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Participants' Briefing Handout

DISCUSSION GROUP 3:

Application of Graded Approach in Regulatory and Licensing Process

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1. Background Information

The implementation of SMRs requires that defence in depth principles be applied to ensure the health and safety of persons and the protection of the environment.

Levels of defence in depth	Objective	Essential means
Level 1	Prevention of abnormal operation and failures	Conservative design and high quality in construction and operation
Level 2	Control of abnormal operation and detection of failures	Control, limiting and protection systems and other surveillance features
Level 3	Control of accidents within the design basis	Engineered safety features and accident procedures
Level 4	Control of severe plant conditions, including prevention of accident progression and mitigation of the consequences of severe accidents	Complementary measures and accident management
Level 5	Mitigation of radiological consequences of significant releases of radioactive materials	Off-site emergency response

Existing guidance documents are mostly focussed on addressing the safety of large nuclear power plants (NPPs). There are significant differences in the risks associated with SMRs, as compared to NPPs. For example, compared to NPPs, SMRs may exhibit (depending on design, site location, etc):

- Small power output (low decay heat)
- Fully passive safety features
- Modular design
    - Modular construction
    - Several modules at one site

  - Mass production of a standardised design
- Remote location

Regardless of the size of the reactor, the measures that are applied to ensure safety should be commensurate with the risk associated with the reactor. This implies that a graded approach to meeting safety requirements should be applied to SMRs.

2. List of consolidated issues for this topic

The topics to be discussed are:

1) Application of Graded Approach to Emergency Planning and Accident Response **(Cross-cutting with Groups 1 and 2)**
2) Demonstration of Innovative Features **(Cross-cutting with Group 1)**
3) Research & Development Programmes **(Cross-cutting with Group 1)**
4) Safety Analysis – Codes & Methodology **(Cross-cutting with Group 1)**
5) Instrumentation and Controls – Increased Use of Automation **(Cross-cutting with Group 1)**
6) Plant Staffing **(Cross-cutting with Groups 1 and 4)**
7) Licensing Process for Multiple Modules **(Cross-cutting with Group 1 and 4)**

3. Brief description of each issue

1) Issue: Application of Graded Approach to Emergency Planning and Accident Response
Brief description Concept and background - Emergency planning is part of level 5 Defence in Depth - SMRs may be proposed to be installed near populated areas or in very remote regions. Both of these scenarios present additional challenges to emergency planning. Because risks from radiation exposures may be only a fraction of that from a larger Nuclear Power Plant it may be possible to apply grading to some emergency planning requirements without impacting on the ability to respond to accidents. Specific sub-issues and concerns to be discussed and addressed

- Can core inventory be tied to the application of grading of emergency response requirements?
- Can the other 4 defence is depth levels be strengthened to permit this grading?
- Some Member States have an exclusion zone limit; can this be relaxed based on the analysis of dose rates under a worst possible scenario?
- Can site boundary play a role? (If it can be demonstrated that there are no radiological consequences beyond site boundary for public, only an emergency notification may be necessary and emergency planning measures such as evacuation may not be required).

The emergency procedures and mockup drills are very important to address public concerns to ensure public acceptance.

- Malevolent acts addressed in design should be addressed through off/on site accident management procedures and inherent safety features
- Effective emergency response plan

2) Issue: Demonstration of Innovative Features

Brief description

Concept and background

- Some SMR designs will utilize innovative / novel design features to enhance inherent safety and economy. These features are intended to result in enhanced defense in depth (DID) with more independence within DID. It is necessary to achieve higher safety & reliability. It is also necessary to demonstrate the reliability of satisfactory functioning of these systems before implementation.

Specific sub-issues and concerns to be discussed and addressed

- Design characteristics of innovative features
- Fundamental requirements that should be addressed when proposing the use of innovative / novel design features in a facility safety case for example, the proposal shall:
  - demonstrate that safety as a whole will not be compromised
  - be considered in an overall defence-in-depth context
  - be supported by documented and traceable evidence including quality assured:
    - research and development activities (e.g. experiments, peer-reviewed papers)
    - calculations and analyses
    - results from validated models
  - identify any applicable codes and standards and limitations imposed by them
  - where proposing the use of alternative codes and standards, include a gap analysis that indicates that gaps between the proposed codes and standards and the accepted

national codes and standards are understood and will be addressed - Validation and licensing strategy of innovative features - What can really be construed as inherently safe?
3) Issue: Research & Development Programmes
Brief description Concept and background - R&D studies are essential to ensure that innovative/novel features work as per design intent and experimentally verified. Specific sub-issues and concerns to be discussed and addressed - R&D studies should be such that confidence levels on the performance of innovative features/systems should be same or better than for existing facilities. - Experimental plans for innovative features.
4) Issue: Safety Analysis – Codes & Methodology
Brief description Concept and background - In some cases, it may be necessary to develop new safety analysis codes and methodologies or even to adapt existing ones for use when analyzing SMR behaviour for a safety case. The analysis codes should be validated against suitable international benchmarks. Specific sub-issues and concerns to be discussed and addressed - Development of safety analysis - Development of methodology (conservative deterministic method, best-estimate conservative deterministic method, risk-informed deterministic method)
5) Issue: Plant Staffing

Brief description

Concept and background

- Some SMR designs may propose higher levels of automation as an approach to reduce human interactions that may lead to events due to human factors issues. In fact, for some very small SMR designs, there are proponents proposing the full automation of the reactor facility with remote monitoring and control from offsite. There is a need to discuss the state of research on the increased use of automation and reduced staffing and the resultant human factors issues.

Specific sub-issues and concerns to be discussed and addressed

- How are human factors requirements tied to instrumentation and control requirements such that the two work in harmony when addressing a safety case proposing increased use of automation?
- Are new requirements and guidance needed to address remote monitoring and operation?
- Licensing process for different environmental condition and life cycle
- Increased use of automation
- More automation can also mean less vigilance, how does one strike a balance?

6) Issue: Licensing Process for Multiple Modules

Brief description

Concept and background

Some SMR designs propose to use multiple modules on a site that may or may not share systems important to safety. Multiple module facilities are a new concept for some countries, but not all. As a result, some countries are seeking input on the strategy to licence multiple module facilities . These include legal, safety, and environmental concerns.

Specific sub-issues and concerns to be discussed and addressed

- What are existing member state strategies for licensing multiple module facilities?
- Are common SSCs encompassed by a different licence from the reactor modules
- How are modules of different vintages addressed? (if installed and placed in service over a long period of time)
- Public acceptance

4. Breakout Session Organization

4 Format of Session:

- Topic Lead, Co-Lead, IAEA staff member in role as facilitators
- If less than 10 attendees: A single discussion group
  If more than 10 attendees: Multiple discussion groups of no less than 5 people.

4.1 List of Necessary Session Materials:

The following will be provided in each room

- Electronic copy of IAEA PowerPoint template, and Topic Report template (for use by rapporteur to produce a topical report and presentation for the Plenary)
- A copy of this planning sheet for all participants
- 1 reference copy of the Terms of Reference of the Dialogue Forum
- 3 reference copy of each of the following IAEA Specific Safety Guides :
  - Safety of Nuclear Power Plants: Design - Specific Safety Requirements Series No. SSR-2/1
  - Fundamental Safety Principles
    No. SF-1
  - Establishing the Safety Infrastructure for a Nuclear Power Programme - Specific Safety Guide No. SSG-16
  - Licensing Process for Nuclear Installations - Specific Safety Guide
    No. SSG-12
  - Use of a Graded Approach in the Application of the Safety Requirements for Research Reactors – Specific Safety Guide SSG-22
  - Proposal for a Technology-Neutral Safety Approach for New Reactor Designs IAEA-TECDOC-1570

4.2 Discussion Process Outline

Presentation 1 by Lead – 15 minutes - Brief overview of how the discussions are to proceed.

Presentation 2 by IAEA technical facilitator knowledgeable in use of Graded Approach – 30 min.

Confirm with attendees whether there are additional issues over and above those listed in this document that:

- should be discussed in this forum
- are noteworthy to point out to the IAEA for future discussions at a later date

Confirm Priority of issues and decide how go through them (e.g., one group or sub-groups based on number of issues)

The results of discussions of each issue should reflect primarily the views of technology users and regulators but be well-informed by the views of other valuable attendees (vendors, industry groups, regulator forums)

- The primary focus of the discussions should discuss where gaps in IAEA guidance and requirements may exist for SMRs
- Paths forward to be addressed by the IAEA should be discussed with attending IAEA representative to ensure it is reasonable and workable
- Paths forward should also address Member State roles
- Where no agreement can be reached for a discussion, the reason for the lack of agreement should be recorded such that the differing viewpoints can be understood

At the end of each breakout session day, the topic rapporteur collects all the group results and documents them for use in the official topic report.

All Session Leaders are expected to report at a plenary session on the status of their work, identifying progress, challenges and any needed programme adjustments such as reassignments, combining groups etc.

On Thursday, the group should focus efforts on finalizing the topic report and presentation for the Plenary. Sufficient time should be allowed for the preparation of the presentations that will be delivered on the last day of the workshop.

The material presented at the Plenary will be used as basis for the final topic report that will be sent to the IAEA secretariat three weeks following the workshop. The IAEA secretariat will consolidate the input from all groups into a final workshop report. Assignments for writing the topical report should be made during the breakout sessions. The outline should include:

introduction/background, issues and considerations, summary of discussion, conclusions and recommendations.

4.3 Case Studies for use in the Group Discussions

In order to facilitate focused discussions, three case studies have been provided on the following pages. Each case study is meant to illustrate different real world siting challenges that face member states for different SMR applications. Each case study involves a hypothetical member state with real world conditions and challenges and is not meant to single out any existing member state.

CONSIDERATIONS AND ASSUMPTIONS COMMON TO ALL CASE STUDIES

The following considerations and assumptions should be taken into account in each of the three following case studies.

- The member state has no current domestic experience with nuclear power.

- The member state's regulatory body and regulatory framework is at an early stage of development. As a result, the regulator and the utility are working with the country-of-origin's regulatory body and vendors / utilities to understand the rules under which the technology has been or is being designed and reviewed.

- In parallel with developing a national regulatory framework, the member state will be relying heavily on the IAEA's safety and security framework documents as part of their overall regulatory strategy.

- The member state's regulatory framework will be designed to be technology neutral (i.e. not based on a single technology) and will employ a mix of performance-based and prescriptive requirements.

- Assume there is political/civil unrest in the member state and significant threats to nuclear facilities cannot be discounted.

Note: Additional member state attributes are assigned in each case study to introduce different challenges to siting.

CASE STUDY #1:

Siting in a Densely Populated Member State with Significant External Hazards

A member state has chosen to investigate possible candidate sites for a number of possible 2-unit sites utilizing a reactor type expected to have an electrical output of approximately 200 MWe per unit.

Key Considerations:

- Additional Member State Attributes for this case study:
  - Due to geology and geographical features, the interior of the country is sparsely inhabited and the population is distributed along the coast-line with higher density regions cities near natural coastal harbours. The member state has only recently begun examining the need for greater controls over land-use planning due to overcrowding in certain parts of the country.
  - Population density as a whole is high and land for industrial use is generally at a premium. Remote nuclear sites in this member site are not an option.
- The preferred reactor type will be a foreign design and will be sited below-grade (i.e. majority of the nuclear island is underground). The member state is also considering an above-ground design as an alternative technology.
- The majority of power being supplied to the existing grid comes from a limited number of generation sources spread throughout the country. Typical existing supply source output to the grid is 100-200 MWe but there are also many smaller contributors to the grid. The existing grid has reliability issues because growth of the population has outpaced the deployment of new power supply. The intent is to have the nuclear units sited to improve grid reliability.
- The member state is exposed to significant and possible coincidental external hazards. It experiences periodic volcanism and significant seismic activity from both inside and outside the member state. Infrastructure has existed for some time to measure and characterise hazards and this infrastructure has received a reasonable amount of support from the government allowing it to modernize with time. Emergency services exist to cope with these events however they have never been tested for response under multiple scenarios.
- The only real source of viable condenser cooling water comes from the coastal ocean.

CASE STUDY #2:

Siting a Marine-based nuclear power and steam technology

A member state has chosen to encourage regional economic growth in a currently undeveloped and underserviced coastal region of the country by siting a number of industrial projects there. (project zone) The projects being contemplated for the first phase of the project zone are:

- an oil refinery
- a liquefied natural gas production facility
- an offshore tanker loading terminal for each of the above

The member state has plans in place to expand the project zone for additional projects over the next 50 years.

The projects are expected to be very energy intensive and there is a need for both electricity and process heating steam. Surplus power will be being made available to the national / regional grid.

Key Considerations:

- Additional Member State Attributes for this case study:
  - Population density of the member state as a whole is low to medium.
  - The proposed site locations are chosen. It is expected that a city of about 50,000 people will emerge near the project zone. This city will grow as the project zone grows.
  - The geography of the coastline region is low-lying (elevation low compared to sea-level) and is exposed to seasonal monsoons, and other tropical storms. Tsunamis have been recorded from offshore seismic events.
  - Seismic activity in the local region are poorly documented but anecdotally it is a low seismic region.
- Assume that land-based nuclear power facilities in that region are not an option.
- The preferred reactor type will be a single-sourced foreign design.
- The majority of power being supplied to the existing grid comes from a limited number of generation sources spread throughout the country. Typical existing supply source output to the grid is 100-200 MWe but there are also many smaller contributors to the grid. The existing grid has reliability issues because growth of the population has outpaced the deployment of new power supply. It is not certain whether these nuclear units would improve overall grid reliability because of the significant project zone energy demand.
- In the region, there is no infrastructure to measure and characterise hazards.

- There are no existing emergency services in the region. The nearest existing region with significant hospitals, fire-rescue, police is 200 km away by poorly serviced roads.
- The only real source of viable condenser cooling water comes from the coastal ocean.

CASE STUDY #3:

Siting a fleet of micro-nuclear power facilities in an extreme remote region

A member state has a large region of the country which is unserviced by power grids. Other regional services such as hospitals, police, roads etc. are minimal and the sites would require basic infrastructure (roads, camps) to be developed as early as the site evaluation stage. Hundreds of small communities no larger than 1000 people per community are distributed throughout this region, generally located near deep freshwater aquifers, small freshwater lakes or rivers and ocean shorelines or adjacent to major natural resource projects (e.g. mining projects). These communities or sites are in some cases hundreds of kilometres apart from each other.

Power at each of these locations is generated using small fixed fossil-fuel sources that are becoming unreliable and uneconomical. The member state does not have the resources to expand either regional or national grids to this region. As a result, the utilities that support the existing regional population are considering the deployment of a number of 10 MWe micro-nuclear facilities to provide both electrical power and process steam (assume for heater or water purification).

Key Considerations:

- Additional Member State Attributes for this case study:
  - The geology and geography of the various sites in the region varies, however all sites in the region experience extreme temperatures and precipitation events. These events have led to long periods of isolation where travel to and from the sites is not possible.
  - Seismic activity in the whole region is poorly documented but anecdotally it is a low seismic region.
- The preferred reactor type will be a single-sourced foreign design. The design employs a sealed and fuelled reactor module that is delivered from the vendor nation to the site and removed from the site back to an offsite disposal facility when the core is depleted. The vendor's intent is to have only a limited skeleton staff on site to operate and maintain each facility. The units are being designed to be autonomous and remotely monitored. Remote operator intervention is designed to be a secondary response.
- In the region, there is no infrastructure to measure and characterise hazards.
- There are no significant emergency services in the region. Each community or project is supported locally. Typically, the nearest existing region with significant hospitals, fire-rescue, police is more than 500 km away by in some cases, seasonally serviced roads, in other cases only by air transport.

- During extreme temperatures and precipitation events, it is normal that offsite emergency services can be delayed by days to weeks.
- There is nowhere to evacuate the population of a site to if a nuclear accident reaches a sheltering or evacuation threshold.

Appendix A:

Original List of Identified Issues for Group 3:

1. Flexibility in emergency planning requirements, accident response, application of graded approach **(Cross-cutting with Groups 1 and 2)**
2. Licensing (safety analyses) codes and methodologies **(Cross-cutting with Group 1)**
3. Plant staffing **(Cross-cutting with Groups 1 and 4)**
4. R&D programmes **(Cross-cutting with Group 1)**
5. Demonstration of innovative features **(Cross-cutting with Group 1)**
6. Nuclear security and robustness **(Cross-cutting with Group 4)**
7. Licensing process for multiple modules **(Cross-cutting with Group 4)**
8. Probabilistic Safety Assessment, reliability data **(Cross-cutting with Group 1)**
9. Instrumentations and controls, increased use of automation **(Cross-cutting with Group 1)**
10. Source term calculation **(Cross-cutting with Groups 1 and 2)**
11. Spent fuel pool cooling and monitoring **(Cross-cutting with Group 1)**
12. Transportation of fuelled-NPPs (modules) **(Cross-cutting with Groups 1,2,4,5)**