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Applicability of IAEA safety standards to the Safe Operation and Regulation of evolutionary and innovative reactor designs including SMRs

Speakers:
Paula Calle Vives
Miroslav Lipar
Miguel Santini
Mario Santos

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Welcome!

Thank you for your participation in this installment of the webinar series on the review the applicability of the Safety Standards to Evolutionary and Innovative Reactor Designs including SMRs

Please visit the website dedicated to NSNI webinars to view previous instalments in this series.

Our presenters:

- **Miroslav Lipar**

  Mr Lipar has over 40 years of experience in nuclear power plant management, operation, commissioning, leadership and management for safety, and safety assessment. He is knowledgeable about the IAEA safety standards and has contributed to the development of IAEA safety standards in the domain of Nuclear Power Plant Operations and Leadership and Management for Safety.

- **Miguel Santini**

  Mr Miguel Santini is the Scientific Secretary of the SMR Regulators Forum and participated in the review of Applicability of Safety Standards to the regulation of evolutionary and innovative reactor designs.

- **Mario Santos**

  Mr Mario Santos works as part of the SMR Regulators' Forum Secretariat and participated in the preparation of IAEA-TECDOC-2003 – Lessons Learned in Regulating Small Modular Reactors.

- **Paula Calle Vives**

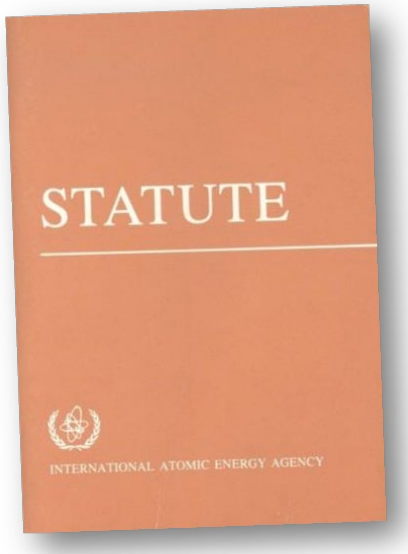
  Ms Calle Vives is the Chair of the IAEA Working Group on SMR Safety. She has led the review of applicability of the IAEA safety standards to non-water cooled reactors and SMRs and coordinated the SMR safety activities at the IAEA.

Logistics

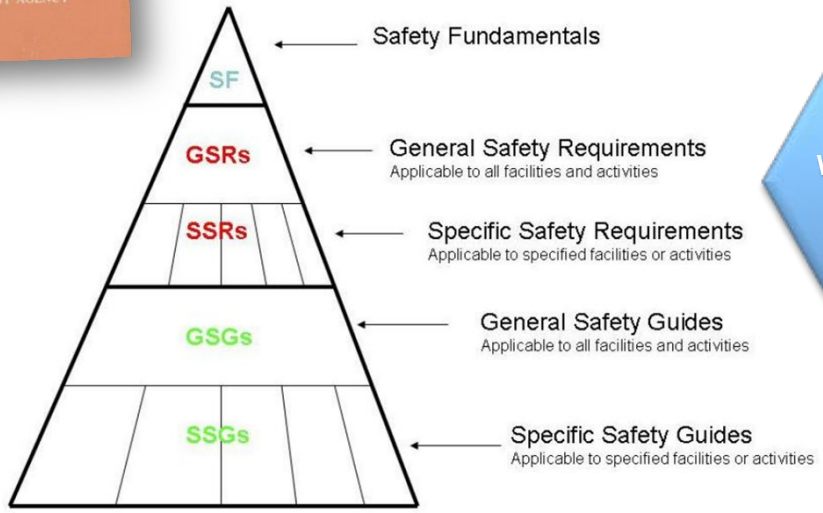
- There will be three presentations followed by twenty minutes for Q&A with all of our presenters
- Questions by Chat submission. You may use this at any time, but questions will be addressed at the end of all presentations.
- Please send your questions to the general chat or moderator (Heather) otherwise your question may be missed.

This webinar will be recorded and made available on the IAEA website.

Background

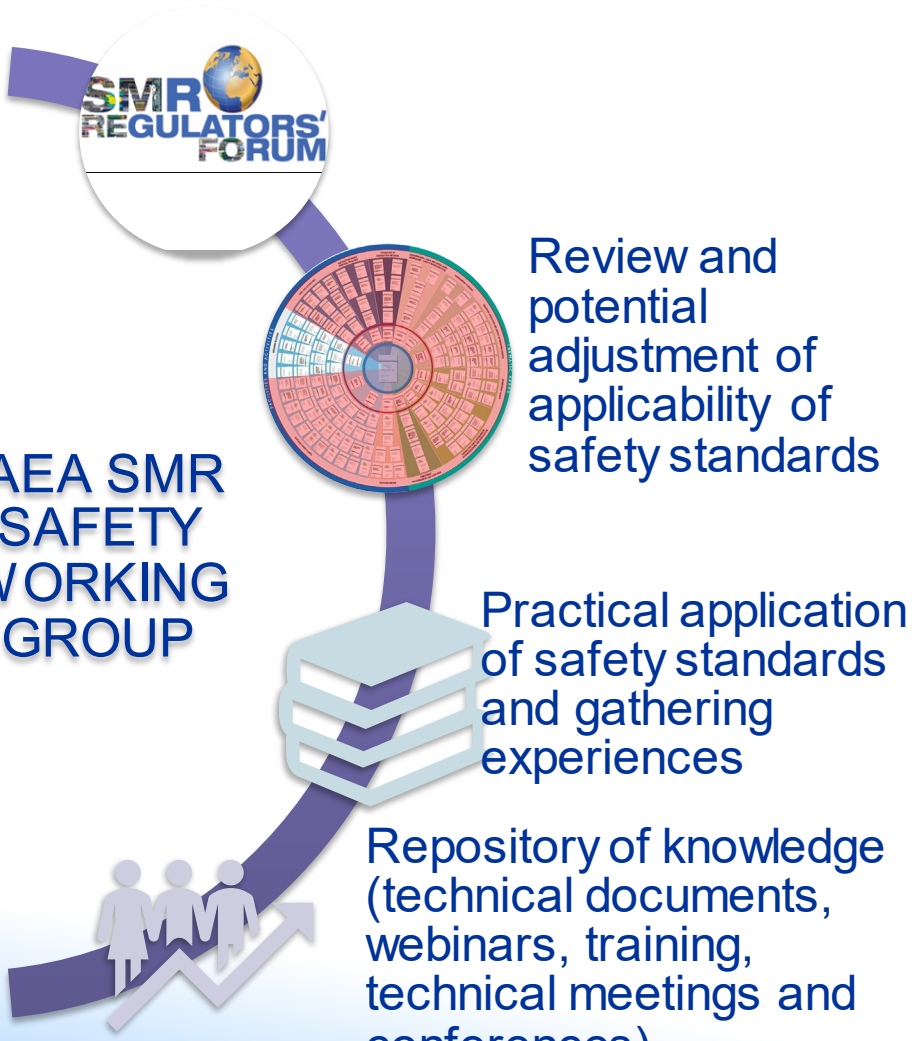


"**To establish or adopt**, in consultation and, where appropriate, in collaboration with the competent organs of the United Nations and with the specialized agencies concerned, **standards of safety for protection of health and minimization of danger to life and property**, and to **provide for the application of these standards** to its own operation as well as to the operations making use of materials, services, equipment, facilities, and information made available by the Agency…"



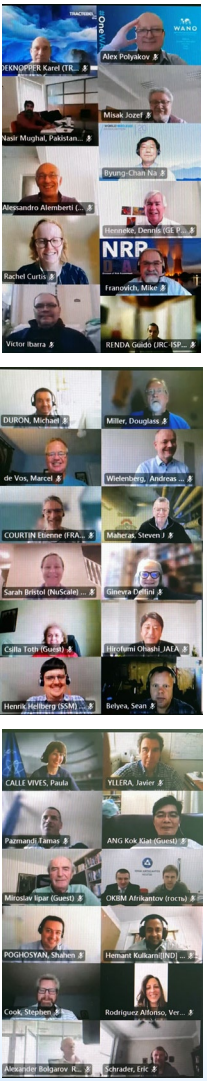
- *Mostly developed under the prominence of land-based, large water cooled reactors*
- *The development of safety standards is a long process*

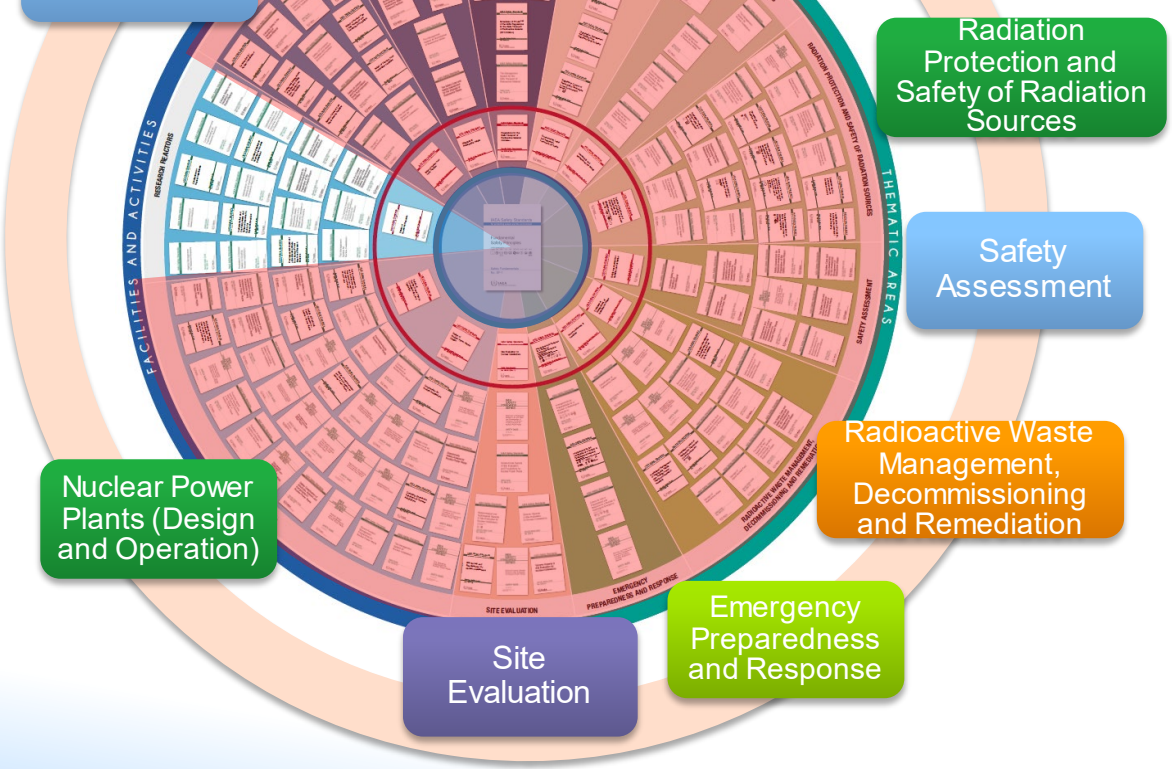
IAEA Activities on Evolutionary and Innovative Reactor Designs (EIDs) Safety, including SMRs

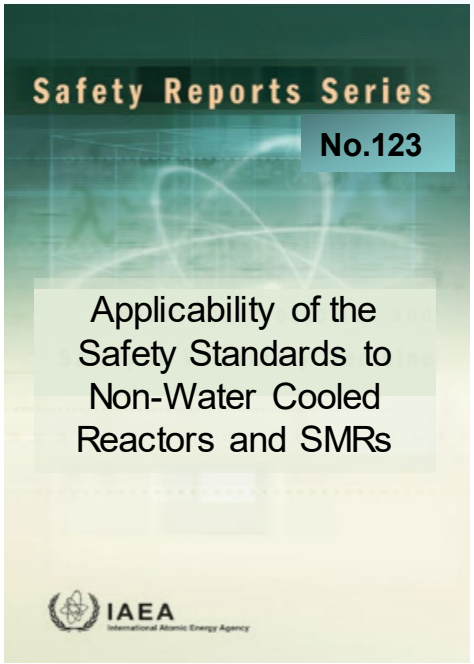


- Webinar on Applicability of IAEA Safety Standards to the Safe Operation and Regulation of Evolutionary and Innovative Reactor Designs including SMRs
- Webinar on Application of a Graded Approach for SMRs Site Evaluation
- Webinar on Safety, Security and Safeguards Interfaces and Challenges for Novel Advanced Reactors
- Webinar on IAEA Applicability of IAEA Safety Standards to the Design of Novel Advanced Reactors including SMRs
- Today: Webinar on IAEA Applicability of IAEA Safety Standards to the Safety Analysis of Evolutionary and Innovative Reactor Designs including SMRs

Are Safety Standards Sufficient and Relevant to Ensure the Safety of EIDs, including SMRs?







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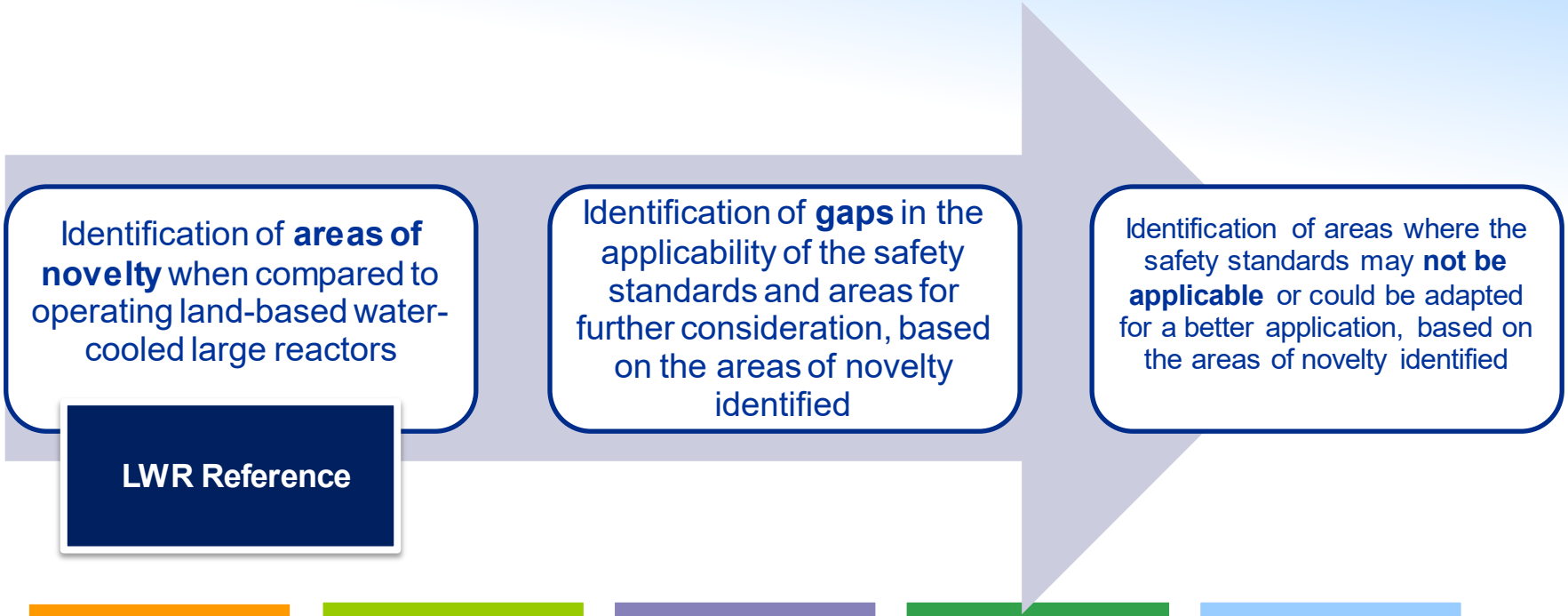
Review Approach



Siting	Design	Construction	Commissioning and operation	Radiation Protection
Fuel Facilities	Management of waste and spent fuel	Decommissioning	Emergency preparedness and response	Deployment models, Regulation, Transportation

Safety Standards Covered by the Review

And over 50 supporting Safety Guides

IAEA Plans to Enhance Applicability of Safety Standards to EID Safety, including SMRs

In view of the findings of the review of applicability of the safety standards and the safety issues identified, the IAEA is planning to:

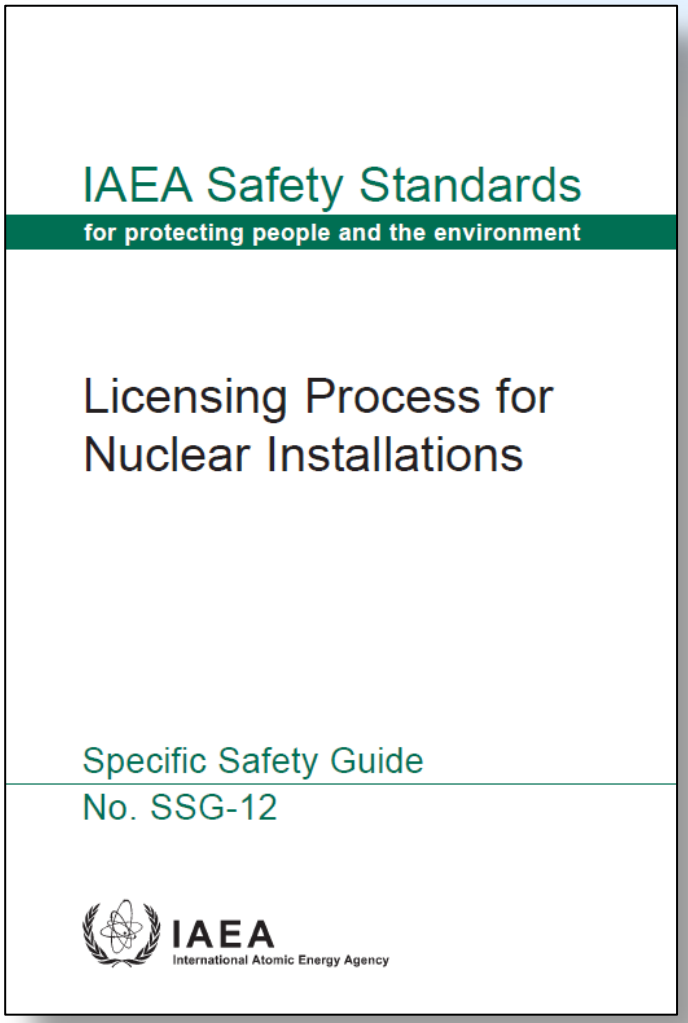
1. Enhance applicability of safety standards to EIDs (SMRs and non-water cooled reactors)

2. Develop publications to capture practical examples of application of safety standards for specific technologies

3. Develop a repository of technology specific knowledge

Revision of Licensing Process for Nuclear Installations (SSG-12)

- Collaboration among regulators of different member states
- Adaptation of the licensing process for newly proposed deployment models for EIDs, particularly SMRs
- Regulatory bodies collaboration when the licensing process is applied simultaneously to a design by two or more jurisdictions
- Address potential changes or adjustments to the licensing process in the case of licensing of first of a kind (FOAK) reactors
- New Appendices with recommendations to:
  - Support regulatory bodies collaboration
  - Reduce regulatory burden for designs deployer in more than one country



Revision of Safety of NPPs: Commissioning and Operation (SSR2/2)

- Alternative operating models, such as factory commissioning prior to transport to the operating site, autonomous operation, refuelling (possibly at the factory) and remote monitoring and intervention
- Implications from novel designs characteristics. For example, the need to verify the operability of passive safety systems. The implications of modularity, shared systems among modules and novel chemistry and hazards for the commissioning and operation, and the definition of severe accident for technologies where core melt is claimed to be not relevant

Proposed New Safety Guide

- Current lack of guidance on how to overcome specific challenges of innovative technologies that are first of a kind and not as mature as current (proven) designs with respect to knowledge, regulatory and operating experience.
- Complement existing safety standards
- Capture experience available accumulated through years of demonstrations of the previous and current generation of reactors as well as early interactions between regulatory bodies and developers

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IAEA webinar: Review of Applicability of Safety Standards to 'evolutionary and innovative designs (EIDs)'

SSR-2/2 Rev.1 and associated Safety Guides

Miroslav Lipar, senior consultant, Slovakia

30 August 2022

Contents

- Objective and scope
- Key areas of novelty relevant for the review
- Scope of SSR-2/2 Rev.1
- List of relevant Safety Guides
- Review outcomes
- Conclusions

Objective

Presentation of the results of the high-level review and gap analysis for the applicability of the SSR-2/2 Rev.1, Requirements for Commissioning and Operation of NPPs and relevant Safety Guides in relation to the operation of NPPs of ‘evolutionary and innovative designs (EIDs)’.

Scope of the review

The main topical areas for which the Safety Requirements and Safety Guides provides requirements and recommendations are the following:

- Management and organizational structure of the operating organization (Requirements 1–4)
- Management of operational safety (Requirements 5-16)
- Operational safety programmes (Requirements 17-24)
- Plant commissioning (Requirement 25)
- Plant operations (Requirements 26-30)
- Maintenance, testing, surveillance and inspection (Req. 31-32)
- Preparation for decommissioning (Requirements 33)

KEY AREAS OF NOVELTY IMPACTING THE REVIEW

Information regarding novelties is from the following documents:

- Questionnaires for EID vendors,
- Advances in small modular reactor technology developments 2020 Edition,
- Small Modular Reactors Regulators' Forum Interim reports.
- IAEA consultancy meetings

KEY AREAS OF NOVELTY IMPACTING THE REVIEW

The following generic operation novelties are taken into consideration during the review:

- Extensive use of passive design features and systems;
- Integrated designs;
- Modular construction;
- Mutualised operation;
- Mutualised plant systems;
- Staged construction;
- Optimised maintenance;
- Limited or no staff present during normal operations;
- More extensive use of remote monitoring and support centres.

KEY AREAS OF NOVELTY IMPACTING THE REVIEW

Some additional specific novelties/concerns:

- Electrical grid integration – short-term shutdowns/restarts, the ability to load follow;
- District heating systems – lengthy shutdown periods or minimal power level;
- Availability of passive safety features during periods of open containment, reactor pressure vessel;
- Testability of passive systems;
- Transportation of a fuelled reactor;
- Long refuelling period, refuelling at the factory, outage at the factory;
- Fuelling (refuelling) using irradiated fuel;
- Majority of commissioning can occur at factory;
- No local spent fuel storage.

Scope of the SSR-2/2 Rev.1

The safe commissioning and operation of a NPPs. It covers commissioning and operation up to the removal of nuclear fuel from the plant, including maintenance and modifications made throughout the lifetime of the plant. It covers the preparation for decommissioning. Normal operation and anticipated operational occurrences as well as accident conditions are taken into account.

List of relevant Safety Guides

- SSG-77 Protection against internal and external hazards in the operation of NPPs;
- SSG-70 Operational Limits and Conditions and Operating Procedures for NPPs;
- SSG-71 Modifications to NPPs;
- SSG-72 The Operating Organization for NPPs;
- SSG-73 Core Management and Fuel Handling for NPPs;
- SSG-74 Maintenance, Testing, Surveillance and Inspection in NPPs;

List of relevant Safety Guides

- SSG-75 Recruitment, Qualification and Training of Personnel for NPPs;
- SSG-76 Conduct of Operations at NPPs;
- SSG-13 Chemistry Programme for Water Cooled NPPs;
- SSG-25 Periodic Safety Review for NPPs;
- SSG-28 Commissioning for NPPs;
- SSG-48 Ageing Management and Development of a Programme for Long Term Operation of NPPs;
- SSG-50 Operating Experience Feedback for Nuclear Installations.

Review outcomes

Requirement 1: Responsibilities of the operating organization

Requirement 2: Management system

Requirement 3: Structure and functions of the operating organization

Requirement 5: Safety policy

Requirement 6: Operational limits and conditions

Requirement 9: Monitoring and review of safety performance

Requirement 11: Management of modifications

Requirement 12: Periodic safety review

Requirement 15: Records and reports

Review outcomes

Requirement 17: Consideration of objectives of nuclear security in safety programmes

Requirement 23: Non-radiation-related safety

Requirement 24: Feedback of operating experience

Requirement 26: Operating procedures

Requirement 27: Operation control rooms and control equipment

Requirement 28: Material conditions and housekeeping

Requirement 33: Preparation for decommissioning

These overarching requirements including detailed requirements are fully applicable to the operation of the 'evolutionary and innovative designs'. However, the relevant plant programmes should take into account specificity of each particular design and graded approach.

Areas of non-applicability were not identified.

Review outcomes-identified gaps

Requirement 4: Staffing of the operating organization.

Some EIDs may be operated remotely, there are situations where a very limited number of personnel are present at the site, but this is not considered.

Requirement 7: Qualification and training of personnel.

Some specific features are not considered such as: the training programme for remote operations, monitoring and control strategies for remote operations, multi-unit and multi-design site operations, and novel refuelling strategies.

Review outcomes-identified gaps

Requirement 8: Performance of safety related activities.
Safety related activities for multiple unit EIDs and EIDs with alternative operating models including autonomous systems and remote monitoring and intervention capabilities are not considered.

Requirement 10: Control of plant configuration.
Configuration management for multi-reactor modules plants, particularly with a single NPP with multi-reactor modules that may be located in shared structures, is not considered.

Review outcomes-identified gaps

Requirement 13: Equipment qualification.

The impact of higher temperatures, different chemistry, components integrated with the reactor, and the importance of capturing any lessons learnt from new operating conditions are not considered.

Requirements 14 and 16: Ageing management and programme for long term operation.

The influence of higher operating temperatures, and different chemistry and component materials are not considered. In addition, some new activities may include replacement of major modules, including in some cases a whole reactor, maintenance/refuelling that is performed off-site. Remote surveillance, inspection, and testing techniques.

Review outcomes-identified gaps

Requirement 20: Radiation protection.

The need to ensure that applicable lessons learned from operations with novel coolants, maintenance practices, and long refuelling intervals from EIDs is not considered.

Requirement 22: Fire safety.

Hazard assessments for the type of reactor coolants, and the type of combustible materials that may be present at EIDs and firefighting arrangements at multi-unit sites and where systems are shared are not considered.

Review outcomes-identified gaps

Requirement 25: Commissioning.

There is a gap regarding commissioning at the factory versus the NPP site and the role of the operator in both. In particular, R 25 does not include criticality testing at the manufacturer's site prior to transportation and the need for any additional on-site commissioning tests required to verify that the results obtained off-site are still valid at the plant. In addition, the representativeness of commissioning tests have to be demonstrated to prove that passive safety systems will perform as expected in accident conditions.

Review outcomes-identified gaps

Requirement 27: Operation control rooms and control equipment.

A gap exists for cases where NPPs may employ combinations of in-plant autonomous systems and local operator control facilities combined with the capability to be able to monitor and intervene from a remote location.

In the case of multiple units or sites of EIDs, there may be a main control room which gets data from a series of localized control rooms. Requirement is not provided on establishing a control hierarchy or on how operations should be coordinated from remote facilities.

The type and function of supplementary control room also needs further consideration.

Review outcomes-identified gaps

Requirement 29: Chemistry programme.

Consideration of the types of coolants of non-water-cooled EIDs and their impact on plant components' materials is not included.

Requirement 30: Core management and fuel handling.

R 30 does not cover:

- Fuel that has no cladding, and fuel defects in some EIDs;
- Situations where different organizations are responsible for fuel-loading and unloading if this takes place at the factory or at the site
- The electrical grid integration and in particular the resilience of the design to grid imposed short-term shutdowns and restarts and the ability to load follow.

Review outcomes-identified gaps

Requirement 31: Maintenance, testing, surveillance and inspection programmes.

The use of remote monitoring for testing, inspection, maintenance, and control is not considered. Also, the maintenance, surveillance, and periodic testing of passive equipment is not fully considered.

Requirement 32: Outage management.

The outage management may not consider simpler designs, less SSCs, replacement of major components, ability to perform maintenance activities remotely, remote surveillance, inspection and testing techniques, access to the equipment, outage frequency and, in some cases, outage work at the factory.

Review outcomes Safety Guide SSG-77, Protection Against Internal and External Hazards in the Operation of NPPs

SSG-77 is applicable to the evolutionary and innovative designs.

Identified gaps and areas for additional consideration:

- The site-specific hazards protection provisions for cases where autonomous operation with or without local on-site staff coupled with remote control and monitoring are not covered.
- Consideration on how hazards protection can still be locally assured before the arrival of off-site resources.
- Appendix I does not consider the type of reactor coolant, the type of combustible materials that might be used in an EID, the coordination of firefighting activities that would be required for a multi-module NPP. Similar issues can be highlighted for other hazards.

Review outcomes SSG-70 Operational limits and conditions and operating procedures for NPPs

SSG-70 is applicable to the evolutionary and innovative designs.

Identified gaps and areas for additional consideration:

- SG does not adequately address first of a kind NPPs. Guidance does not currently assist the user to understand that a conservative approach may be necessary in establishing OLCs.
- The development of operating procedures will need to include more frequent use of human performance error-reduction tools by operators.
- There is also a gap where remote surveillance and testing is used, so additional guidance is required to prevent situations where there is a discrepancy between site measured parameters and those measured remotely to ensure that test and surveillance results are an accurate representation of plant values.

Review outcomes SSG-71 Modifications to NPPs

SSG-71 is applicable to the evolutionary and innovative designs.

Identified gaps and areas for additional consideration:

- Some EIDs are being proposed as ‘fleets’ of standardized NPPs. This will need to be coordinated across the fleet in a controlled manner to keep tight control of the configuration at each facility.
- For the first of a kind facility, the types and natures of modifications and how they are justified to be necessary or not may represent a significant challenge.

Review outcomes SSG-72 The operating organization for NPPs

SSG-72 is applicable to the evolutionary and innovative designs.

Identified gaps and areas for additional consideration:

- EID proponents are considering different operational models that may have some staff located at the site for specific NPP activities, and potential 'fleet service facility' operating staff with a role to provide operational functions and support to the site this is not covered by current SG.
- For some EIDs, the use of 'off the shelf' manufacturing means that the site operator may not be known at the time of manufacturing. Furthermore, the responsible organization during transportation may be different from the operator. At present, the roles and responsibilities of the different types of organizations are not clear.

Preliminary review outcomes SSG-73 Plants core management and fuel handling for NPPs

SSG-73 is applicable to the evolutionary and innovative designs.

Identified gaps and areas for additional consideration:

- Fuel loading, reloading, unloading, or refuelling when it is performed at a separate off-site facility.
- How specific issues and hazards are to be handled when irradiated fuel is not stored on-site.
- The consequences of novel fuel types and fuel defects.
- Situations where different organizations are responsible for fuel-loading and unloading, regardless of whether this takes place on-site or off-site.

Review outcomes SSG-74 Maintenance, testing, surveillance and inspection in NPPs

SSG-74 is applicable to the evolutionary and innovative designs.

Identified gaps and areas for additional consideration:

- A programme that involves multiple reactor modules within a single facility and the use of shared and/or common SSCs.
- Use of technologies for autonomous and/or remote monitoring for testing, inspection, surveillance, and maintenance.
- Maintenance, surveillance, and periodic testing of systems supporting inherent and passive safety functions.
- Compact designs that cannot accommodate physical inspections or bulky inspection equipment. For example: Maintenance, surveillance, inspections, and periodic testing of equipment integrated within the reactor vessel.

Review outcomes SSG-74 Maintenance, testing, surveillance and inspection in NPPs cont.

- Ability for on-site measurement collection approaches to manage in situations where there has been a remote plant data system failure (e.g. inferring data on factors such as fluence and chemistry, when a direct measure is not possible).
- Availability of staff needed for local site activities in case of remote activities or autonomous operations failure.
- Maintenance, testing, surveillance, and inspection of a fleet of standardized technologies. This will need to be coordinated, and the lessons learned from these activities need to be shared.

Review outcomes SSG-75 Recruitment, qualification and training of personnel for NPPs

SSG-75 is applicable to the evolutionary and innovative designs.

Identified gaps and areas for additional consideration:

- The operation of multiple reactor modules from the same MCR.
- Some EID fleets may share technical staff so that an individual EID may have limited numbers of staff or even no staff present during normal operations.
- EIDs that are located in remote regions may need to operate with an unreliable or limited grid connection.
- Remote monitoring of the plant and for the execution of surveillance, testing, inspection, and maintenance activities.
- Handling and storage of both fresh and irradiated fuel at factory fueled facilities.

Review outcomes SSG-76 Conduct of operations at NPPs

SSG-76 is applicable to the evolutionary and innovative designs.

Identified gaps and areas for additional consideration:

- The operation of multiple reactor modules from the same MCR and plant systems shared by all or some reactor modules;
- Use of autonomous and remote monitoring and intervention technologies in plant operations both from on-site and off-site;
- Assurance of human factors and human performance in consideration of novel operator aids/tools and communications equipment between the plant and remote-control centre operations facilities.

Review outcomes SSG-13 Chemistry programme for water cooled NPPs

SSG-13 is applicable to the evolutionary and innovative designs. (Not applicable for not water cooled NPPs)

Identified gaps and areas for additional consideration:

- SG include specific guidance on primary coolant chemistry in different WCR types. The guidance might not be fully applicable or comprehensive for novel fuel designs.
- SG include guidance on secondary circuit water chemistry, which are also applicable to, but might not be comprehensive for, non-water-cooled EIDs, if they utilize water in a secondary or tertiary circuit (such as SFRs) to generate subcritical steam.

Preliminary review outcomes SSG-25 Periodic safety review for NPPs

SSG-25 is applicable to the evolutionary and innovative designs.

Identified gaps and areas for additional consideration:

- No gap was found.

Preliminary review outcomes SSG-28 COMMISSIONING FOR NPPs

SSG-28 is applicable to the evolutionary and innovative designs.

Identified gaps and areas for additional consideration:

- Commissioning of a modular NPP. Common SSC may require certain commissioning activities to take place as the first modules are installed and placed into service.
- Commissioning of the unit may have the objective to demonstrate/verify the compatibility with the existing units.
- Commissioning at the factory, including operating organization involvement. A further set of on-site commissioning tests will have to be performed to check that the results obtained off-site are valid for the plant.
- Common system performance when adding units or modules and whether additional or new or repeated commissioning tests may be needed.

Preliminary review outcomes SSG-48 AGEING MANAGEMENT AND DEVELOPMENT OF A PROGRAMME FOR LTO OF NPPs

SSG-48 is applicable to the evolutionary and innovative designs.

Identified gaps and areas for additional consideration:

There is a gap regarding chemistry of all “fluid-filled” systems within a chemistry programme including the different primary, secondary, and tertiary circuit coolants and component materials.

Review outcomes SSG-50 Operating experience feedback for nuclear installations

SSG-50 is applicable to the evolutionary and innovative designs.

Identified gaps and areas for additional consideration:

- No gap was found.

CONCLUSIONS

- Safety standards for operation of NPPs, SSR-2/2 Rev.1 and relevant Safety Guides are applicable to the evolutionary and innovative designs.
- Areas of non-applicability were not identified.
- Gaps or needs for additional considerations are described.
- Requirements18 Emergency preparedness, 19 Accident management programme and 21 Management of radioactive waste are evaluated separately.

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IAEA webinar: Review of Applicability of Safety Standards to 'evolutionary and innovative designs (EIDs)'

GSR Part 2 and associated Safety Guides

Miroslav Lipar, senior consultant, Slovakia

30 August 2022

Contents

- Objective and scope
- Key areas of novelty relevant for the review
- Scope of GSR Part 2
- List of relevant Safety Guides
- Review outcomes
- Conclusions

Objective

Presentation of the results of the high-level review and gap analysis for the applicability of the GSR Part 2, Requirements for Leadership and Management for Safety and relevant Safety Guides in relation to the Leadership and Management for Safety of NPPs of ‘evolutionary and innovative designs’(EIDs).

Scope of the review

- The main topical areas for which the Safety Requirements and Safety Guides provides requirements and recommendations are the following:
- Responsibility for safety (R 1)
- Leadership for safety (R 2)
- Management for safety (R 3-11)
- Culture for safety (R 12)
- Measurement, assessment and improvement (R 13-14)

KEY AREAS OF NOVELTY IMPACTING THE REVIEW

Information regarding novelties is from the following documents:

- Questionnaires for EIDs vendors,
- Advances in small modular reactor technology developments 2020 Edition,
- Small Modular Reactors Regulators' Forum Interim reports.
- IAEA consultancy meetings

KEY AREAS OF NOVELTY IMPACTING THE REVIEW

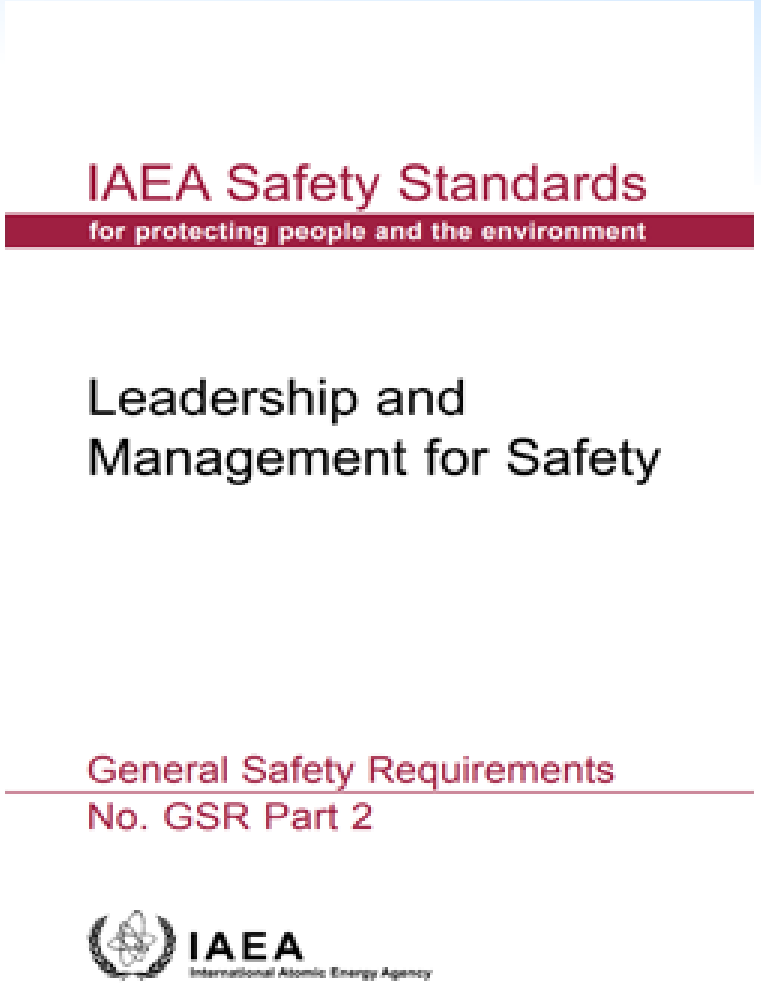
The following generic novelties are taken into consideration:

- Integrated designs;
- Modular construction;
- Staged construction and operation;
- Extensive use passive features and systems;
- NPPs integrated with external industrial process facilities;
- More extensive use of autonomus and remote monitoring and support centres and remote operation approaches tied to alternative staffing arrangements;
- Ownership
- Supply Chain Management (SCM).

Scope of the GSR Part 2

The requirements apply to types of facilities and activities that give rise to radiation risks, as follows:

(a) Nuclear installations (including nuclear power plants; research reactors (including subcritical and critical assemblies)



List of relevant Safety Guides

- SSG-72 The Operating Organization for Nuclear Power Plants;
- GS-G-3.1 The Application of Management Systems to Facilities
- GS-G-3.5 The Management System for Nuclear Installations

Review outcomes

Requirement 1: Achieving the fundamental safety objective

Requirement 2: Demonstration of leadership for safety by managers

Requirement 3: Responsibility of senior management for the management system

Requirement 4: Goals, strategies, plans and objectives

Requirement 5: Interaction with interested parties

Requirement 6: Integration of the management system

Requirement 7: Application of the graded approach to the management system

Review outcomes

Requirement 8: Documentation of the management system

Requirement 9: Provision of resources

Requirement 10: Management of processes and activities

Requirement 13: Measurement, assessment and improvement of the management system

Requirement 14: Measurement, assessment and improvement of leadership for safety and of safety culture

These requirements are fully applicable to the Leadership and Management for safety of ‘evolutionary and innovative designs’

Review outcomes

Requirement 11: Management of the supply chain

Overarching requirement 11 and detailed requirements 4.33-4.36 are fully applicable to the Leadership and Management for Safety of the 'evolutionary and innovative designs'.

The following potential gaps were identified:

- Oversight and quality control of suppliers in cases where the future owner and operator are not known.
- Guidance for targeted inspection of quality compliance, together with checks of quality assurance arrangements and the management of deviations.
- In view of some novel ideas of ownership that have been proposed (e.g. leasing of reactors), the standard may not cover who has the responsibility for safety, especially when the ownership arrangements are made between two Member States.

Review outcomes

Requirement 12: Fostering a culture for safety

„ Individuals in the organization, from senior managers downwards, shall foster a strong safety culture. The management system and leadership for safety shall be such as to foster and sustain a strong safety culture. “

Overarching requirement 12 and detailed requirements 5.1-5.2 are fully applicable to the Leadership and Management for Safety of the ‘evolutionary and innovative designs’.

The current text does not cover the need by the Licensee to instil an appropriate nuclear safety culture amongst its suppliers and contractors at all tiers in the supply chain.

Review outcomes SSG-72 The operating organization for nuclear power plants

SSG-72, part related to the Leadership and Management for Safety is fully applicable of the ‘evolutionary and innovative designs’.

However, the described areas of novelty should be taken into account.

Review outcomes GS-G-3.1 The Application of Management Systems to Facilities

GS-G-3.1 is fully applicable for the 'evolutionary and innovative designs'. However, the described novelties should be taken into account.

The followings gaps/need for guidelines have been identified:

- Oversight and quality control over supply chains that are increasingly complex and international and may also include non-nuclear suppliers.
- Ownership and operating models for fleets of geographically dispersed EIDs may diverge from the traditional norm of a single owner-operator-licensee.
- Responsibilities for demonstrating regulatory compliance, suitability, quality control and other relevant characteristics when procuring first of a kind components and services and commercial grade components in cases where the future licensee is not known.

Review outcomes GS-G-3.5 The Management System for Nuclear Installations

GS-G-3.5 is fully applicable for the 'evolutionary and innovative designs'. However, the described novelties in should be taken into account.

The followings gaps/need for guideline have been identified:

- Licensee resources for oversight and quality control of suppliers considering different, and possibly more complex, supply chains compared to those traditionally used for WCRs.
- Ownership and operating models for fleets of geographically dispersed EIDs.

CONCLUSIONS

- Safety standards for Leadership and management for safety and relevant Safety Guides are applicable to the ‘evolutionary and innovative designs’.
- Areas of non-applicability were not identified.
- There are some areas that need further consideration.

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Thank you!

Questions?

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LEGAL AND REGULATORY FRAMEWORK ASPECTS APLICABILITY OF IAEA SAFETY STANDARDS TO SMRs

Webinar on Applicability of IAEA Safety Standards to the Safe Operation and Regulation of Evolutionary and Innovative Reactor Designs including SMRs

30 August 2022

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Department of Nuclear Safety and Security (NS)
International Atomic Energy Agency (IAEA)

Outline

- Objective, Background and Regulatory Challenges
- Applicability of IAEA Safety Standards to Evolutionary and Innovative Design (EID) technologies
- Licensing of Nuclear Installations - SSG-12 Revision
- Gathering Experience in Licensing SMRs

Objective

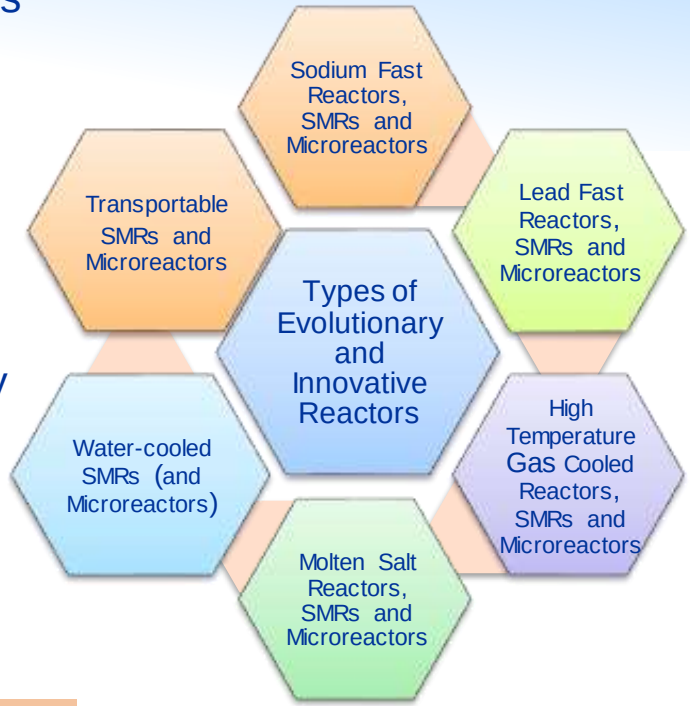
Present the challenges of regulating evolutionary and innovative designs (EIDs) and IAEA undertakings to resolve the gaps of the Safety Standards on the legal and regulatory framework requirements and guides.

Background

Growing interest in these technologies due to many factors

Evolutionary and innovative reactors can be very different from the current operating fleet:

- Different neutron spectrum
- Different coolants and moderators
- Simplified designs and passive means to maintain safety
- Advances in engineering, materials, manufacturing
- Serial factory, modular construction and standardization
- Deployment models and transportation



Are IAEA safety standards currently in use sufficient and relevant to ensure the safety of these innovative designs?

Regulatory Challenges (1)

- Large number of innovative designs (first of kind)
  - IAEA booklet on SMRs (2020)
- Unproven technology
  - Comprehensive analyses, simulations, and testing needed to close knowledge gaps
  - New design philosophy
  - New materials
  - New safety systems strategies
- Lack of operational experience
- Implications of SMR supply chain on licensee's core safety capabilities
- Faster construction time

Regulatory Challenges (2)

- New deployment approaches
  - Serial production, largely in factories
  - Factory fuelling
  - Transport to final location
  - Factory (partial) commissioning
  - More than one regulatory jurisdiction involved in licensing/regulatory review

- Regulatory processes need to be adapted, as appropriate
  - Rules and Regulation
  - Safety Requirements and Guides

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Legal and Regulatory Framework

Governmental, Legal and Regulatory Framework for Safety (GSR Part 1 (REV.1))

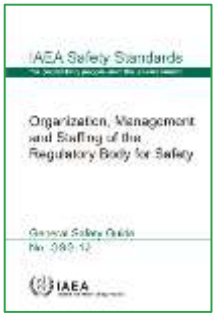
Organization, Management and Staffing of the Regulatory Body for Safety (GSG-12)

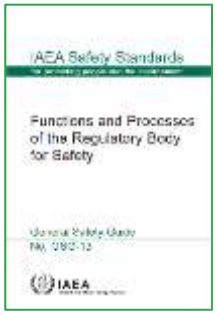
Functions and Processes of the Regulatory Body for Safety (GSG-13)

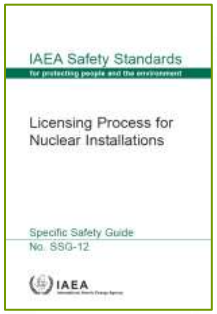
Licensing Process for Nuclear Installations (SSG-12)

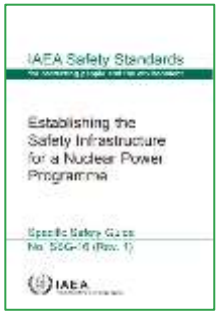
Communication and Consultation with Interested Parties by the Regulatory Body (GSG-6)

Establishing the Safety Infrastructure for a Nuclear Power Programme (SSG-16 Rev.1)

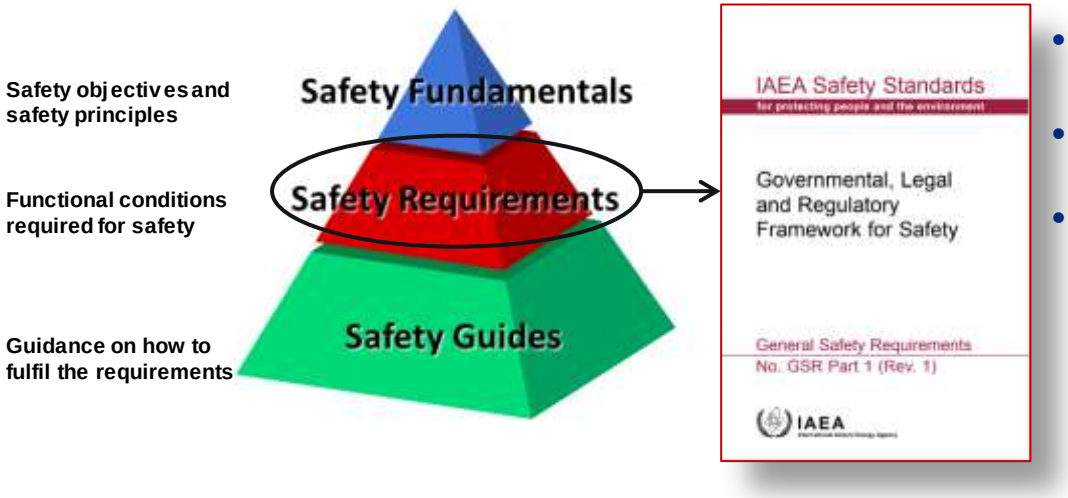








Safety Requirements GSR Part 1 (Rev. 1), Governmental, Legal and Regulatory Framework for Safety



- Published in 2016
- 36 requirements (technology neutral)
- Main purpose is to help Member States to develop laws and an effective regulatory body to adequately ensure the safety of nuclear facilities.

Safety Requirements GSR Part 1 (Rev. 1), Governmental, Legal and Regulatory Framework for Safety – Review findings

- **Areas of applicability**

  All requirements are applicable to EID.

- **Areas of non-applicability**

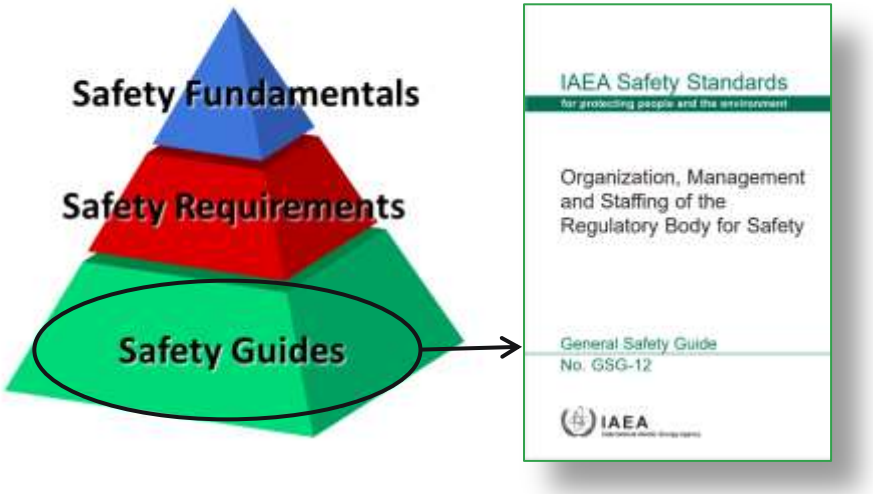
  Not identified.

- **Identified gaps and areas for additional consideration**

  Deployment models guidance on:

  - RB effective cooperation, assistance, and sharing of experience
  - Transfer or sharing of oversight from one RB to another,
  - Potential sharing of regulatory responsibilities for the different stages of the lifetime of the facility.

Safety Guide GSG-12, Organization, Management and Staffing of the Regulatory Body for Safety



- Published in 2018
- Outlines recommendations on the organizational structure, management, and staffing of a regulatory body to support this body in carrying out its responsibilities and functions efficiently, effectively, and in an independent manner.

Safety Guide GSG-12, Organization, Management and Staffing of the Regulatory Body for Safety – Review findings

- **Areas of applicability**

  All recommendations in GSG-12 are applicable to Evolutionary and Innovative Design (EID) technology and deployment.

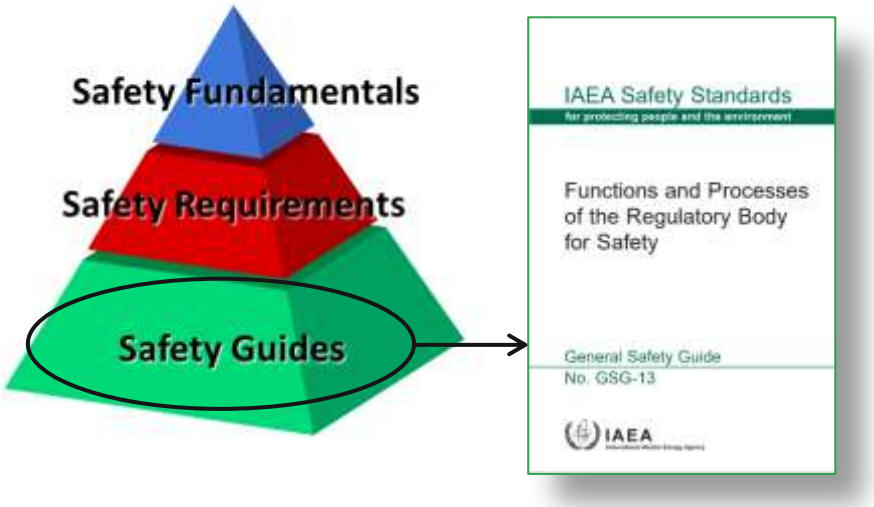
- **Areas of non-applicability**

  No specific areas of non-applicability were identified.

- **Identified gaps and areas for additional consideration**

  Guidance on regulatory oversight of many (similar) small reactors, scattered over a country and in remote areas (possibly with limited infrastructure).

Safety Guide GSG-13, Functions and Processes of the Regulatory Body for Safety



- Published in 2018
- Outlines recommendations on the regulatory body's core functions and the associated processes to implement these functions
- GSG-13 partially supersedes SSG-12 and needs to be read in conjunction with it and with GSG-12.

Safety Guide GSG-13, Functions and Processes of the Regulatory Body for Safety – Review findings

- **Areas of applicability**

  All recommendations are applicable EID.

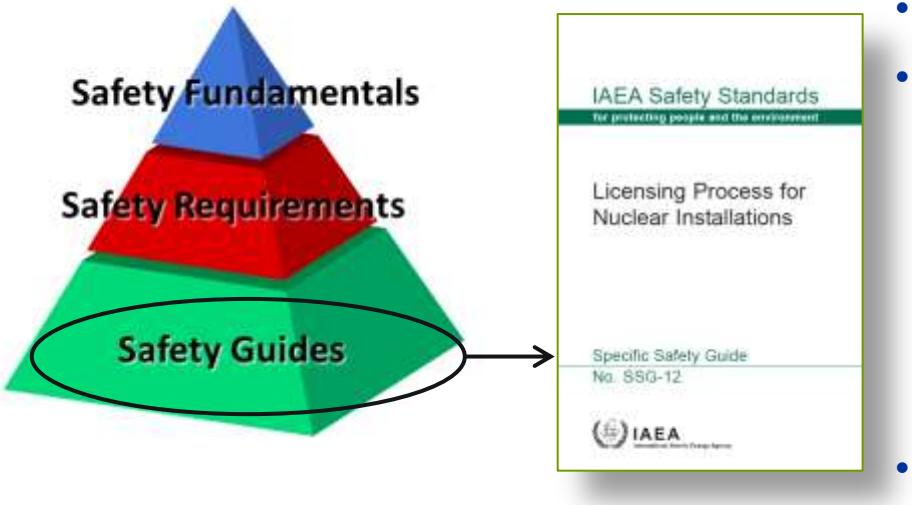
- **Areas of non-applicability**

  Not identified.

- **Identified gaps and areas for additional consideration**

  Explicit guidance on the need for early engagement of the regulator(s) by the designers when developing new designs.

Safety Guide SSG-12, Licensing Process for Nuclear Installations



- Published in 2010
- Outlines recommendations on how the licensing process should be applied at the various stages of the lifetime of a nuclear installation, with discussion of the topics and required documents to be considered at each stage.
- SSG-12 was partially superseded by GSG-13 and needs to be read in conjunction with it and with GSG-12.

Safety Guide SSG-12, Licensing Process for Nuclear Installations – Review findings

- **Areas of applicability**

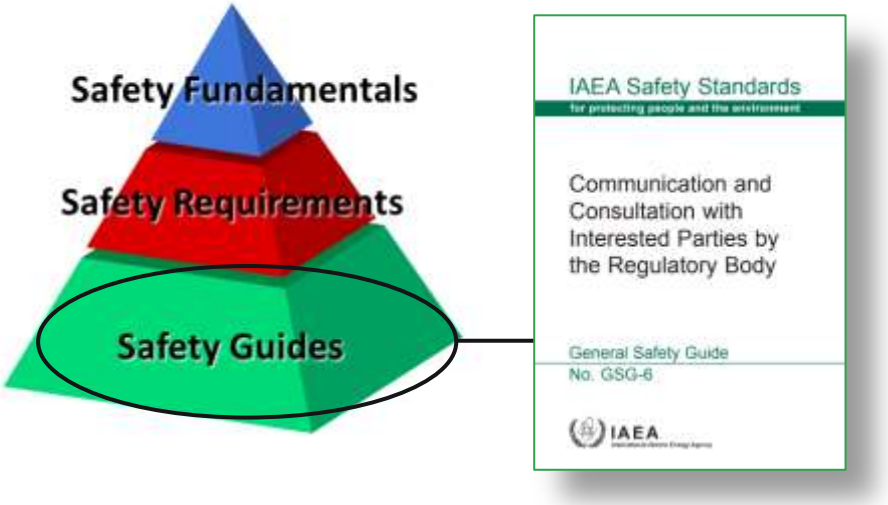
  All recommendations are applicable to EID.

- **Areas of non-applicability**

  Not identified.

- **Identified gaps and areas for additional consideration**
  - Guidance on
    - Early interactions/engagement between the designer and the regulator
    - RB Independent decisions x increased efficiency and minimized duplication.
    - Potential for sharing of regulatory responsibilities.
  - EID deployment models

Safety Guide GSG-6, Communication and Consultation with Interested Parties by the Regulatory Body



- Published in 2017.
- Provides recommendations on meeting the safety requirements concerning communication and consultation with the public and other interested parties by the regulatory body.

Safety Guide GSG-6, Communication and Consultation with Interested Parties by the Regulatory Body – Review findings

- **Areas of applicability**

  All recommendations are applicable to EID.

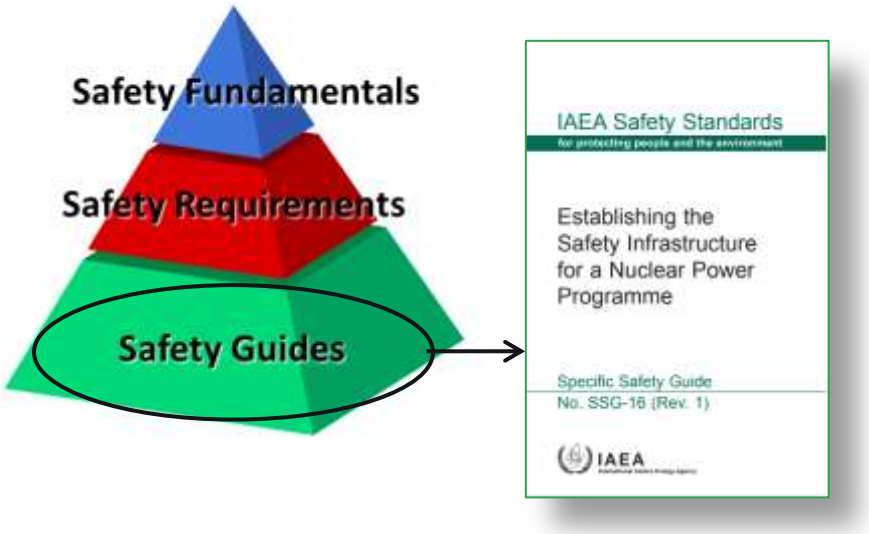
- **Areas of non-applicability**

  Not identified.

- **Identified gaps and areas for additional consideration**

  Not identified.

Specific Safety Guide SSG-16 (Rev. 1), Establishing the Safety Infrastructure for a Nuclear Power Programme



- Published in 2020 (Rev.1)
- Provides guidance for the establishment of the safety infrastructure for a nuclear power programme in the first three phases:
  1) Before a decision to launch a nuclear power programme;
  2) Preparatory work for the construction of a nuclear power plant (NPP); and
  3) Activities to implement the first NPP.

Specific Safety Guide SSG-16 (Rev. 1), Establishing the Safety Infrastructure for a Nuclear Power Programme – Review findings

- **Areas of applicability**
  - Overall, the recommendations are considered generally applicable to EID.
- **Areas of non-applicability**
  - Not identified.
- **Identified gap and areas for additional consideration**
  - If the referenced safety requirements are revised due to gaps, then SSG-16 needs to be updated.
  - Some actions and explanatory texts could require revisions to cover all types of EIDs and deployment models.

Summary Table

SAFETY STANDARDS FOR THE LEGAL AND REGULATORY FRAMEWORK FOR SAFETY

Safety Standards		Main Limitation
GSR Part 1	Governmental, Legal and Regulatory Framework for Safety	Foreign manufacture
GSG-12	Organization, Management and Staffing of the Regulatory Body for Safety	-
GSG-13	Functions and Processes of the Regulatory Body for Safety	FOAK and early engagement with Regulatory Body Foreign manufacture
SSG-12	Licensing Process for Nuclear Installations	
GSG-6	Communication and Consultation with Interested Parties by the Regulatory Body	-
GSG-9	Regulatory Control of Radioactive Discharges to the Environment	Underground EIDs
SSG-16 (Rev. 1)	Establishing the Safety Infrastructure for a Nuclear Power Programme	Various updates

No applicability considerations

Small number of applicability considerations or very small impact on the safety standard

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- Gathering Experience in Licensing SMRs

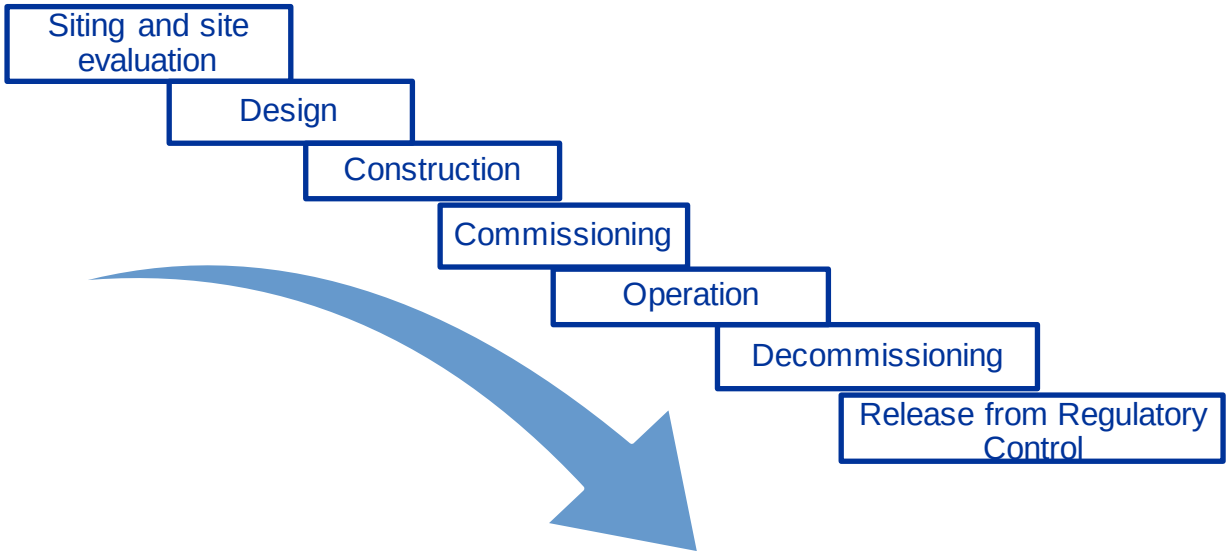
Licensing Stages

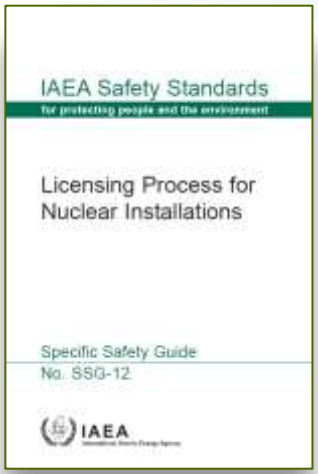
GSR Part 1 - Requirement 24: Demonstration of safety for the authorization of facilities and activities

§4.29 Different types of authorization shall be obtained for the different stages in the lifetime of a facility or the duration of an activity. The regulatory body shall be able to modify authorizations for safety related purposes.

Licensing Stages for NPPs

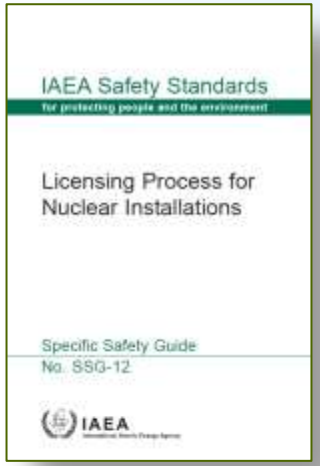
Life of a nuclear installation includes 7 major steps





Licensing Process for Nuclear Installations (SSG-12)
Background

- The Safety Guide provides recommendations on the licensing process for nuclear installations;
- It is a supporting guide to GSR Part 1;
- TECDOC-2003, Lessons Learned in Regulating Small Modular Reactors
- Recommendations by the SMR Regulators' Forum



Licensing Process for Nuclear Installations
SSG-12 Revision

Changes needed to provide guidance on:

- Collaboration among regulators of different member states
- Adaptation of the licensing process for newly proposed deployment models for SMRs
- Regulatory bodies collaboration when the licensing process is applied simultaneously to SMRs by two or more jurisdictions.

"Deployment model" is understood as the approach taken for the deployment of a NPP that will impact the general ownership of the NPP, the responsibility for the lifetime of the NPP including operation, decommissioning and management of spent fuel and radioactive waste, and the responsibility for liability for nuclear damage in case of a nuclear accident.

Licensing Process for Nuclear Installations
SSG-12 Revision

- Address potential changes or adjustments to the licensing process in the case of licensing of first of a kind (FOAK) reactors – safety demonstration

- New Appendixes with recommendations to:
  - Support regulatory bodies collaboration
  - Reduce regulatory burden for designs deployer in more than one country

Licensing Process for Nuclear Installations
SSG-12 Revision

The revision was initiated to:

- Ensure consistency with other IAEA document in the hierarchy published after 2010
- Incorporate the current international state of practice in IAEA Member States
- Include the feedback from working groups on licensing and technology challenges of nuclear installations
- Incorporate guidance to facilitate collaboration among regulatory bodies

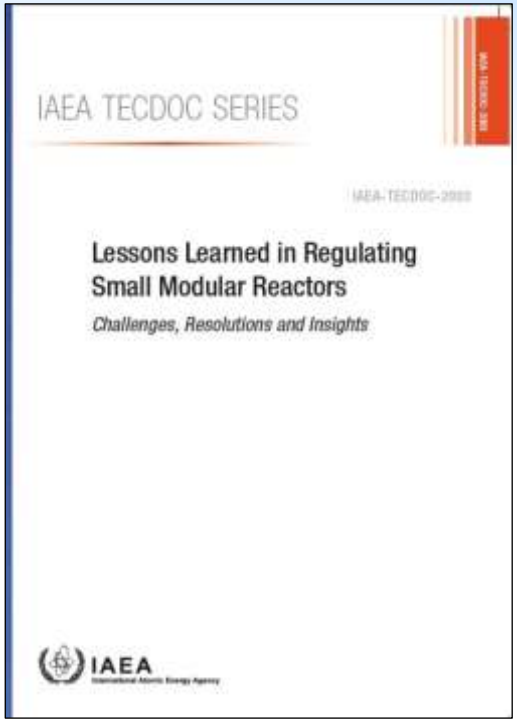
Due to the large scope of the Guide, all Standards Committees were involved in the review

Outline


Objective, Background and Regulatory Challenges
Applicability of IAEA Safety Standards to Evolutionary and Innovative Design (EID) technologies
Licensing of Nuclear Installations - SSG-12 Revision
Gathering Experience in Licensing SMRs

Gathering Experience in Regulating SMRs
TECDOC-2003

- Compiling experience of Member States which:
  - Have gone through the process of licensing and regulating SMRs; or
  - Have worked intensively in preparing to licensing SMRs.
- Developed a set of questions about challenges in different areas and how they resolved them.
- The questionnaire covered challenges to framework, safety requirements, licensing process and regulatory approach, inspection, security, safeguards, etc.



Gathering Experience on Licensing SMRs

SMR Regulators' Forum (SMR RF)

What is the Forum?

Regulator-to-Regulator group with 11 participating countries

Members

- Canada
- China
- Czech
- Finland
- France
- Japan
- Republic of Korea
- Russian Federation
- South Africa
- United Kingdom
- United States

Observers

- European Commission (JRC)
- OECD Nuclear Energy Agency
- WNA-CORDEL

Scientific Secretariat (IAEA)

Gathering Experience on Licensing SMRs

SMR RF's Timeline

2012
First talks about creating an international forum to discuss regulatory issues for SMRs

2013
Several IAEA MS express interest at the INPRO Dialogue Forum on Licensing and Safety Issues for SMRs

2014
The IAEA organizes 2 consultancy meetings resulting in the preparation of draft ToRs and a Pilot Project Plan

2015
Two-year pilot project (Phase 1) starts

2017
Definition of Phase 2 topics of work

2018
Publication of the Pilot Project Report

Work on Phase 2 starts

2019
Publication of interim reports on Phase 2 topics

2020
Definition of Phase 3 topics of work

Work on Phase 2 reports continues

2021
Publication of Phase 2 reports (May 2021)

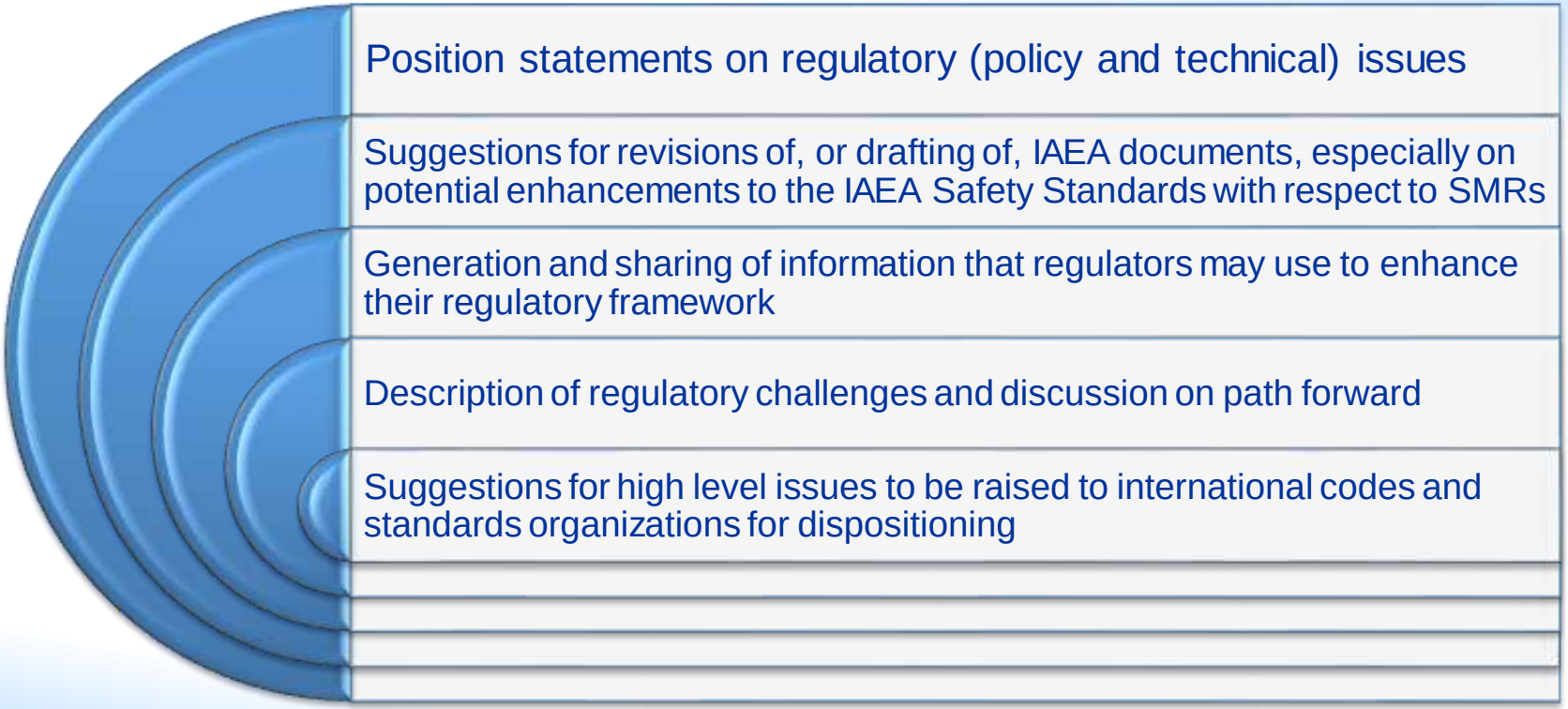
Work on Phase 3 starts

2022
Publication of interim reports on Phase 3 topics

Work on Phase 3 continues

Gathering Experience on Licensing SMRs

SMR RF's Outcomes



Gathering Experience on Licensing SMRs

SMR RF - Working Group Topics

1st Phase	2nd and 3rd Phases
• Graded Approach • Defense in Depth • Emergency Planning Zone	• Licensing Issues • Design and Safety Analysis • Manufacturing, Construction, Commissioning, and Operations

3rd Phase
In Progress Now

1st and 2nd Phase Reports are published on the website
https://www.iaea.org/topics/small-modular-reactors/smr-regulators-forum

IAEA's Nuclear Harmonization and Standardization Initiative (NHSI)

- A roadmap with concrete actions and milestones for technology holders and operators
- A roadmap with concrete actions and milestones for increasing regulatory collaboration towards global harmonisation in the pre-licensing process, and international certification of selected SMR designs

NHSI - Regulatory Track

- NHSI-RT-WG1: Building a framework for sharing of technical information among regulators
- NHSI-RT-WG2: International pre-licensing regulatory design review process for a generic design
- NHSI-RT-WG3: Process for leveraging other regulatory bodies' reviews

SMRRF support of NHSI-RT-WG3

Licensing WG
- Framework for mutual recognition of regulators' assessment/joint assessments/ collaboration - Harmonization
The Forum Terms of Reference had to be amended to allow the cooperative work with non-Forum members and the production of an IAEA Document

NHSI-RT-WG3
- Process for leveraging other regulatory bodies' reviews

Work to start In October 2023

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Thank you!

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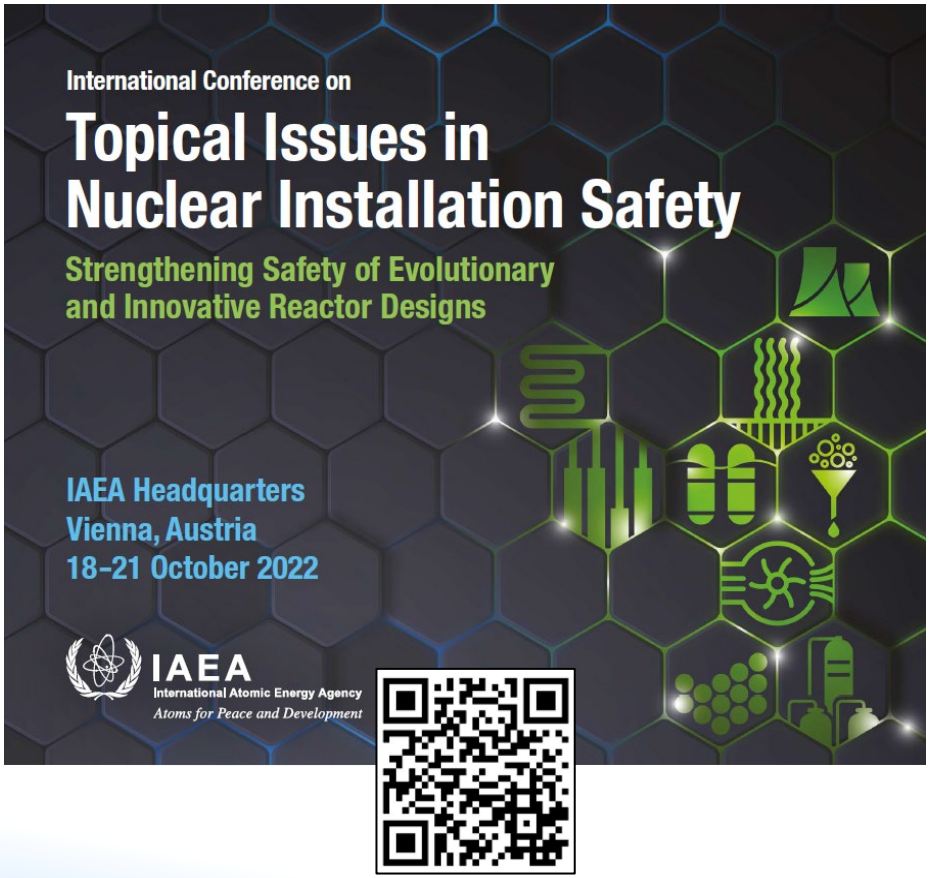
Q&A

Please type your question into the chat.

TIC2022 conference



- **Registrations are open (no deadline!)**
- **Virtual and in person attendance**

Topic 1. Safety approaches to innovative reactor technologies

Topic 2. Safety of innovative design features

Topic 3. Safety/risk analyses to support integrated decision making

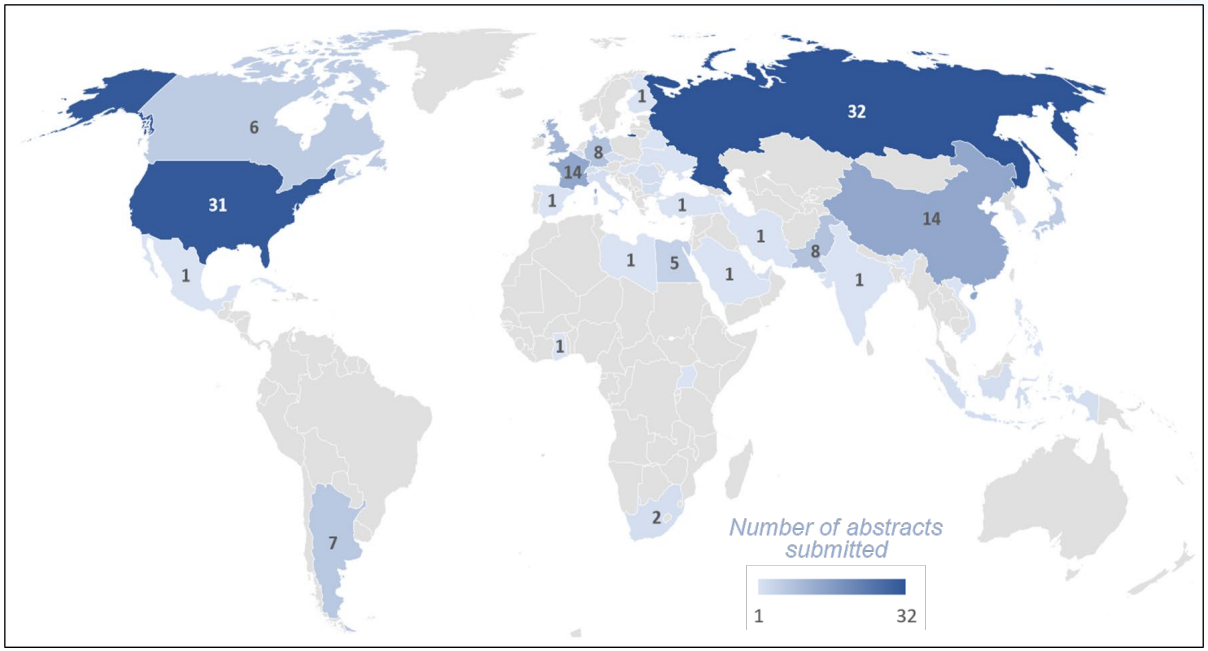
Topic 4. Accelerating innovations for safety assessment through the advanced simulation and modelling, and experimental programmes

Web-site: https://www.iaea.org/events/tic-2022

Contact: tic-2022@iaea.org

TIC2022 conference (stats and key messages)

- **Robust safety demonstration** is a paramount prerequisite for deployment of innovative reactors
- **Harmonization of safety approaches** is vital (IAEA NHSI initiative)
- **IAEA Safety Standards** are a key international reference for safety of innovative reactors
- **Unique time window to implement 3S** by design for innovative reactors (Safety, Security and Safeguards)



Around 200 abstracts *received from* ***39*** *Member States and* ***4*** *International Organisations (ECJRC, IAEA, OECD/NEA, WNA)*

Webinar series continuation

- **Webinar** on Safety Analysis for Evolutionary and Innovative reactors

- **Registration** will be soon available here: https://www.iaea.org/ns-webinars/nuclear-installation-safety

- **When:** January 2023

- **Topics** to be covered:
  - Applicability of IAEA Safety Standards on Safety Analysis for various technologies
  - Challenges and experiences on DSA
  - Challenges and experiences on PSA
  - DSA & PSA integration

- Please look for the recording of this webinar posted to the webinar page in the next few days
- Feel free to share with any colleagues who may be interested.

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Thank you!