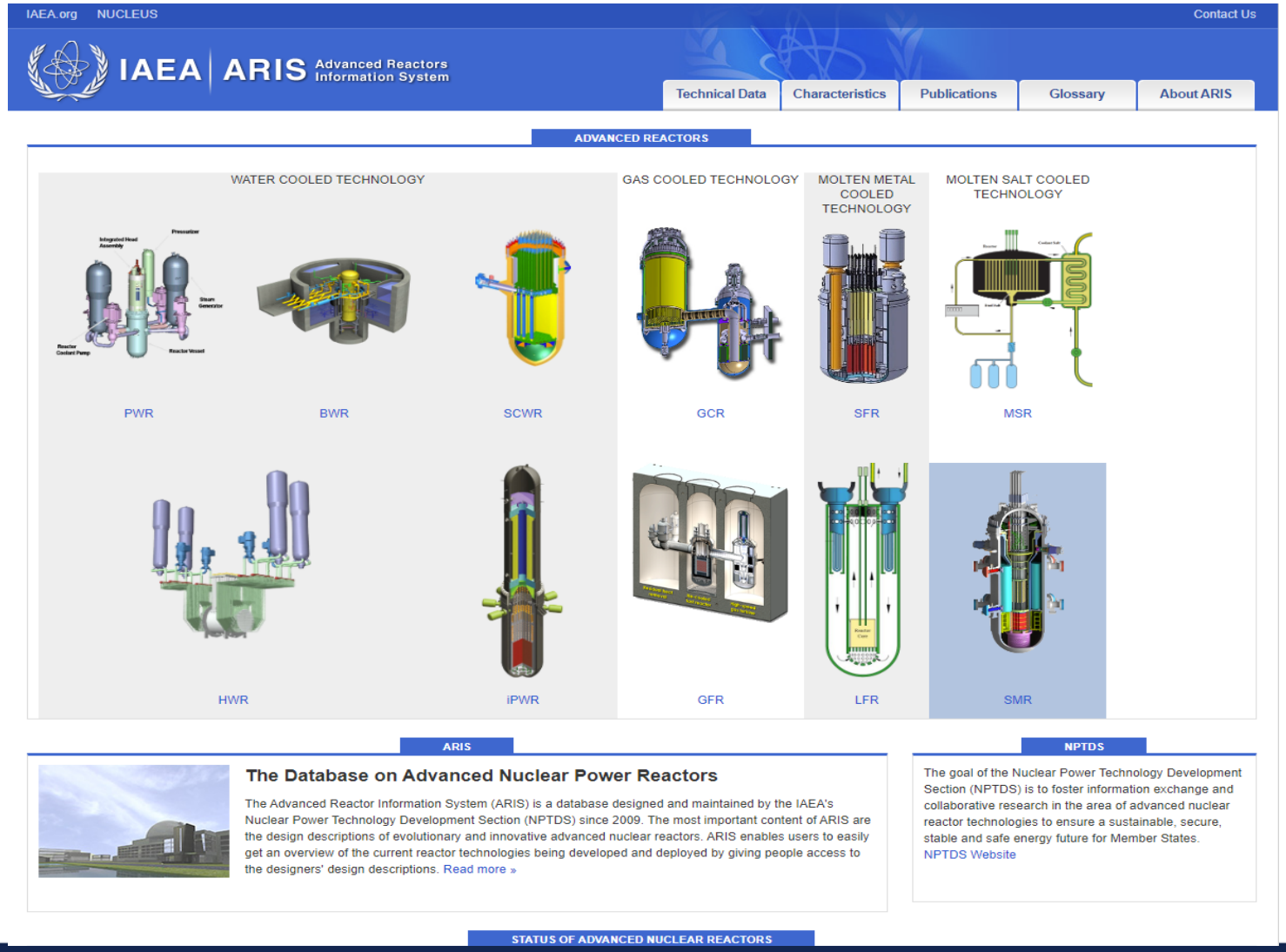
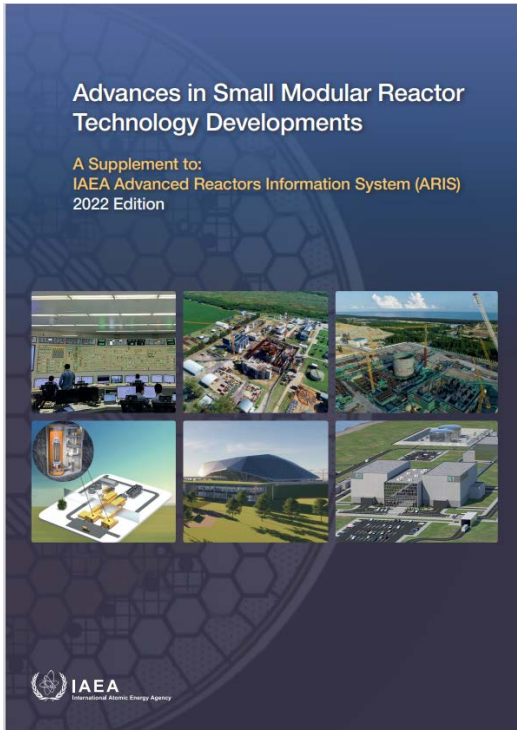
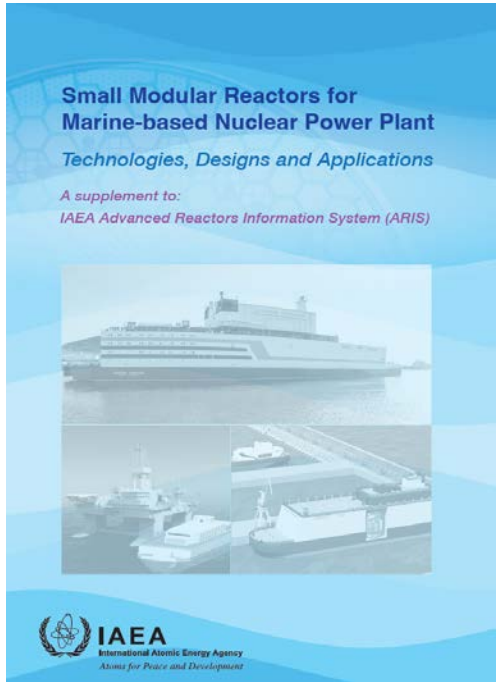
Nuclear Harmonization and Standardization Initiative



Advanced Reactors Information System



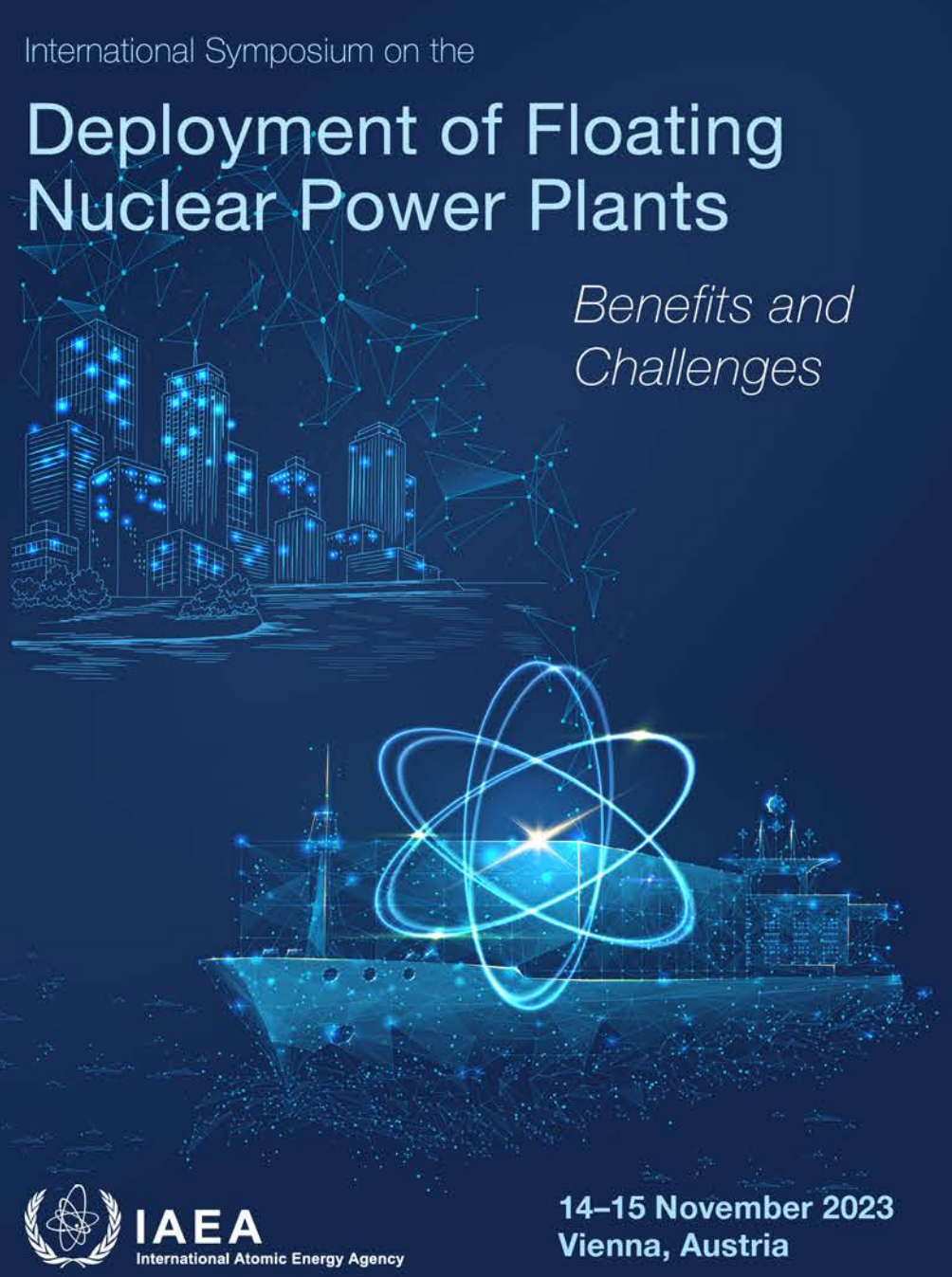




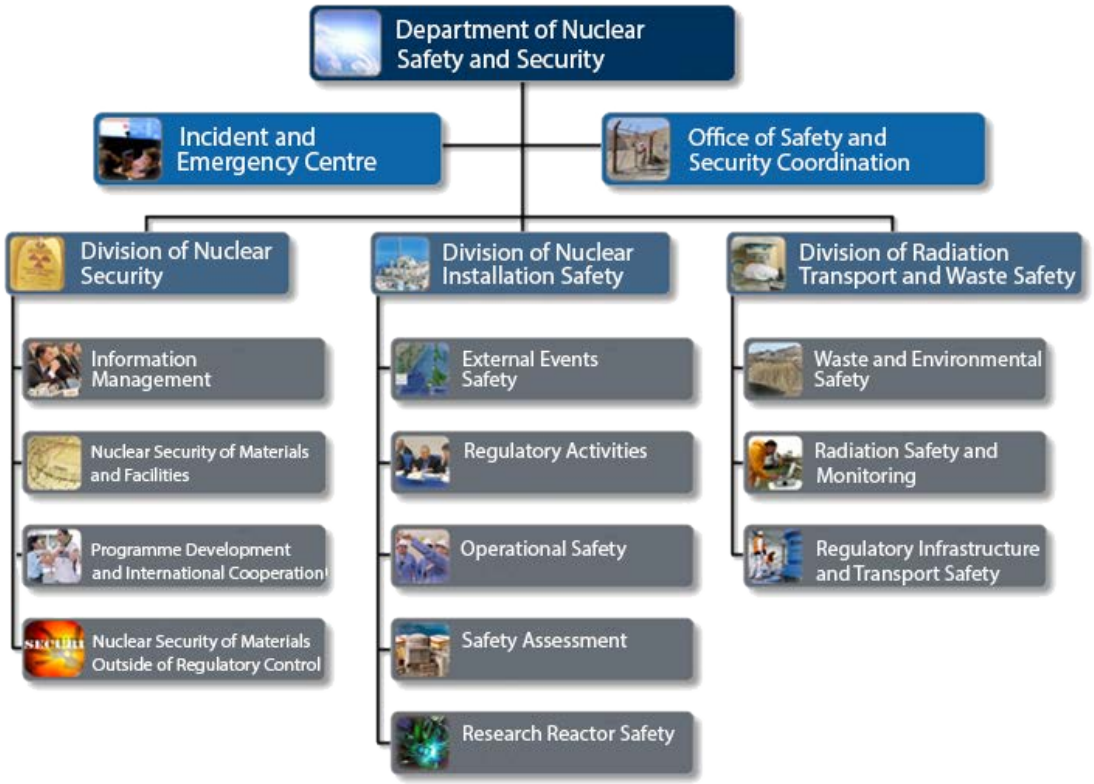
https://aris.iaea.org/

IAEA Department of Nuclear Safety and Security

Ongoing activities towards the safety and security of floating nuclear power plants



Department of Nuclear Safety and Security (NS)



- Our mission: The protection of people, society and the environment from the **harmful effects of ionizing radiation**
- The Department supports the Member States in their national efforts to further strengthen nuclear safety and nuclear security
- Key roles include contributing to the **development or adoption of Safety Standards** and organising **training and capacity building** for the Member States

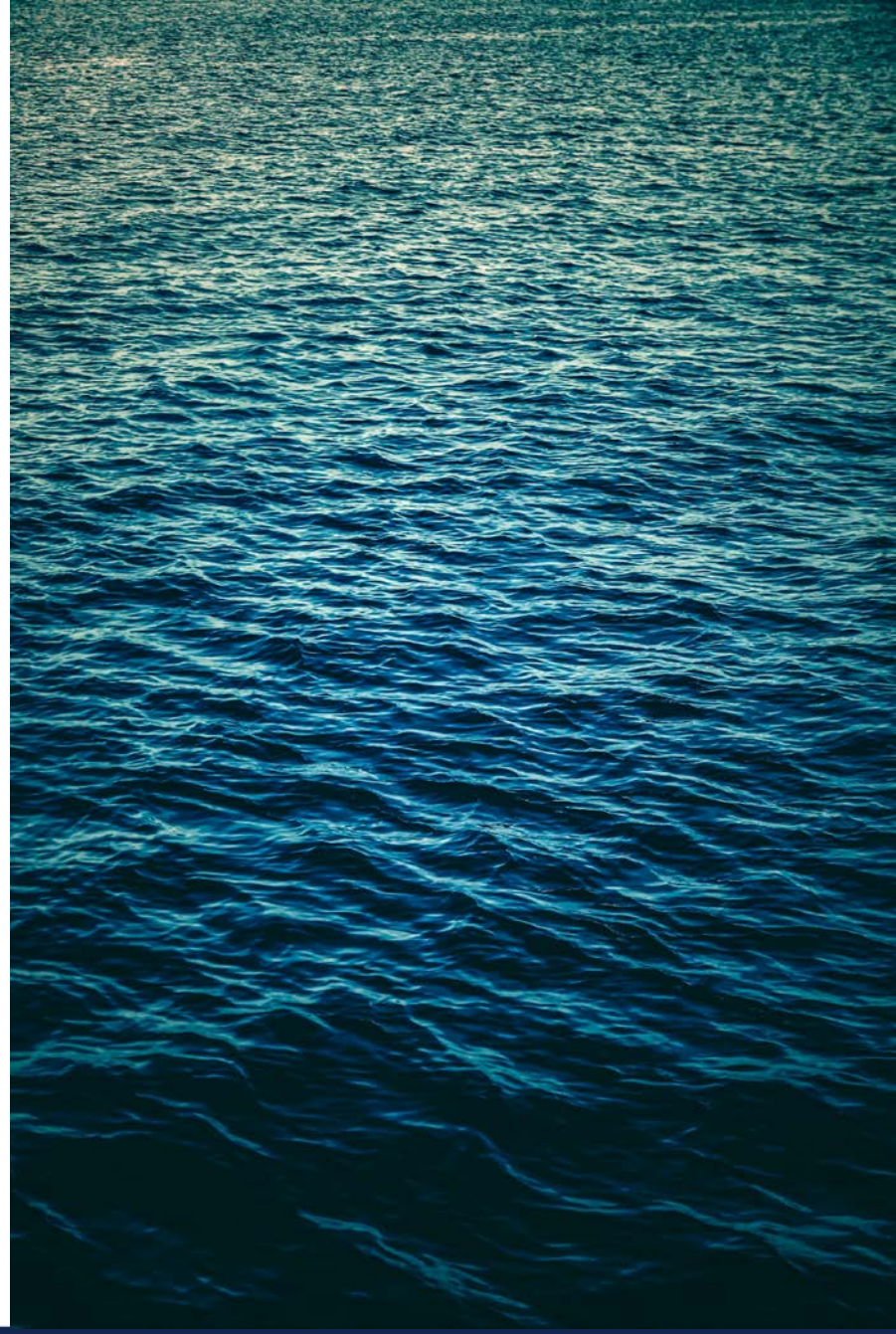
How is the work of NS relevant for FNPPs?

- **Division of Nuclear Installation Safety (NSNI)**
  - Responsibility: Safety of nuclear power installations
  - Interest: FNPPs are a special type of power installation
- **Incident and Emergency Centre (IEC)**
  - Responsibility: Preparedness and response for nucl. and rad. emergencies
  - Interest: EPR for FNPPs, including during transport
- **Division of Radiation Transport and Waste Safety (NSRW)**
  - Responsibility: Transport & radioactive waste safety, protection of public/environment
  - Interest: How to address waste, environmental issues and transport safety for FNPPs
- **Division of Nuclear Security (NSNS)**
  - Responsibility: Security of nuclear materials at facilities and in transport
  - Interest: Ensuring security of nuclear materials during transport & operation of FNPPs

NSNI - Safety Assessment

Things to consider:

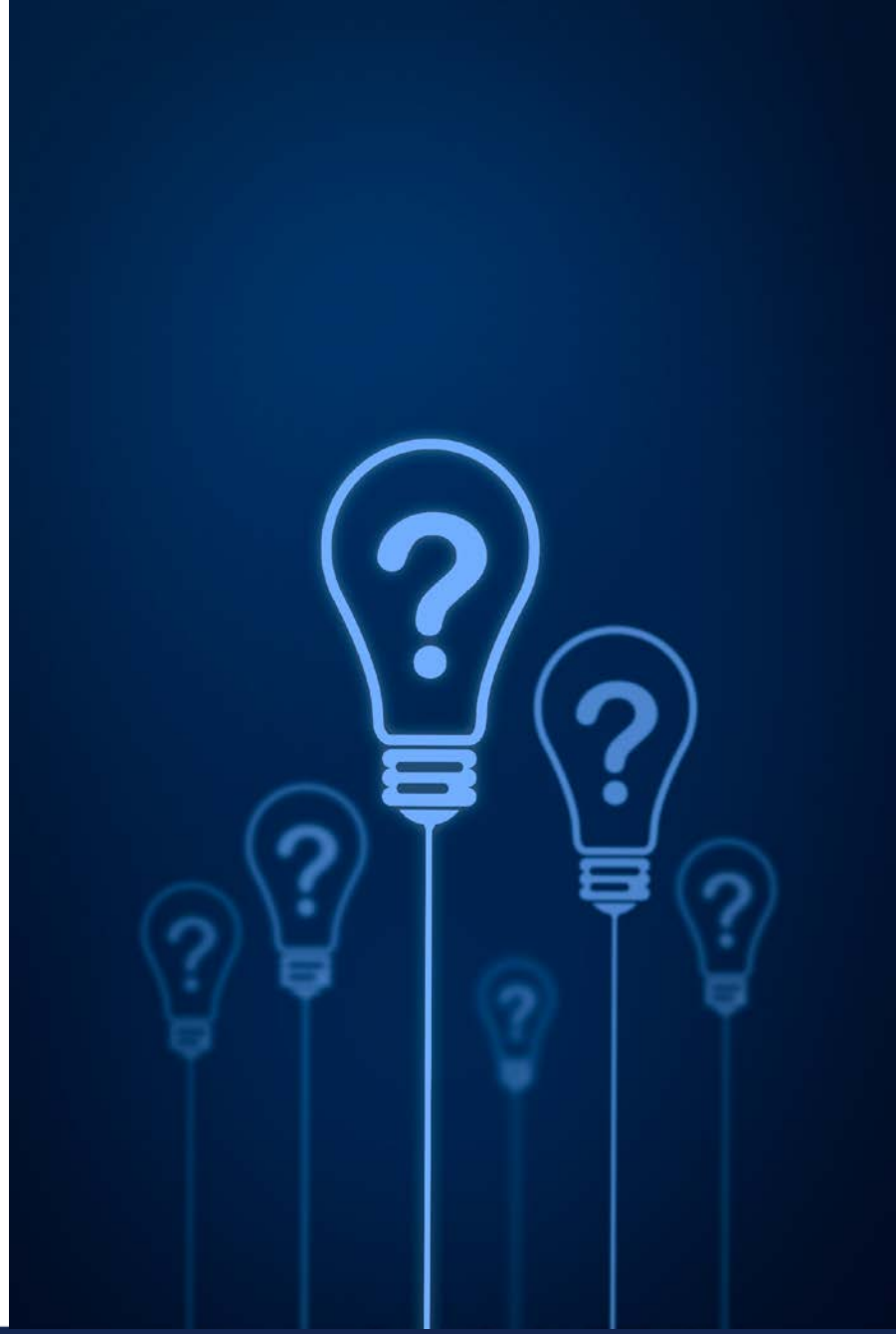
- Our Safety Standards were developed for land-based facilities
- May be difficult to meet some requirements, others may not be relevant
- Lower-level guides have more applicability issues than high-level requirements
- Limited guidance on addressing marine-based hazards
- Some FNPPs will use non-water-cooled reactors



NSNI - Safety Assessment

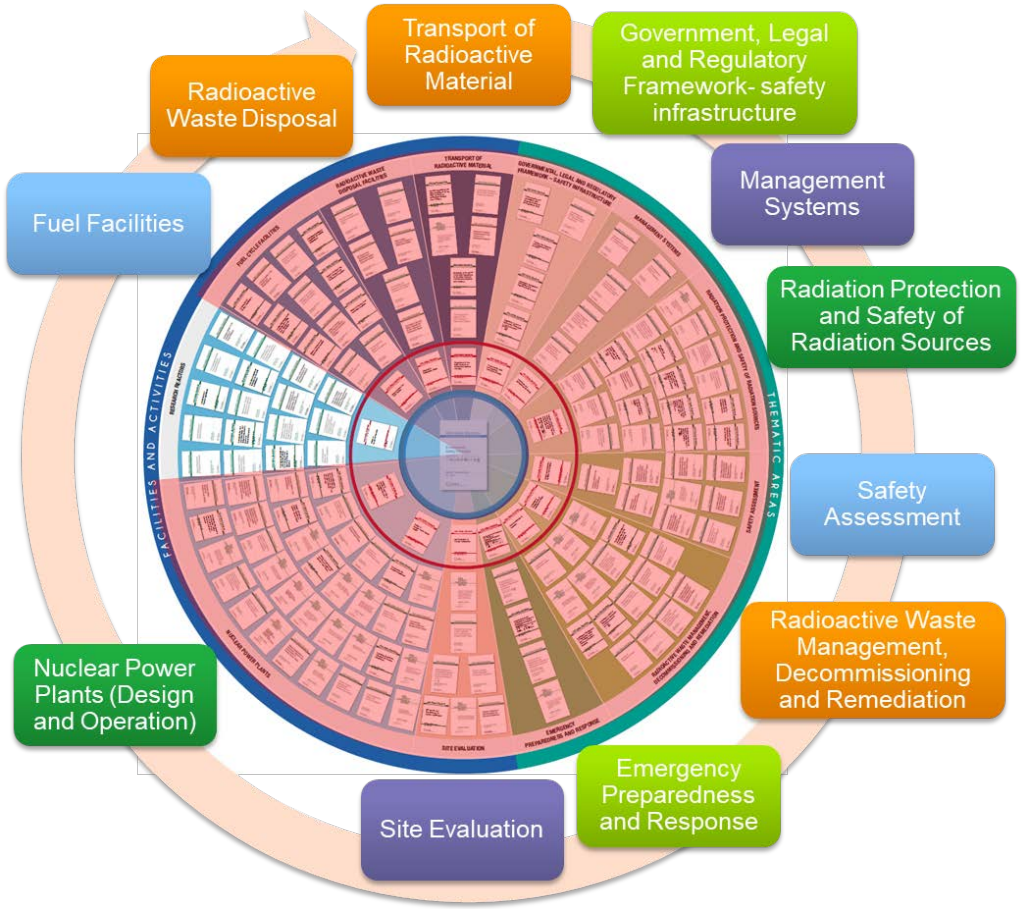
How we are preparing for FNPPs:

- We have already **reviewed applicability of our standards** for SMRs and non-water-cooled reactors – including FNPPs (SR-123 in pre-print)
- We're developing guidance on **safety demonstration for innovative technology** in power reactor designs
- We're developing guidance on non-water-cooled reactors (relevant for some FNPPs)
  - E.g., TECDOC on Safety Considerations on Molten Salt Reactors
- We're developing a **Technical Report** on Safety & Security considerations of floating NPPs
- We are part of Agency-wide harmonization and standardization initiative (NHSI)



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

Safety Reports Series No. 123



- Carried out in 2021-22 (in pre-print)
- Covered SMRs and non-WCRs, incl. FNPPs
- Around 90 standards reviewed
- Whole lifecycle considered
- Two main objectives:
  a. Assessed applicability of standards
  b. Identified gaps (novel safety issues, aspects not, or only partially, addressed)

Scan QR code to access the pre-print →

New Safety Guide under development

Will provide recommendations on how to resolve unknowns associated with innovative technology to support safety demonstrations.

Includes transportability issues relevant to FNPPs.

NS department-wide project

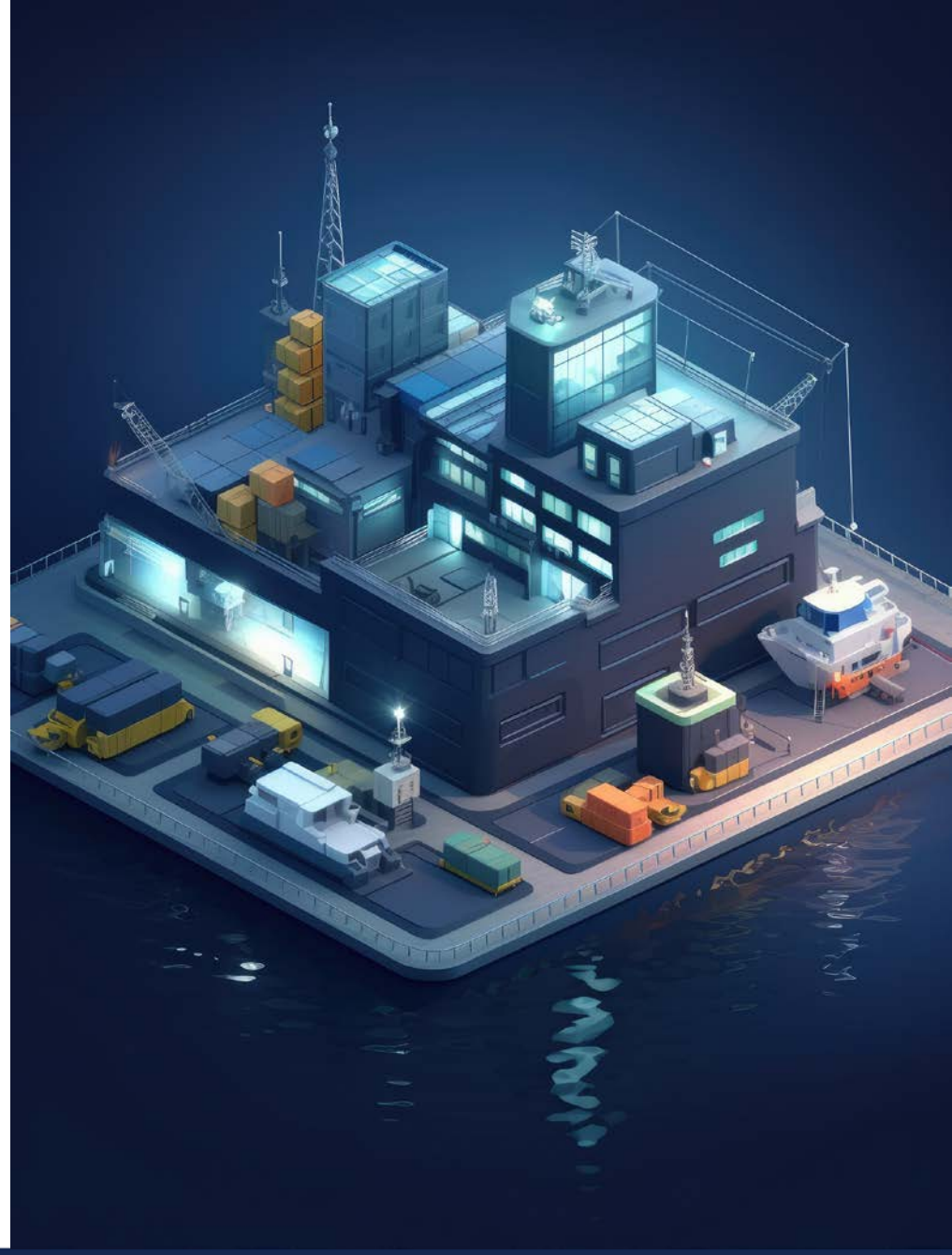
Technical Report: Design Safety and Security Considerations for Floating Nuclear Power Plants

- IAEA's first safety and security-focussed report on FNPPs
- Will consider range of transport and operational scenarios
- We look at applicability of some key IAEA Safety Standards to FNPP designs (e.g., SSR-2/1, SSR-1, SSR-6)
- Will consider relevance of codes from maritime safety world (SOLAS, IMO Res. A.491(XII))

NSNI – External Events

Things to consider:

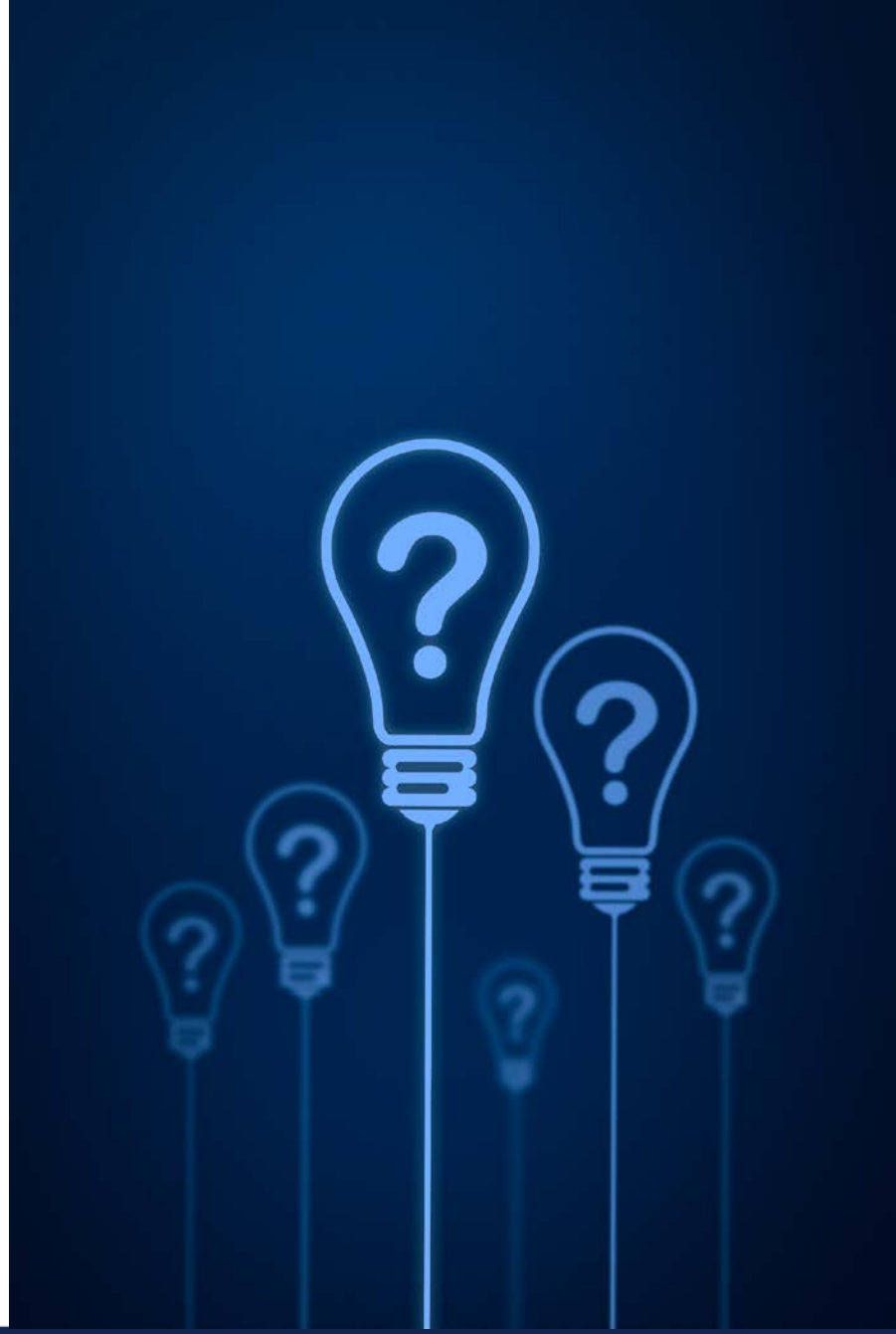
- Site characterization: meteorological, hydrological, tsunami and human induced events (incl collisions) understood, but interpretation of standards may be needed
- Special emphasis needed on stability of vessel; potential for extreme oscillations, capsizing or sinking
- Design of (potentially safety-important) mooring and protective structures (e.g., sea walls)
- How to address defence-in-depth Levels 4 and 5 (radiological dispersion, emergency planning) in marine environment



NSNI – External Events

How we are preparing for FNPPs:

- Taking part in NS-wide study into *Design Safety and Security Considerations for Floating Nuclear Power Plants*
- Ongoing, periodic review of Safety Guides and technical documents will consider their suitability for FNPPs
- Consider whether further guides needed on characterising marine-specific hazards



NS-Incident and Emergency Response Centre

Things to consider:

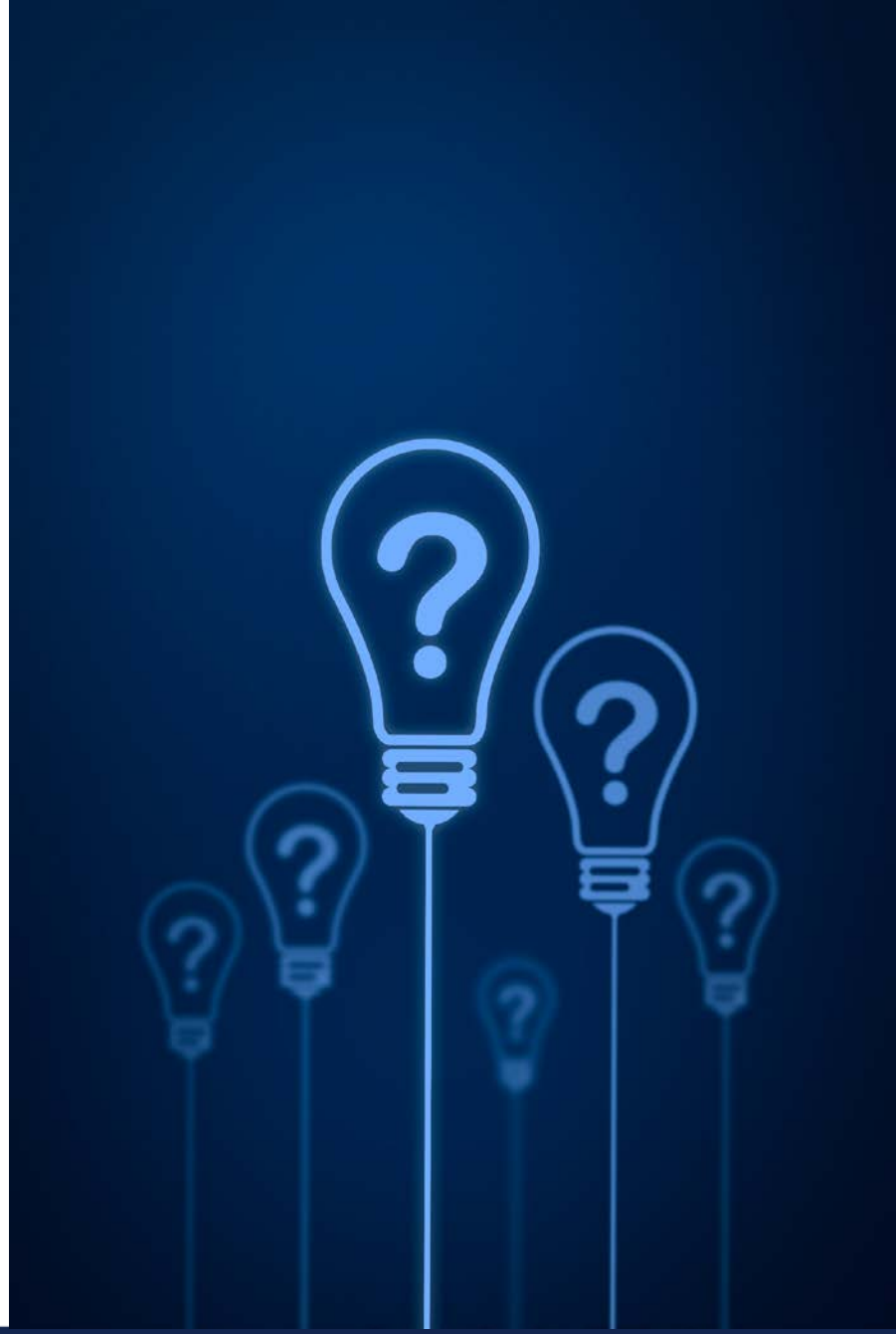
- EPR Safety Standards are technology neutral and rely on the concept of graded approach
- Hazard assessment needed to categorize a site under Emergency Preparedness Category (EPC) I, II or III (see GSR Part 7)
- Once the relevant EPC is identified, subsequent guidance for that EPC can be followed
- However, FNPPs raise new challenges

NS-Incident and Emergency Response Centre

How we are preparing for FNPPs:

Addressing key aspects such as:

- Potential discrepancies in EPR arrangements (incl. EPZs and EPDs) between the country that provides the FNPP and the country that operates it
- How to promptly and effectively take urgent protective actions at the FNPP, the surrounding facility and the area around it in case of an emergency?



NSNS - Security

Things to consider:

- FNPP protection concerns may differ from those for land-based NPPs
- Cooperation and collaboration between the supplier state and the recipient state essential
- Transfer of responsibility between States (shipping country, transit through third countries, receiving country)
- How to resolve any conflict between safety and security requirements
- Colocation of FNPP with other port infrastructure should be taken into consideration as part of nuclear security

NSNS - Security

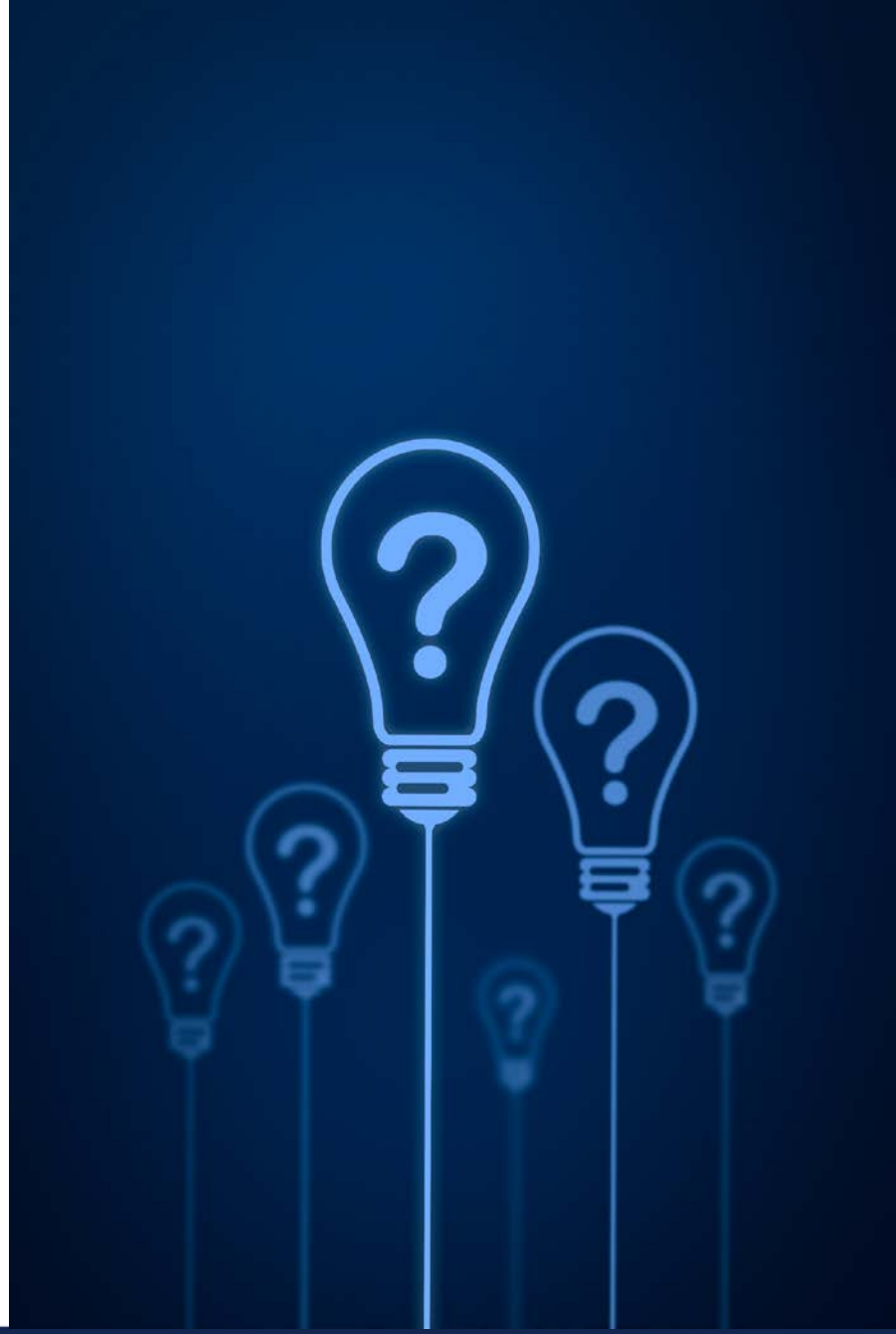
Things to consider:

- FNPPs need to establish an effective nuclear security threat assessment and consider applicable DBT(s) when designing nuclear security measures
- If transported internationally, FNPPs may have to deal with different national radiological consequence criteria (URC, HRC) for sabotage
- Implementation of special security arrangements during relocation of the FNPP within Member State
- Specific security considerations for international transport routes (e.g., exclusion zone, limited routes, need for additional personnel, etc.)

NSNS - Security

How we are preparing for FNPPs:

- Taking part in NS-wide study into *Design Safety and Security Considerations for Floating Nuclear Power Plants*
- NSNS believes nuclear security guidance (NSS 13, NSS 26-G or NSS 27-G, etc.) could be used for FNPPs
- We are considering:
  - Applicability of international legal instruments (CPPNM and its amendment)
  - How to address marine security threats
  - Access to sensitive information for international transport
  - How to apply 3S (safety, security, safeguards) for FNPPs



NSRW - Transport Safety

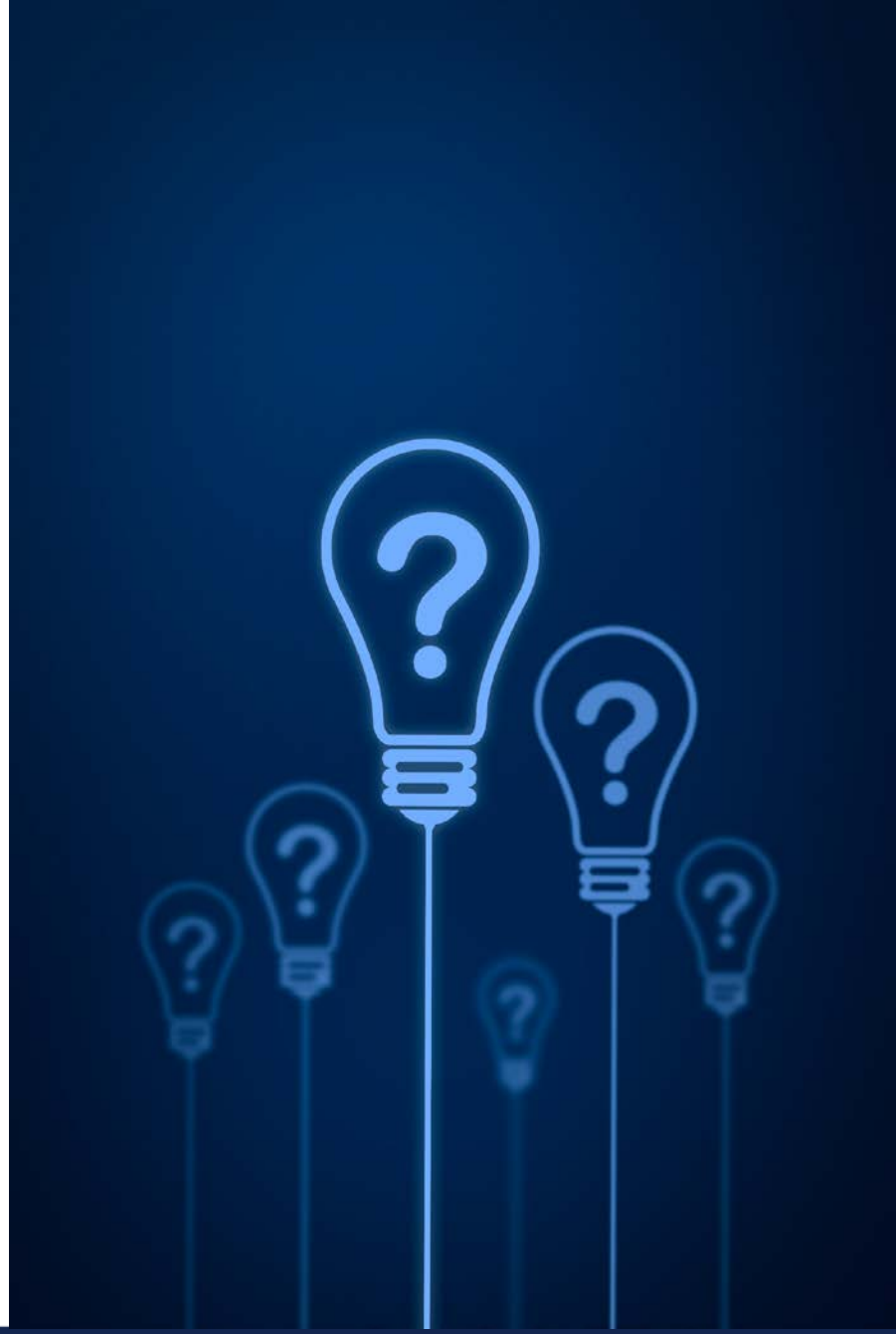
Things to consider:

- IAEA Transport Regulations SSR-6 (Rev.1) designed for transport of radioactive material in packages
- Safety by controlling contents and use of packaging
- Use-case of FNPPs (i.e., moveable reactor/NPP) not envisaged when SSR-6 was developed
- Transport of fresh and irradiated fuel in-core or other non SSR-6 compliant package not covered
- May be challenging to develop regulatory framework that is acceptable to regulators around the world

NSRW - Transport Safety

How we are preparing for FNPPs:

- Taking part in NS-wide study into *Design Safety and Security Considerations for Floating Nuclear Power Plants*
- Working closely with SMR-PIT Taskforce on TNPP
- Considering what would be appropriate requirements for design safety of FNPPs in transport
- Transport Safety Standards Committee created working group on Transportable NPPs in 2021.
  - Considering all types of TNPPs
  - Looking at whether to adapt existing Safety Standards or propose new ones
  - IMO is TRANSSC member
- Working closely with Office of Legal Affairs



NSRW – Waste and Environmental Safety

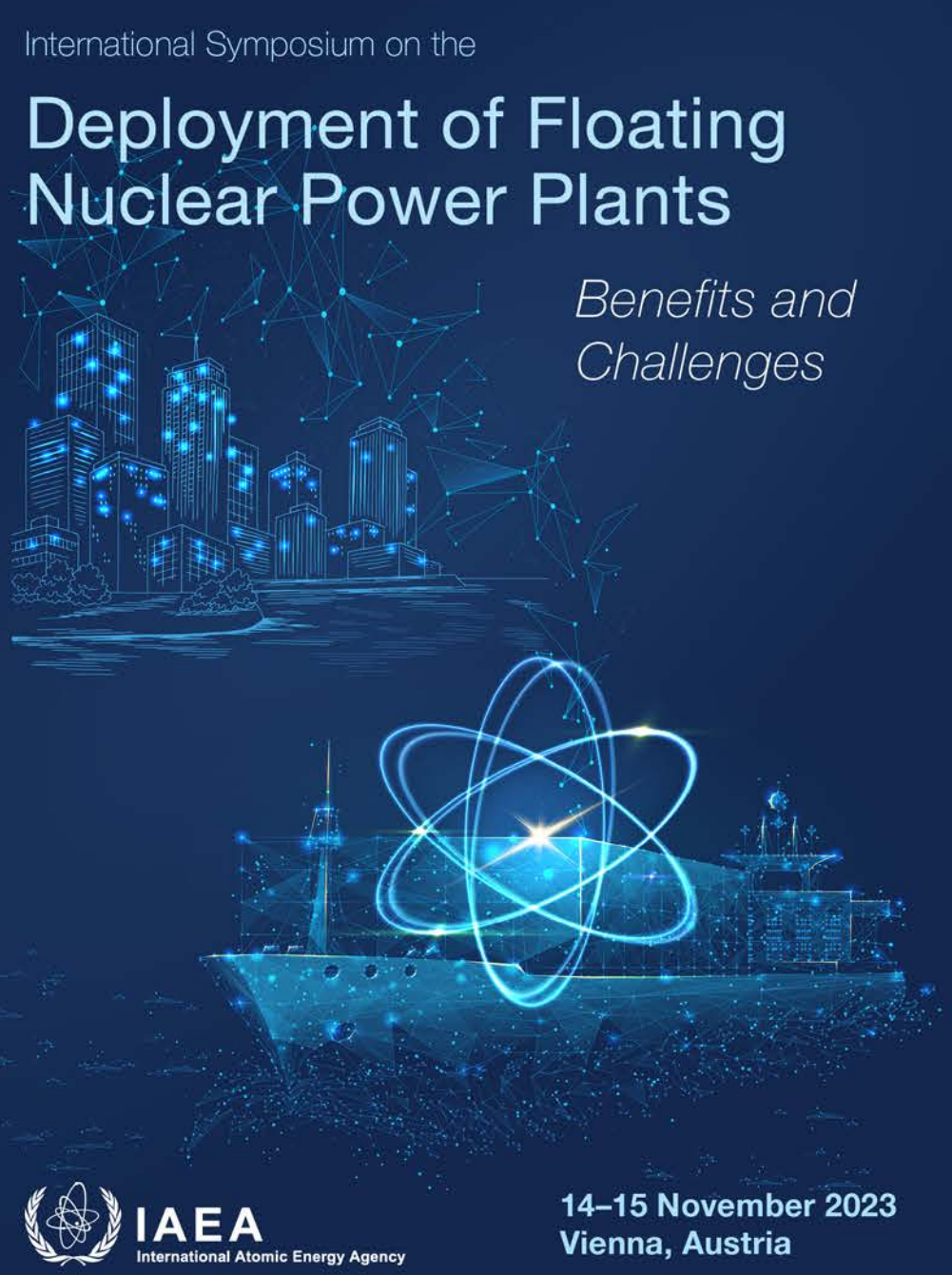
Things to consider:

- Joint Convention for the Safety of Radioactive Waste and Spent Fuel applies to FNPPs
- Requirements for protection of the public and the environment, waste management and decommissioning are generic – apply to FNPPs
  - GSR Part 3, GSR Part 5, SSR-5 and GSR-Part 6 apply

How we are preparing for FNPPs:

- We will consider as part of future planned updates whether our safety guides need interpretation or updating to address issues specific to FNPPs

IAEA Department of Safeguards



Safeguards by design: preparing for advanced reactors

IAEA International Symposium on the Deployment of Floating Nuclear Power Plants – 14 & 15 November 2023, Vienna, Austria

Traci Newton

Senior Safeguards Analyst (Approaches), SG Concepts and Planning

Department of Safeguards, IAEA

T.Newton@iaea.org

IAEA safeguards

IAEA Safeguards

- Technical means implemented by the IAEA to verify a State is honouring its international obligations to use nuclear material exclusively for peaceful purposes

- States have different safeguards obligations depending on the type of safeguards agreement in force with the IAEA

Three types of IAEA safeguards agreements

IAEA Safeguards

Comprehensive Safeguards Agreement (CSA)

Voluntary Offer Agreement (VOA)

Item-Specific Agreement (INFCIRC/66)

States with a CSA

IAEA Safeguards

- Safeguards apply to all source or special fissionable material in all peaceful nuclear activities within the territory of the State, under its jurisdiction or carried out under its control anywhere

- Safeguards are applied to all nuclear facilities in such States, regardless of the size, complexity, accessibility, owner/operator, or the supplier of the technology

Changing nuclear landscape

IAEA Safeguards

- Novel designs
  - Floating reactors
  - Microreactors
- Innovative fuel cycles
- Transportable and sealed cores
- Remote and non-static locations

The IAEA supports its Member States' goals for the

safe, secure, timely

deployment of advanced reactors

Safeguards considerations

- Many vendors unaware of legal obligation for States to implement IAEA safeguards
  - General lack of awareness of IAEA safeguards, or perception that it does/will not impact design

- Advanced reactors may require new types of safeguards approaches (which may require research and development)
  - New core/fuel designs, plant layouts, spent fuel management, fuel cycle facilities

Safeguards By Design (SBD)

- A voluntary process involving early engagement with designers
- Integration of safeguards considerations into design process of new or modified nuclear facility or location outside facility
- Improves safeguards implementation by jointly identifying opportunities and developing solutions for improved efficiency and effectiveness early in the design process

SBD benefits all stakeholders

- **IAEA & Operators:** Improve effectiveness and efficiency of safeguards implementation
- **Operators:** Reduce risk to scope, schedule and budget, while avoiding potentially costly retrofits
- **Vendors/Designers:** Better understanding of customer needs

IAEA SBD Activities

- Seven Member States voluntary support application of the SBD approach to 10 advanced reactor designs, including:
  - Floating reactors
  - Integral PWRs
  - Molten salt reactors
  - Pebble bed reactors
  - Microreactors
- Internal collaboration with Nuclear Safety and Nuclear Security initiatives (3S)
- External engagements with stakeholders through third-party interactions and collaborations

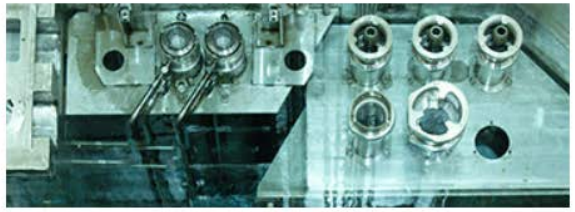
IAEA general safeguards training

IAEA Safeguards

IAEA Open Learning Management System:

https://elearning.iaea.org

Nuclear Technology & Applications



→ Nuclear Energy
→ Knowledge Management
→ more...

Nuclear Safety & Security

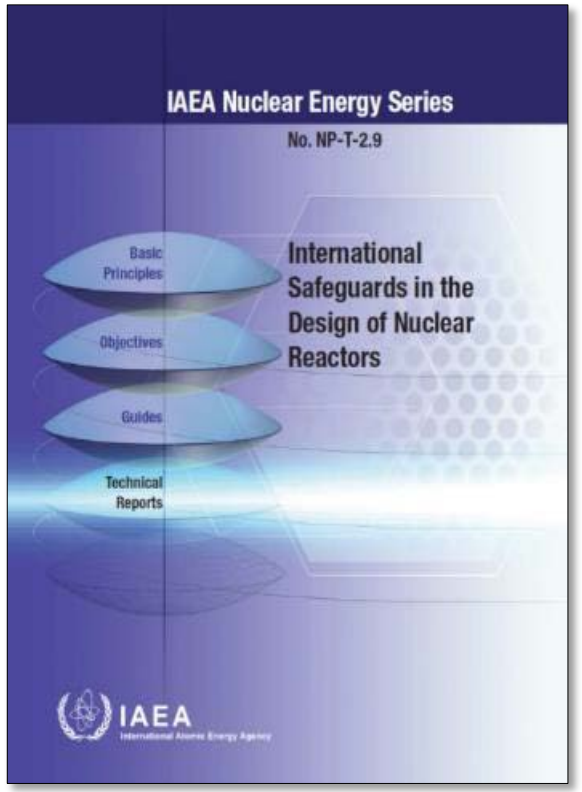
→ Nuclear Security
→ Nuclear Safety
→ more...

Cooperation Partners

Safeguards & Verification

IAEA safeguards-by-design guidance

IAEA Safeguards



International Symposium on the

Deployment of Floating Nuclear Power Plants

Benefits and Challenges

14–15 November 2023
Vienna, Austria

IAEA
International Atomic Energy Agency