IAEA Technical Meeting

Global Nuclear Energy Sustainability: Licensing and Safety Issues for Small- and Medium-sized Reactors (SMRs)

Proceedings of the 6th INPRO Dialogue Forum

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IAEA
International Atomic Energy Agency
Atoms for Peace

INPRO
International Project on Innovative Nuclear Reactors and Fuel Cycles

Organized by the IAEA Department of Nuclear Energy (INPRO Group and NPTDS) in Cooperation with Department of Nuclear Safety and Security

Disclaimer

This document summarizes all presentations and discussions of the 6th INPRO Dialogue Forum and represents the final report of the meeting. ***It is not an official IAEA publication.***

All meeting materials including PowerPoint Presentations of the 6th INPRO Dialogue Forum and other Dialogue Forums are available at http://www.iaea.org/INPRO/DFs/index.html

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I. Introduction

The International Atomic Energy Agency (IAEA) seeks to bring together technology holders and technology users to discuss and share information on desirable innovations, both technical and institutional, to ensure that nuclear energy is available to meet long-term global energy needs in a sustainable manner. The INPRO Dialogue Forum is one mechanism for technology holders and users to discuss such innovations.

The 56th IAEA General Conference resolution GC(56)/RES/12 stressed the importance, when planning and deploying nuclear energy, including nuclear power and related fuel cycle activities, of ensuring the highest standards of safety and emergency preparedness and response, including incorporating the lessons learned from the Fukushima Daiichi accident.

In October 2011, the 3rd INPRO Dialogue Forum on “Nuclear Energy Innovations: Common User Considerations for Small and Medium-sized Nuclear Power Reactors” was held to discuss common user considerations for small and medium-sized reactors (SMRs) in light of the conclusions reached in the study on common user considerations undertaken in 2007-2008, as well as of recent developments in SMR technologies.

The IAEA Technical Meeting/Workshop on Technology Assessment of Small and Medium Sized Reactors for Near Term Deployment, held in December 2011, concluded with respect to their safety and licensing aspects as follows: (i) Since many innovative SMRs contain a certain degree of ‘first-of-a-kind’ engineering systems and components, licensing and regulatory issues must be addressed; (ii) Many newcomers are still in favour of ‘proven’ technology and want SMR technologies to be first deployed in the country of origin to minimize licensing and performance risks; (iii) In light of the Fukushima Daiichi Nuclear Power Plant accident, the technology users have paid particular attention to the implications of multi-module plants relating to extreme natural events that could potentially lead to severe nuclear accidents; and (iv) The technology holders should incorporate lessons learned from the Fukushima accident into the reactor design.

In December 2012, the INPRO Group, in cooperation with the IAEA’s Nuclear Power Technology Development Section and Division of Nuclear Installation Safety, organized a consultancy meeting composed of Member State regulators, technical support organisations and decision makers to prepare this INPRO Dialogue Forum and to discuss the possibility of setting up an “SMR Regulator’s Forum” in the IAEA Member States. At this consultancy meeting, participants discussed and identified specific topics and consolidated key issues to be discussed at this Dialogue Forum. Also in order to prepare agenda and breakout session working materials, one video- and several tele-conferences had been held during the period of April to June 2013, joined by IAEA team members and Member State participants in the consultancy.

II. Organization of the Meeting

1. Objectives and Outputs

The traditional objective of the INPRO Dialogue Forum is to bring together nuclear technology users and technology holders from all interested IAEA Member States to discuss issues related to sustainable nuclear energy development and deployment. This dialogue facilitates mutual understanding of the needs and potential roles of technology users and the possibilities and limitations of technology holders. To date, five INPRO Dialogue Forums have been held since 2010. For details, see: http://www.iaea.org/INPRO/DFs/index.html.

The 6th INPRO Dialogue Forum was expressly designed to focus on on-going discussions between regulators and potential licensees of SMR technologies. It aimed to discuss the following major licensing and safety issues related to SMRs: Considerations to take into account in the design of SMRs; Siting considerations for SMRs; Application of a graded approach in the regulatory and licensing processes; Legal and regulatory framework of SMRs; and Public participation in the SMR licensing process.

The primary audience for this Dialogue Forum was expressly designed to be nuclear regulators and operating organizations in the IAEA Member States that are potentially licensing or preparing to license SMRs. Other stakeholders such as technology support organizations, vendors, and 'codes and standards' organizations were also participating.

All participants discussed common issues for deployment of SMRs. For those countries considering SMRs in their nuclear power development programme, the 6th Dialogue Forum provided their delegates with an opportunity to benefit from the licensing and regulatory knowledge and experience of technology holders, as well as to discuss common safety issues with them. Participating Member States considering the use of SMR technology were expected to draw up a priority list of licensing and safety issues, to develop an understanding of related work in other forums and of the recommended path forward to resolve challenges in the deployment of SMRs, and to address the issues identified through participation in a working group. The Terms of Reference for the 6th INPRO Dialogue Forum is attached (*Annex 1)*.

2. Attendance

The 6th Dialogue Forum was conducted over one week and, was attended by some 120 participants from 37 Member States and four international organizations including the American Society of Mechanical Engineers (ASME), the Nuclear Energy Agency (OECD/NEA), the World Nuclear Association (WNA), and the Western European Nuclear Regulators Association (WENRA). The list of participants is attached *(Annex 3)*.

The participants came from governments, academia, nuclear regulators, vendors and operators, and research institutions. There were around 45 speakers including IAEA experts and speakers representing international organizations and Member States. All meeting materials including PowerPoint Presentations of the 6th INPRO Dialogue Forum and other Dialogue Forums are available at http://www.iaea.org/INPRO/DFs/index.html.

3. Elected Officers

The following persons contributed as chairpersons, rapporteurs, and group leaders:

Plenary Session:	Chair:	Mr David Newland
	Co-Chair:	Mr Poong Eil Juhn
	Rapporteur	Mr Dan Ingersoll
	Rapporteur	Mr Mohammad Iqbal
Breakout Session		
Group1	Leader:	Ms Kristiina Soderholm
	Co-Leader	Mr Marco Ricotti
	Facilitator	Mr Hadid Subki
Group2	Leader:	Mr Marcel de Vos
	Co-Leader:	Mr Ferhat Aziz
	Facilitator:	Mr Kamran Qureshi
Group3	Leader:	Mr A. Ramakrishna
	Co-Leader:	Mr James Walker
	Facilitator:	Mr Deshraju Venkat H. Rao
Group4	Leader:	Mr Stewart Magruder
	Co-Leader:	Mr Myung Jo Jhung
	Facilitator:	Mr Russell Gibbs

Group5	Leader:	Mr Muhammad Rawi bin
	Co-Leader:	Mr Muhammad Ali
	Facilitator:	Mr Pill-Hwan Park

4. Agenda

The meeting proceeded as per the adopted agenda which is attached as Annex 2.

III. Opening and Introduction

1. Opening Addresses

The meeting was opened by **Mr Jong Kyun PARK**, Director, Division of Nuclear Power, the IAEA Department of Nuclear Energy. Mr Pill-Hwan Park (INPRO Group), Mr Hadid Subki (NPTDS), and Mr Russell Gibbs (NSNI) served as Scientific Secretaries.

In his opening address, Mr J.K. Park welcomed all participants to the 6th INPRO Dialogue Forum on Licensing and Safety Issues for Small- and Medium-sized Reactors. He emphasised that there has been an increasing global interest in small and medium-sized reactors (SMRs) that can play an important role in the global sustainable energy development as part of an optimal energy mix so it is timely to address licensing and safety issues for SMRs in this Forum. Also he pointed out that many embarking countries have expressed their interest in SMRs and their wish that technology developers, regulators, and operators need to incorporate the lessons learned from the Fukushima accident into the operating plants as well as in advanced nuclear new-builds including SMRs.

With respect to the IAEA SMR programme, he highlighted that, given the importance of SMRs' role in the future, the Agency continues its various programmes such as formulating a nuclear technology roadmap, reviewing newcomer countries' requirements including regulatory infrastructure, and defining performance indicators for operation through the organization of technical meetings, workshops and dialogue forums. He stressed that this Forum will provide valuable feedback for Member States' regulatory bodies, and several countries developing different types of SMRs will benefit from the exchange of knowledge and experience among Member States as well. Finally he conveyed special thanks to the governments of the Republic of Korea and the United States of America for their generous Extra-Budgetary contributions.

Mr James E. Lyons made an opening address and complemented on a large turnout for this Dialogue Forum. He pointed out the bright potential future of SMR technologies, mentioning that the SMR designs are considered more inherently safe with the use of more passive safety systems and lower source terms. However, he emphasised that, due to these more innovative features, there have been concerns being raised as to whether different approaches to licensing are needed, including such issues as first-of-kind engineering features, the size of the emergency preparedness exclusion area, security requirements, deployment in areas of higher density population, control room staffing, the use of graded approaches to safety, and public acceptance of such new and innovative designs. In this respect, he conveyed his belief that participants will be able to identify key issues needing follow-up during the five breakout sessions and formulate recommendations and path forward to address the identified issues in this Forum.

Also, he suggested the idea of a forum of SMR regulators as a way to move these issues forward and stressed that, if necessary and appropriate, the Agency will encourage the formation of such forum and is willing to help facilitate and promote the forum. Finally, he expressed that the stage is set for an outstanding opportunity to make a difference in how SMRs might become a viable option for safer and secure nuclear power.

Those opening addresses are presented in Annex 4.

2. Program Overview

Mr P.H. Park, a Scientific Secretary, presented the program overview and its objectives. In his presentation, he introduced the background and preparation process of this meeting, its objectives, agenda overview, panel discussions and breakout session. According to the agenda, in the first day there will be introductory presentations by IAEA followed by Member State presentations and panel discussions on licensing and safety issues for SMRs. From the second day to the fourth day, the intensive breakout session on identified issues will be conducted through 5 group discussions and this is followed by presentations by four international organizations. In the fifth day, there will be report on the breakout session results by each group leaders, followed by summary report by rapporteur and chairman on findings and recommendations. The agenda was approved as proposed.

3. Introductory Presentations

IAEA staffs and Chairman of the last Consultancy gave introductory presentations as follows: INPRO activities in support of transition to sustainable nuclear energy systems by Mr Drace, Head of INRPO Group; Summary of results of the preparation consultancy meeting by Mr Magruder, USA; Status of global SMR development and prospects for deployment by Mr Subki, NPTDS; Licensing process considerations for SMRs by Mr Gibbs, NSNI; and Proposal for a technology-neutral safety approach for new reactor designs by Mr Yllera, NSNI.

This session was consisted of five presentations followed by questions and answers. A summary of the presentations is provided in the below table.

TABLE 1: Summary of introductory presentations

Speaker and presentation title	Summary of presentations
1. **Mr Drace**/ INPRO activities in support of transition to sustainable NES	Firstly Mr Drace gave an overview of INPTO including its establishment, main objectives, membership, and INPRO projects in 2012-2013. Then he introduced details of the current four projects: National nuclear energy strategies and NESAs using INPRO methodology; Global nuclear energy scenarios; Innovations by collaborative projects; and the Dialogue Forum. He also introduced some of new projects in area of "Innovation" currently under definitions and design including TNPP II: Case study for the development of factory fuelled small sized reactor.
2. **Mr Magruder**/ Summary of results of the preparation consultancy meeting	Mr Magruder gave summary of the last preparation consultancy meeting for 6th Dialogue Forum held in December 2012, as the Chair evaluated that the results exceeded his expectations. The consultancy comprised presentations by Member States to share experiences of SMR development, licensing and deployment among technology; discussion on potential SMR Regulators Forum; brainstorming to identify key issues; and review and discussion of the draft prospectus. Specifically he complemented the brainstorming session was quite successful so that the list of key issues was prioritised and prepared.
3. **Mr Subki**/ Status of global SMR development and prospects for deployment	According to Mr Subki's presentation, MS's development and deployment of SMRs is motivated due to the need for flexible power generation for different applications, low carbon emission, the increased level of safety, better affordability, and potential for innovative energy systems. Currently, 9 countries are developing some 40 SMR designs with different time scales of deployment and 7 units are under construction (see the below table: updates for global SMR development). He also suggested the following four categorization of SMRs: (i) Advanced SMRs including modular reactors and integrated PWRs; (ii) Innovative SMRs including small-sized Gen-IV reactors with non-water coolant/moderator; (iii) Converted and Modified SMRs including barge-mounted floating NPP and seabed-moored submarine-like reactors; and (iv)

	Conventional SMRs, those of Gen-II technologies and still being deployed. He singled out perceived advantages and challenges made through the IAEA observation. For instance, in terms of technical aspects some of advantages include shorter construction period (modularization), potential for enhanced safety and reliability, design simplicity, suitability for non-electric application, and replacement for aging fossil plants where as challenges are licensability and operability of first-of-a-kind designs, non-LWR technologies, human factor engineering, operator staffing for multiple-modules plant, and Post Fukushima action items on design and safe. Finally, he introduced major IAEA activities on SMR technology development for 2014 – 2015 and emphasized that there is the need to facilitate capacity building in new entrants on SMR technology assessment by identifying common positions on specific SMR issues.
4. **Mr Gibbs**/ Licensing process considerations for SMRs	At the outset of his presentation, he raised a fundamental question whether it is possible for the existing IAEA safety standards to be applied for SMRs, especially focusing on Fundamental Safety Principles (SF-1); Governmental, Legal and Regulatory Framework for Safety (GSR Part 1); and Licensing Process for Nuclear Installations (SSG-12). Then he raised some related questions for facilitating discussions on the five topic areas including design considerations, siting considerations, application of graded approach, public participation, and legal and regulatory framework. For instance, how do regulators ensure that SMR designs are safe? Will SMRs become an attractive technology once design becomes a proven technology? Do SMRs realistically pose a limited risk to reduce the regulatory requirements? *(See the TABLE 3).* He pointed out that rules might be changed for SMRs but we need to identify what the changes are because SMRs are being described as simple designs and inherently safe. For initiating the needed international dialogue, he emphasized that there is a need to identify and prioritize a set of substantive licensing and safety issues that SMRs might pose and to propose a path for resolution.
5. **Mr Yllera**/ Proposal for a technology neutral safety approach for new reactor designs	At the outset of his presentation, Mr Yllera raised some challenging questions: Is the current safety approach suitable for innovative SMRs and is it possible to develop technology neutral safety approach and design safety requirements? Then, he introduced IAEA-TECDOC-1570 "Proposal for a technology neutral safety approach for new reactor designs." He pointed out that new approach should be more risk-informed and less prescriptive and main pillars of design and licensing rules for a given innovative reactors include quantitative safety goals, fundamental safety functions, and defence in depth taken into account probabilistic considerations. He informed that the GIF risk and safety working group referred this IAEA TECDOC in developing the detailed safety approach for Gen-IV reactors. Finally he introduced IAEA Design & Safety Assessment Review Service (DSARS).

Floor Discussions

The discussion after the presentation on status of global SMR development and prospects for deployment is as follows:

- One of USA participants suggested that the Holtec design needs to be included in the list of practical categorization of SMRs (Mr Subki responded that this information is based on the IAEA "ARIS (Advanced Reactors Information System Database)" and we will update this database).
- An Indian representative made a question that with several SMRs currently deployed in the world, whether there are any design common standards to be applied in the licensing process. (Mr Subki responded that there are no standards in place but the IAEA has just developed common user considerations (CUC), similar to utility design documents).
- Jordan participant asked about core damage frequency (CDF), that is, if 10 modules (100 MWe each) were constructed on one site, what the core damage probability would be. (Mr Gibbs responded that policy decision on how one reflects multiple unit sites in regulatory and

licensing framework may be very important issues after the Fukushima accident: whether to treat them individually or collectively, case of multiple failures in the multiple unit site, and other technical and policy issues. Mr deVos also informed that this issue will be discussed under topic 2 in breakout session.

The discussion after the presentation on licensing process considerations for SMRs is as follows:

- An Indian representative made a question on how safe is safe enough and whether it is necessary and possible to develop an index, index of designs. (Mr Gibbs responded that the IAEA does not compare reactor designs and rank them according to the level of safety.)
- Kenya participant made an inquiry about whether there are any grid constraints, considering experiences and lessons learned from SMRs that have been already deployed.
- There were some discussions on the meaning of the "M" in SMR. The Dialogue Forum was focused on multi-modules, modular-based and integral-PWR SMRs. B&W, mPower and NuScale feature multi-module small modular reactor: mPower has 2-4 modules and NuScale has up to 12 modules. The Korean SMART and Westinghouse SMR have one module, with high degree of modularization for construction. All the designs are of integral-PWR based SMR, in which all nuclear steam supply system (NSSS) components are placed inside the reactor *vessel (i.e. in the same compartment with the core).*

TABLE 2: Updates on global SMR development and deployment

SMR types	Current status of development and deployment
CAREM-25 (Argentina)	• Site excavation for CAREM-25 prototype construction was started in September 2011; first concrete pour is expected by end 2013 (2017-2018 to be started, CNEA)
CEFR HTR-PM ACP-100 CAP-150 (China)	• 2 modules under construction (2017-2018 to be started, Tsinghua Univ.) • To be constructed by 2015 (CNNC) • SNERDI developing CAP-150 and CAP-FNPP
Flexblue (France)	• DCNS originated Flexblue capsule, 160 MWe, 60-100m seabed-moored, 5-15 km from the coast, off-shore and local control rooms
PFBR PHWRs (220, 540, 700) AHWR 300-LEU (India)	• Prototype FBR500 prepared for start-up commissioning (IGCAR) • 4 units of PHWR-700 under construction, 4 more units to follow • AHWR300-LEU at final detailed design stage and ready for construction
IRIS (Italy)	• Politecnico di Milano (POLIMI) and universities in Croatia & Japan are continuing the development of IRIS design - previously lead by the Westinghouse Consortium
4S (Japan)	• Toshiba had promoted the 10 MWe 4S for a design certification with the US NRC for application in Alaska and newcomer countries
SMART (Korea)	• On 4 July 2012, the Korean Nuclear Safety and Security Commission issued the Standard Design Approval for the 100 MWe SMART – the first iPWR in the world received certification
KLT-40S SVBR-100 BREST-300 SHELF (Russia)	• Construction of 2 modules of barge-mounted KLT-40s near completion • Both Lead Bismuth cooled SVBR-100 & Lead-cooled BREST-300 to be deployed by 2018 • SHELF seabed-based conceptual design
mPower NuScale W-SMR SMR-160 (USA)	• Some have utilities to deploy in specific sites. B&W received US-DOE funding for mPower design. The total funding is 452M$/5 years for 2 out of 4 competing iPWR based-SMRs. The mPower got the award in the first round. The DOE will have 2nd round of funding award in November 2013

TABLE 3: Initial questions for discussion of the five topic areas

Topic area	Initial questions
Design considerations	What safety issues might licensees face in deploying SMRs and how does the regulator prepare to provide oversight for these issues?
Siting considerations	Should SMRs be located in high population density areas? How does SMRs' lower source term affect emergency planning? What are the implications of siting SMRs in remote locations and of marine based and transportable SMRs?
Application of graded approach	Do SMRs realistically pose a sufficient reduction in risk to apply the graded approach to the regulatory requirements?
Legal and regulatory framework	Would a national legislation be expected to change for SMRs? Would regulations need to be developed or revised specific to SMRs? Are changes to the Safety Standards needed? How might the licensing process for SMRs be different?
Public participation	How might SMRs cause public concerns? Where will the plant be located? How could be it to communicate terms such as inherently safe, passive safety systems, and smaller source term, etc.?

IV. Experiences and Preparations for SMR Licensing/ Deployment

1. Member State Presentations

In Session 2 on "Experiences and Preparations for SMR Licensing and Deployment," taken place in the afternoon of the 1st day, the following INPRO Member States gave presentations: Canada, China, France, India, Japan, Republic of Korea, Russia, and USA. They briefed status of development and deployment for SMRs in their countries including safety issues and concerns for SMRs. They also presented briefly licensing for SMR deployment in their countries including licensing framework, current status of licensing or pre-licensing activities, and special considerations for the Fukushima accident. They also shared their view on suggestions on the main topic and the path forward. A summary of MS presentations is provided in the below table.

TABLE 4: Summary of Member States presentations

Country	Summary of MS presentations
Canada/ Mr deVos	In Canada two distinct SMR uses are developing: in the far north, "Very Small SMRs" in the range of 2-25 MWe per unit used for resource projects and northern communities; in the south, more traditional "normal sized SMRs" for smaller grids and replacing older coal generation or diversifying grid. Canadian regulatory requirements tend to be worded in a more performance-based fashion and this gives some flexibility to the proponent to propose how the requirements will be met including the use of grading. This requirement is technology neutral and can be met in different ways dependent of the size of the reactor and the risk presented. CNSC is ready to engage with proponents of SMR reactors in design reviews or licensing discussions. Canada is implementing the vendor design review process to help reduce regulatory risks by encouraging early engagement but certification is not currently done. Canada already has licensing process suitable for SMRs to permit parallel reviews depending on the applicant's state of readiness and quality of submissions. CNSC has committed to fixed review timelines (environment and site – construction-operation) but the public portion of the process takes up a large part of the licensing process so community acceptance is very important. Canada is now developing more specific requirements and guidance for small reactors.

	• A Poland participant questioned: How long is the fixed timelines for review: Answer: A 2 year timeline is needed for the review of environmental impacts and siting, long public hearing process, and review CL and OL applications.
China/ F. Zhong	Mr Zhong's presentation on safety features and licensing of ACP100 includes design features, severe accident prevention/mitigation, standard design approval, and licensing strategy. In 2010, CNNC launched R&D project for ACP100 with the following milestones: basic design approval by December 2012, preliminary design by the end of 2013, and PSAR approval by 2014. The demonstration ACP100 (310 MWt two reactors) will be located in Putian, Fujian Province in the east coast area of China. Engineering safety systems comprise passive safety system, passive core cooling system, passive residual heat system, passive containment system, and automatic depressurization system. ACP100 also incorporates several measures for severe accident prevention and mitigation such as passive containment hydrogen control, reactor cavity flooding system, high concentration boron injection system, and multi-layer defence system to mitigate extreme beyond-design basis accidents. During the period of 2011-2014 CNNC has been conducting diverse testing and evaluation to obtain standard design certificate including control rod drive line cold and hot testing, passive core cooling integration testing, fuel assembly critical heat flux testing, CMT and PRHR HX testing, and control rod drive line shock testing. CNNC is carrying out safety joint research projects with Nuclear and Radiation Safety Centre (NSC) to prepare ACP100 licensing.
France/ Mrs C. Lecomte	Mrs Lecomte gave a presentation on Flexblue®: a Subsea Reactor Project - Considerations for its licensing. Flexblue is a 160 MWe subsea module, mooring up to 100 meters depth. It uses full scale of passive safety systems with extended grace period. Regarding inherent nuclear safety, Flexblue has specific advantages such as elimination of main external hazards due to immersion, fully automated operation and control, and easier recovery of site. Regarding licensing considerations for the concept of Flexblue, SMR related issues include passive systems with infinite heat sink, multi-module control room, and reduced source term and EPZ. In terms of TNPP issues and subsea aspects there is no existing regulatory framework fully relevant for transportation of fuelled TNPPs that requests to adapt existing rules and guidance documents, an international consensus, and transport related specifications for safety systems.
India/ Mr A. Ramakrishna	Mr Ramakrishna made a presentation on Nuclear Regulation for SMR in India – Current Perspectives, focusing on SMR program, licensing process for SMRs, pre-licensing design safety review of AHWR, and current perspectives for licensing approach for new NPPs. AHWR has unique design features to develop the fuel cycle technologies of thorium utilization. It is a 300 MWe boiling light water cooled, heavy water moderated, vertical pressure tube type reactor designed to produce most of its power from thorium. AERB has completed the Pre-licensing Design of AHWR. Some of AERB licensing approaches for new NPPs are: design of foreign origin should be licensable in the country of its origin; review to be based on AERB codes & guides to the extent applicable; for advanced or innovative designs, safety criteria to be established in consultation with TSO and designers; different safety approaches/philosophies can be accepted with adequate justification; and lessons learnt from Fukushima to be addressed adequately. General expectations for the Dialogue Forum: to address R&D activities related to reactor physics, PSA, high temperature and radiation effects on fuels and materials, and high efficiency power conversion systems; to discuss regulations for new concept reactors, economic viability and competition with large reactors.
Japan/ Mr T. Mochida	Mr Mochida gave a presentation Status of SMR development and challenges for design assessment in Japan. Japanese vendors keep high capability to develop and deploy SMRs both for Gen-III and Gen-IV type. Gen-IV SMRs developed in Japan include 4S (Toshiba), HTR-50s (JAEA/Toshiba/Fuji Electric), and MHR-50/100is (JAEA/MHI) whereas Gen-III LWR based SMRs are CCR (JAPC/Toshiba), IMR

	(JAPC/MHI), and DMS (JAPC/Hitachi). There are no current plans to deploy SMR designs in Japan. The LWR-based SMR projects are driven by the private sectors and they are looking for overseas customers for the development of their SMR technologies. In terms of licensing framework in Japan, there are no differences on process, basic requirement and criteria between SMRs and large NPPs. Currently, Some of SMR designs were applied or will be applied for a pre-licensing in USA or Canada. It is noted that Japan does not have a process of vendor's design assessment such as DC in USA, GDA in UK or VDR in Canada. It is recommended as the path forward that continuous and uninterrupted opportunity for information exchange in SMR license methodology and regulatory framework is essential and needed. Pakistan participant suggested that very small reactors such as 10 MWe reactors may be newly categorized as "VSR."
Korea/ Mr M.J. Jhung	Mr Jhung made a presentation on Licensing review of SMART for standard design approval in Korea. KAERI and KEPCO jointly developed SMART (System-integrated Modular Advanced ReacTor), an integral PWR type of 100MWe SMR in 2010 and the standard design approval (SDA) was awarded in July 2012 by Nuclear Safety and Security Commission (NSSC) through the review process of 1,500 items of Q&A. Korea has two step licensing (C/P to O/L) process and SDA is an optional licensing process for design certification that aims to reduce licensing uncertainty and risk for construction. In the process of SDA review, the following major licensing issues were identified: basis for the accident classification, evaluation of source terms from radioactive waste system, basis for the design application of ALARA concept, verification of safety analyses code, and depth and scope for SDA. Regarding the Fukushima actions items, among 50 items developed by the regulatory authority, 34 items should be applied for SMART licensing: 10 items for standard design, 8 items for construction, and 16 items for operation. For instance, the Fukushima actions implemented in standard design are: adding automatic seismic trip system; providing watertight door & drain pump; securing mobile generator & battery; measures to cool-down spent fuel pool; providing external safety injection flow path; and providing passive autocatalytic hydrogen recombiner. One of lessons learned from the SDA review process is that additional activities, pre-application review and regulatory research contributed to a successful SDA review by providing regulatory insights for safety review and licensing process.
Russia/ Mr I. Bylov	Mr Bylov made a presentation on safety provisions for the KLT-40S reactor plant - Floating power unit. The KLT-40S reactor plant design is developed in compliance with the Russian laws, regulatory rules for marine nuclear propulsion plants, and safety principles set by the world's nuclear community and reflected in IAEA recommendations. The KLT-40S reactor plant safety based on defence-in-depth concept incorporates inherent safety features and engineered safety features and procedures including: passive safety systems, self-actuating devices, proven engineering practices and up-to-date design experience. The reactor plant is designed to withstand the external hazards such as marine environmental conditions, shock resistance, unit submersion, and aircraft crash. After the Fukushima Daiichi accident the stress analysis of the floating power unit had been conducted in such areas as seismic impact, tsunami waves, total blackout and core meltdown and confirmed no radiological consequences to public and environment. Also, probabilistic safety assessment (Level 1) was performed and its results indicated that KLT-40S design is well balanced and its safety level meets Russian regulatory requirements and IAEA recommendations. It is noted that PSA Level 2 wasn't performed as it is not required by the current Russian regulation to obtain operating license.
USA/ Mr T. Beville; Mr S. Magruder	Mr Beville presented about Status update on USDOE small modular reactor licensing technical support program. In 2012, DOE initiated the SMR Licensing Technical Support program focusing on facilitating and accelerating commercial

	development and deployment of U.S.-based SMR designs at domestic locations. This program aims to support financial assistance for design, certification and licensing of promising technologies: 6 year/$452 M program; minimum of 50% industry cost share required. Generation mPower project was selected in November 2012 for the first project aiming to help resolve generic industry regulatory issues and establish the SMR licensing framework. In March 2013, the second SMR project was announced and award(s) will be made by the end of 2013. This latter project aims to increase available pool of innovative domestic SMR technologies and selection criteria focus on safety, operability, efficiency, economic and security performance. It is noted that DOE funding is already having an impact on accelerating the first movers and building the momentum for the industry.
	Mr Magruder presented the U.S. NRC efforts to prepare for licensing SMRs. USNRC is currently focusing on iPWRs and identified policy and technical issues for SMR licensing including use of risk insights to focus reviews, operator staffing, emergency planning and preparedness framework, insurance and liability requirements, ASME Code applicability, and DID and treatment of non-safety related components. USNRC uses the existing licensing process used so criteria and basic requirements will not change. USNRC developed design specific review standard for B&W mPower and is currently doing significant pre-application interaction with several vendors. Regarding the Fukushima considerations, NRC preliminary indications are that SMR designs will meet new requirements. Regarding the suggestions for this Forum, there is a need to identify common issues and solutions and select key issues that should be pursued further.

2. Panel Discussions on Licensing and Safety Issues

This session aimed to provide participants with some useful insights through interactive discussions among panellists and participants before the breakout session. This session was moderated by Chairman of the plenary session and six panellists from Canada, France, Jordan, Italy, Korea, and Russia made their views on the main topic and actively discussed about the following sub-topics: challenges and issues for SMR early deployment and licensing; lessons learned from the Fukushima accident for SMRs; and international cooperation on SMR licensing and safety. After panellists' brief statements on the suggested topics, there were interactive discussions among participants and panellists.

A summary of panellists' statements is provided in below table.

TABLE 5: Major points of panellists' statements

Panellist	Major points of panellists' statements
Mr S.H Rhee (Korea)	SMR is more promising for early deployment in view of safety and grid capacity than large sized power plants. Korea is currently developing four types of SMRs including iPWR SMR (SMART), sodium cooled SMR (KALIMER), helium cooled SMR, and lead bismuth cooled SMR (URANUS-40). It is expected that this Dialogue Forum could facilitate the exchange of different concepts, ideas, safety aspects, and licensing experiences for the early deployment of SMRs. 'Green Life Intellectual Network (GLIN)' is commissioned to play the key role to promote international cooperation networking for SMRs by the Korean government. It is proposed for the exchange of MOU on SMR international networking between GLIN and interested participants of the Forum.
Mr I. Bylov (Russia)	Russia has a number of different TNPP designs and some of them like KLT-40S are now under construction. The number of TNPP designs in the world is growing. Meanwhile small-sized reactors and TNPPs are rather different nuclear installations than even medium-sized reactors so it may be needed to consider different approaches. In this connection, Russian participants suggest the following topics on for discussion during this Forum: (i) different approaches to licensing and safety assessment of stationary

	based SMRs and TNPPs; (ii) use of a different approach for TNPPs including legal and institutional issues. He noted that TNPPs might not require comprehensive infrastructure in the newcomer country for TNPPs.
Mr D.Newland (Canada)	Regulatory and licensing framework needs to be sufficiently broad to address technologies being considered. In Canada, proponents are considering many designs, small to large, traditional to Gen- IV. For existing in-service fleet: requirements, codes and standards were developed over a long period of time and evolved with experience. In this regard, there is a need to work towards regulatory positions on: issues around cyber security and I&C design, severe accident mitigation for different SMRs, acceptable passive features and forms of inherent safety, SMR related terminology, and emergency planning. Lessons learned from the Fukushima accident for SMRs: Emergency planning still has a key role in defence-in-depth; need to better understand how and which parts of the plant will need to perform beyond their normal design function (Design Extension Conditions). Regulators working together can be more effective and efficient so a regulatory cooperation framework would be beneficial for SMRs. He mentioned two tracks that can be pursued: generic and technology.
Mr K. Araj (Jordan)	SMR solution for Jordan is very difficult especially in siting for middle and large sized NPPs due to the following constraints: 5th poorest country in water, small grid size, upfront capital cost. Jordan looks forward to flexibility of siting including underground, dry cooling, no emergency zone and modular design. The promising future for SMRs are too good to be true but all promises have to be validated since technology user countries seek internationally certified SMR designs. Initial investment capital cost may be one of the biggest challenges for SMR deployment. Electricity cost generated by SMRs should be competitive compared to large NPPs. It is suggested that minimum generic safety requirements need to be developed through this Dialogue Forum.
Mr R. Seban (France)	What is the future of large scale nuclear power? We need to look into recent trend of large NPPs: (i) increasing higher safety requirements (Gen-II - Gen-III - Post Fukushima); (ii) higher financial risks due to increased investment cost; and (iii) more complex in construction with higher risks on schedule. In this respect, SMR could be a response for many countries due to such factors as increased safety, robustness against internal and external hazards, reduced EPZ, efficient safety and quality control for modularization and factory manufacturing ("Plug and Play"), small core, and small underground reactor building. It is suggested that SMR modularization concept should be "internationally licensed" enabling to have a certification, performed once and not repeated in all countries, as adopted in airplane industry. Through this Forum, it is necessary to share views on SMR benefits and to exchange information inherent safety features and both mature design and mature technologies.
Mr M. Ricotti (Italy)	What is really differential between LRs and SMRs: if SMRs are only "squeezed-LRs", very little differences. SMRs should offer: enhanced safety, better than Gen-III/ III+ plus post-Fukushima. In this regard, we don't need to change safety requirements, to relax the licensing requirements, and to lower the bar. There is not a LR safety standard & licensing process vs. an SMR one. Safety requirements are technology/reactor type based (today: LWR vs. non LWR). Safety is a global issue both in terms of geography and items complexity. In this regards, SMR is an opportunity to be grasped for global collaboration on common safety standards and process and global collaboration on safety authorities and country nuclear system. It is proposed that, as a technical cooperation item, we need to consider a mechanism for "open access" large scale testing facilities for SMRs, like for large reactors in the past (LOBI, BETHSY, PANDA, etc.).

Floor Discussions

The summary of discussion after six panellists' statements on licensing and safety issues for SMRs is as follows:

- With respect to Mr Seban's suggestion on International Design Certification, a USA vendor questioned: In order for implementing global collaboration, certification of country of origins, and approach to international certification, could IAEA initiate by validating designs? France responded: in case of aircraft industry, there are two certifications in the world, implemented by USA and EU respectively. Customers can buy an aircraft with certification.

- Mr Ricotti (academia, Italy): Not only for SMRs but for all the nuclear community, there is one international body to validate the design. European Commission had carried out stress test for all nuclear reactors after the Fukushima accident but recognized it is difficult on the same continent to apply the same rules and regulations. As an intermediate step for international certification, nuclear safety authorities need to work together with vendors.
- Mr Araj (government proponent, Jordan): Vendors need to work together not only with nuclear regulators, but also with an international body for design certification, at least for the generic design basis. Public perception is very important to build trust and confidence for nuclear program.
- Mr Newland (regulator, Canada): Looking into how the MDEP had been set up, initially multi-design approval process was put forward by the US, and then later changed to the current multi-national evaluation program. Initially 10 countries attended the first meeting and it took almost 2 years for MDEP members to understand what they were telling each other and get struggle to find commonalities to the way they regulate, work together before even starting what the certification might look like. It is pointed out that even if you had international certification, each regulator has to do its due diligence in accordance with the IAEA rules.
- Mr. Bylov (vendor, Russia): With respect to "Plug and Play" approach, since there might be a number of legal issues to be resolved among different countries, it is necessary to promote international cooperation among Member States including third parties.
- Mr Park (research institute, Korea): International cooperation is necessary and essential but we need to consider how to mobilize necessary program fund. Therefore, prior to setting up any international certification system, there is a need to establish internal funding.
- USA (vendor): We could benchmark aviation industry as a viable template. If such paper is published, will share it with anybody who would be interested.
- Mr Ricotti (academia, Italy): What is "safe enough" needs to be discussed in topic 5. Nuclear energy has an extraordinary safety record so we do not need to consider lowering the bar and SMRs could pass the bar in a different way than the large NPPs.
- Other comments and discussions: There is a need to improve reliability, economics as well as safety and to lower power density; need to educate political leaders about the advantages of SMRs; need to consider how to select an optimum design among different designs; given the 30 years of GEN-III and SMR history, need to put the first priority on proven technology especially after the Fukushima accident; why should be the level of safety different for SMRs at all - the intention is not to lower the bar but to reach the bar more effectively and efficiently; IAEA should be able to do safety design reviews; can the IAEA do a design safety review of a SMR design? - Review by the IAEA is not a licensing review; IAEA safety standards might not be applicable to SMRs as there are many innovative features in SMR designs.

V. Breakout Session for Licensing and Safety Issues for SMRs

1. Introduction and Setting for Breakout Session

1.1. Organization overview of breakout session

Mr K. Qureshi introduced this session including objectives, topics, group formation, and process of group discussions. Objective of the breakout sessions is to prioritize the list of safety and licensing issues and to address the issues identified in detail. The identification of key issues for this Forum is based on the Consultants' Meeting held in December 2012. The Secretariat formed each group members of discussion based on the results of the Participant Questionnaire requesting their preferences for a group session and multiple nominees from a Member State are placed in different groups for balanced participation. The overview of the five group formation is as follows *(See Annex 5 for details)*.

TABLE 6: The Group formation for the Breakout Session

Group	Topic	# of Participants	Room
1	Considerations for SMR designs	26	F-0817
2	Siting considerations for SMRs	21	F-0814
3	Application of graded approach in regulatory/ licensing process	20	A-0478
4	Legal and regulatory framework for SMRs	40	F-0822
5	Public Participation in SMR licensing process	19	B-0486

The breakout session proceeded as follows: (i) Introduction and session setting for sharing information on session overview and process outline by group leaders and introductory presentation by the IAEA; (ii) Group discussion for brainstorming discussion on key issues and preparation of progress report; and (iii) Finalization of session discussion for preparing group discussion report and reporting it in the final plenary session. The group leaders and co-leaders were requested to submit their final group report to the IAEA by mid-September 2013.

1.2. Issue briefings by each group

Each group leaders briefly introduced their sessions including session overview, organization and process, and case studies according to the IAEA template. The summary of each group's presentations is as follows.

TABLE 7: The summary of each group session

Group 1: Considerations for SMR designs	
Background	• Safety of NPP: Design (SSR-2/1) • Fundamental Safety Principles No. SF-1 • Establishing the Safety Infrastructure (SSG-16) • Licensing Process for Nuclear Installations (SSG-12) • Assessment of Defence in Depth for NPP Safety Reports Series No. 46 • Technology-Neutral Safety Approach for New Reactor Designs (TECDOC-1570)
Key issues	• The main focus is to find differences needed in the documentation by design stages of the lifetime of a nuclear installation when considering SMRs. • Main subject is the defence in depth (DID), both functional and structural, in SMR design and the modifications needed to the current approach used in large NPPs. • SMRs are divided into two groups: LWR designs and Non-LWR designs. (Main points of discussion) Defence in depth in plant design, suitable DID approach to manage international standardization, operational reliability, I&C in SMRs and plant staffing, safety analyses challenges and Fukushima lessons learned
Presentation	• Defence in depth for nuclear power plants (Mr Yllera, IAEA)
Case studies	Case 1: Considering LWR SMR design - the approach to fulfil DID levels Case 2: Considering other technology than LWR coolant SMR design Case 3: Considering LWR SMR design - the approach of practical elimination
Group 2: Siting and siting considerations for SMRs	
Background	In each licensing phase, site evaluation information and the program that maintains the information generally becomes part of the licensing basis and can be used as compliance criteria by regulatory authorities. SMRs could be sited in places that would not have been considered for NPPs in the past (e.g. closer to population centres, near industrial complexes, remote regions with minimal or no grid or infrastructure, and ship-borne).
Key issues	• Determining source-terms for non-water cooled SMRs or novel fuels

	• Siting considerations for fuelled transportable reactors and marine-based reactors • Sites in regions lacking in fundamental infrastructure
Presentation	IAEA safety requirements and evaluation process for siting NPP (Mr Samaddar, IAEA)
Case studies	Case 1: Siting a 2-unit larger SMR plant in a densely populated country Case 2: Siting a Marine-based nuclear power and steam technology Case 3: Siting a fleet of micro-nuclear power facilities in an extreme remote region <MS assumptions for case studies> ✓ No current domestic experience with nuclear power ✓ Regulatory body and regulatory framework is at an early stage of development ✓ Country-of-origin's regulatory body and vendors / utilities are providing support ✓ The national regulatory framework will be relying on the IAEA's safety framework documents
Group 3: Application of graded approach in regulatory and licensing process	
Background	Existing guidance documents are mostly focussed on the safety of large NPPs. However, there are significant differences in the risks associated with SMRs, as compared to NPPs, depending on design and site location, etc. Regardless of the reactor, the measures to ensure safety should be commensurate with the risk associated with the reactor which implies that a graded approach to meet safety requirements should be applied to SMRs.
Key issues	• Application of graded approach to emergency planning and accident response • Demonstration of innovative features • Research & development programmes • Safety analysis – codes & methodology • Instrumentation and Controls – increased use of automation • Plant staffing and licensing process for multiple modules
Presentation	Application of graded approach in licensing process (Mr Rao, IAEA))
Case studies	Case 1: Siting in a densely populated Member State with significant external hazards Case 2: Siting a Marine-based nuclear power and steam technology Case 3: Siting a fleet of micro-nuclear power facilities in an extreme remote region
Group 4: Legal and regulatory framework for SMRs	
Background	SMR designs and concepts of operation may challenge existing laws and regulations so regulators should be prepared to license SMRs. Focus of group discussion will be on the following: Sharing experiences regarding licensing (and preparing to license) SMRs; identifying IAEA documents that may need to be modified or created to facilitate; licensing of SMRs; and identifying other standards that may need to be modified or created to facilitate licensing of SMRs.
Key issues	• Plant staffing • Transportation of fuelled-NPPs (modules) • Licensing process for multiple modules • Identification of required changes to safety standards • Standardization of portion of design and safety classification (Main points of discussion) Where gaps in guidance and requirements may exist and paths forward for IAEA, member states, and standards organizations
Presentations	Major findings of the INPRO activity on legal and institutional issues of transportable NPPs (Mr Drace, IAEA); Establishment of a regulatory framework for safety - GSR Part 1 (Mr Cletienne, IAEA); Issues of insurance of civil liability for nuclear damage for low power NPP (Mr Demin, Russia)
Case studies	Case 1: Staffing requirements for SMRs Case 2: Transportable Nuclear Power Plants
Group 5: Public participation in SMR licensing process	
Background	SMRs introduce some "first-of-a-kind" engineering in nuclear reactor technology and safety assurance of newly design components and related regulations requires an agreement of the public. Public participation in the licensing process of NPP in some countries could be adopted in the case of SMR's Licensing Process.

Key issues	• Fuel types and issues extended periods without re-fuelling • Environmental impact: Siting, source term analysis, and offsite emergency planning • Transportation of fuelled-NPPs (modules) and Spent fuel management
Presentations	Public communication and consultation in the regulatory licensing process (Mr Jubin, IAEA); Stakeholder involvement and public communication (Ms Pagannone, IAEA)
Case studies	• The removal of High Enrich Uranium (HEU) to Russia from Vietnam • Thorium nuclear fuel tested at Halden Research Reactor in Norway, April 2013 • Possible risk assessment analysis of source term and its impact on the environment

(Note) Mr Zin, the leader of Group 5, introduced group organization and discussion process on "Public participation in SMR licensing process," however this group session was cancelled due to low turnout and the general topic of public participation was integrated into the other groups (The small leadership meeting held after the second day session decided that each group will discuss the identified issues of the group 5 in connection with their group issues.)

1.3. Reference presentations by INPRO Group

1.3.1. INPRO Methodology and SMR: Review and recommendations for Task 2 revisions

Mr Korinny, INPRO Group, gave a presentation on INPRO Methodology and SMR focusing on the Methodology update project currently undergoing and INPRO Methodology and SMR.

INPRO Methodology is a criteria-based sustainability assessment tool technology independent, comprehensive, and internationally agreed. It has six areas of assessment including economics, safety, waste management, proliferation resistance, physical protection, environment and infrastructure and comprises three hierarchical structures as shown in the below diagram: Basic principles (14) - goals for development of sustainable NES; User requirements (52) - actions to be done by designer, operator or a state to meet goal; and Criteria (150) - metrics to check whether actions have been taken.

The project to update and revise the current version (published in 2008) has been undergoing in order to incorporate lessons learned from both experiences of NESAs performed in the past and the Fukushima Daiichi NPP accident. Total 194 comments from the Methodology users since 2008 in all areas are to be incorporated and 22 more proposals are to be covered in a separate task. The revised manual on economics is under publication and draft volumes on infrastructure, waste management and physical protection are under review.

In terms of INPRO Methodology and SMR, INPRO Group has been conducting limited experience of SMR assessments for Indonesia and Romania. It is viewed that since many SMRs are conceptually comparable to large scale, INPRO Methodology captures these features and carried out assessment of Gen-IV reactors suggested in the framework of INPRO-GIF collaboration. In order to cover assessment of SMRs, there a need to consider such characteristics of SMR design as learning curve approach in economics; modular design including factory build and shipment for infrastructure; and probability/consequence calculation issues and reference design for safety.

1.3.2. INPRO activities for global deployment of SMRs

Mr Kuznetsov, INPRO Group, gave a presentation on INPRO activities in support of global deployment of SMRs: collaborative projects RISC and TNPPs. His presentation covers overview of INPRO, SMR related INPRO activities.

Innovative SMRs might be an attractive solution in many markets of technology holder and technology user/newcomer countries alike so SMR shall be and are on the Agenda of INPRO, including long-range strategy, global scenarios and innovations. The IAEA supports Member States in developing national long-range nuclear energy strategies by NESAs using INPRO Methodology. INPRO's approach is a holistic and global view of nuclear energy systems together with the pursuit of innovations in nuclear energy.

There are a number of INPRO activities and projects that could support the global deployment of SMR technologies as exemplified in the below:

(On-going activities and projects)

- NESAs: NES with SMRs are being/ could be assessed upon requests of Member States.
- SYNERGIES: SMRs are being considered, along with other thermal and fast reactors, in the analysis and assessment of transition scenarios to future globally sustainable NES.
- ROADMAPS: guidance and template to develop national and regional roadmaps for transition to future globally sustainable nuclear energy systems
- TNPP: completed the 1st study on the Legal and institutional issues of transportable NPPs focussing on its deployment in countries other than the country of origin (In May 2013 IAEA Publication Committee approved its final report: Nuclear Energy Series No. NG-T-3.5 "Legal and Institutional Issues of Transportable NPPs" (Preliminary Study)).

(New activities and projects)

- RISC: review the design and licensing approaches to reduce off-site emergency planning requirements, deterministic with supplementary Level 2 PSA (IAEA Nuclear Energy Series No. NP-T-2.2) and probabilistic based on Level 3 PSA (IAEA TECDOC-1652)
- Phase II of TNPP: examine detailed legal and institutional issues for export deployment of a TNPP with factory fuelled and tested reactor

2. Breakout Session Progress Report

2.1. Group 1: Considerations for SMR Designs

The group discussed key issues and reviewed IAEA document "Safety of Nuclear Power Plants: Design - Specific Safety Requirements Series No. SSR-2/1." Also the Group looked into defence in depth in plant design including DID levels approach and had a consensus that there is no need to modify the DID philosophy, however the approach may be different in SMRs case. There is still a debate whether multiple modules are considered as one facility or individual facilities in the DiD discussion. Questions also arose around maximum number of units permitted on one site, and safety of multiple unit control rooms. There is no need to change safety requirements due to larger safety margins, but a discussion or consideration should be given for modular design.

Regarding the IAEA document SSR-2/1, the Group agreed that all existing requirements can be fulfilled by SMRs and safety margins may be wider. However, the Group identified certain items that should be investigated further and will suggest some specifications for IAEA further actions.

Sufficiency of regulations for large NPPs for SMRs may apply for FOAK case. On public concern, there were questions raised by participants on classification of SMRs according to range of power as classification is important from the public perception.

2.2. Group 2: Siting and Siting Considerations for SMRs

The Group discussed documents NSR3 for site evaluation and DS433 for safety aspects and agreed that most parts are suitable for SMRs but should be verified by the IAEA expert team:

The Group provided recommendations for a few additional items to be addressed for marine-based plants, e.g. addressing rapid changes of water levels (currently only marginally addressed by text on storm surges), and effects on safe operation of floating NPP. Also, supporting guides need to be examined by experts against the three case studies: some modifications will be necessary for below grade designs, sealed units designs, and marine based designs.

The Group discussed key issues. Regarding source terms for non-water cooled SMRs, this issue needs to be addressed so IAEA should consider a future consultation team to investigate and address this issue in greater detail. Regarding siting considerations for TNPP, the Group made tentative recommendation to explore NS-R-3 and DS-433 to include high level guidance on how to consider shipments of new and depleted reactors to and from the site. The issue on sites in regions lacking in fundamental infrastructure will be discussed.

Floor Discussions

On locating SMR in highly dense site, this will depend on individual member state policy on land-use, and is not likely to be addressable in NS-R-3. For a "no exclusion zone" design, regulators need evidence and expect exponents to defend the basis for such a case with design information. Likewise, designers need to know the regulatory requirements.

2.3. Group 3: Graded Approach

The Group received two presentations on the Graded Approach made by Mr D.V. Rao, IAEA and Mr J.R. Walker, Canada. The Group reviewed Participants' Briefing Handout and identified the six discussion items to be reviewed thoroughly over two case studies: 200MWe units in densely-populated Member State and 10MWe units in extremely remote region.

The Group prepared provisional recommendations for IAEA follow-up actions as follows: (i) to consider developing a guidance document explaining the graded approach to the application of safety and licensing requirements of SMRs; (ii) to consider developing a protocol for customer state regulatory inspection within SMR manufacturer's factory; and (iii) to consider acting as a knowledge management centre for experience in design, licensing, and operation of SMRs to assist regulatory bodies of Member States.

Regarding the third item, clarification was given by the IAEA experts and the recommendation is still questionable. The IAEA explained procedures of proposal on safety through the Committee of the Whole during GC, and that Member States can propose issues.

2.4. Group 4: Legal and Regulatory Framework of SMRs

The Group received presentations on the following topics:

- Establishment of a Regulatory Framework for Safety - GSR Part 1 – IAEA/NSNI
- Legal and Institutional Issues of TNPPs – IAEA/INPRO
- Insurance of Civil Liability for Nuclear damage - Russian Federation
- Legal Issues of TNPPs – IAEA/OLAT

The group discussion focussed on "plant staffing" and Transportable Nuclear Power Plants (TNPP) related issues. Plant staffing is dependent on technology and some discussions were made on the minimum number of staffs necessary for the operation of SMRs. IAEA Safety Standards for plant staffing needs to be reviewed and modified, if necessary, based on knowledge gained from SMR licensing activities. TNPP related legal issues are complex relative to international legal instruments and TECDOC near publication developed through the INPRO collaborative project is an excellent start for identifying issues. The Head of INPRO Group clarified that transportation rule is fully applicable, as confirmed by Transportation Section in IAEA (not OLA).

Some findings and discussions so far are as follows:

- Number of plant operators relies on design features; SMR operator training requirements should be examined; IAEA documents related to the plant staffing are SSR-2/2 “Safety of nuclear power plants: commissioning and operation” and NS-G-2.14 “Conduct of operations at nuclear power plants”. Industry proponents including some utilities in attendance argued that there is a need for international design certification, and international training for operators supported by vendors.
- The presentation was given on the issue on industrial standards and guides for inspection. A clear distinction exists between new designs that transport fuel separately and those that transport fuelled. Review is needed on TS-R-1 “Regulations for the safe transport of nuclear material” to confirm it addresses transport of fuelled reactor vessels. INPRO believes it is but this should be confirmed independently.

3. Presentations by International organizations

International organization presentations were made in Session 4: Plenary for Breakout Session Progress Report and International Organizations, taken place in the afternoon of Day 3. The following four organizations made presentations on their respective activities and programs related to licensing and safety for SMRs: ASME, OECD/NEA, WENRA, and WNA.

3.1. ASME nuclear codes and standards: Overview

Mr K. Ennis, Director for ASME Nuclear Codes & Standards, presented the overview of ASME activities related to nuclear codes and standards. ASME performs oversight of nuclear certificate program and accredits the manufacturers’ quality assurance programs. The ASME Stamp is applied for components, parts/appurtenances, supports, and installation. The ASME also accredits material organizations’ quality assurance programs applied by material manufacturers and suppliers.

Codes and Standards are promulgated by approximately 3,000 volunteers of whom about 500 are involved in Nuclear Codes and Standards and some 50% are ASME members. ASME is operating International Working Groups (IWGs) in order to address the challenges presented by time zones, travel constraints, and language barriers. An IWG is a “sub-tier” ASME code committee and is integrated into a Standards Committee hierarchy and its members provide expertise across a diverse mixture of disciplines (e.g. design, materials, QA, etc.).

SMR related Codes and Standards are:

- BPV III – Boiler and Pressure Vessel Code, Section III (initial contact for design only)
- BPV XI – Boiler and Pressure Vessel Code, Section XI (no contact)
- OM – Operation and Maintenance (no contact)
- CNRM – Nuclear Risk Management (no contact)

A key message that Mr. Ennis impressed on the audience was that the SMR industry has not yet engaged in any significant depth with codes and standards organizations to address specific changes necessary for deployment of SMRs. There is a significant lead time needed to prepare changes to codes and standards and that deployment of different designs cannot occur until those codes are ready (generally needed before the construction license review). The diverse types of SMRs currently being promoted also indicate that in some cases, new codes and standards will need to be developed and supported by appropriate R&D.

3.2. OECD/NEA study on the economics and market of small modular reactors

Mr Vladislav Sozoniuk, OECD/NEA, made a summary presentation of the OECD/NEA study on the economics and market of small modular reactors. His presentation focuses on key features of the SMRs, SMR deployment strategies, SMR economics, challenges for marketing and possible markets for SMRs. The development of small nuclear reactors (SMRs) has been in the focus of the OECD Nuclear Energy Agency (NEA) studies since 1990s.

Some of key features of the SMRs are: economy of serial production - expected to be easier to finance; “Modular construction” with factory-built modules; redundancy of production unit; potential co-generation; and potential smaller costs of decommissioning if modules are replaceable and factory disassembled/decommissioned.

SMRs target two general classes of applications: (i) traditional deployment and direct competition for electricity production with large NPP and other sources of power - relatively small upfront capital investment for one unit of a SMR provides more flexibility in staging capacity increases, resulting in smaller financial risks; and (ii) niche applications in remote or isolated areas where large generating capacities are not needed, the electrical grids are poorly developed or absent, and where the non-electrical products are as important as the electricity.

Full cost of electricity with SMR has similar structure to large reactor including: cost of establishment of a nuclear program (for newcomers), licensing, construction, O&M and fuel, provisions for decommissioning and waste management, taxes and levies, grid and backup costs (transport, reserve capacity, etc.). Regarding the challenge to enter the market, levelised cost of electricity (LCOE) for SMR might decrease in case of large scale serial production so large initial order is necessary for launching the process.

The market size for SMRs could potentially be tens to hundreds of units. Possible markets for SMRs are: (i) applications in remote areas - to date, only Russia announced its plans to deploy floating NPP (1st deployment expected in 2016); (ii) on-grid deployment - in the US SMRs is an alternative for replacement of small old coal power plants (about 27 GWe); and (iii) newcomer countries that might be interested in starting with a SMR.

The principal challenge for the SMRs is licensing and difficulties of modifying the existing regulatory and legal frameworks; and other important challenges are siting, multiple units/modules on the same site, the general public acceptability of new nuclear development, etc. If advanced SMRs are successfully licensed and their economic competitiveness is demonstrated, the SMRs may lead to a new renaissance of the nuclear industry.

3.3. WENRA and its expectations on the safety of new NPPs

Mr D. Müller-Ecker (GRS mbH – Germany), Chair of WENRA Technical Secretariat, gave a presentation on WENRA and its expectations on the safety of new NPPs, focusing on WENRA safety objectives, DID concept and approach, and practical eliminations for safety demonstration.

WENRA is operating three Working Groups: RHWG (Reactor Harmonization Working Group), WGWD (Working Group on Waste and Decommissioning), and post Fukushima Ad-hoc Working Groups such as natural hazards, containment integrity, accident management, periodic safety review, and mutual assistance.

WENRA RHWG initiated in 2008 it task on safety of new NPP designs and developed WENRA Safety Objectives (7 items) including a reinforced DID concept for new NPPs in November 2010. Selected key issues for new reactors and lessons learned from the Fukushima accident were incorporated in WENRA Statement and WENRA Report on Safety of new NPP designs in March 2013. Review of the national and international documentation showed consistency on the main lines of expected safety improvements:

- Reinforce the defense-in-depth (each level and their independence)
- Extend the design (include severe accidents as a new level of defense)
- Reduce the necessity of off-site measures in case of accident
- Consider safety issues in existing plants
- Increase components and systems diversity
- Increase protection against hazards
- Pay more attention to security and safety/security interface
- Better consider management of safety

The improved DID approach could be used for new reactors in all WENRA member countries but an appropriate adaptation to the safety related aspects of SMR designs might be necessary.

3.4. The CORDEL perspective on standardization and SMRs challenges and opportunities

Mr A. Wasylyk, Project Manager, World Nuclear Association (WNA), made a presentation on the WNA CORDEL perspective on standardization, and gave a brief view of SMRs challenges and opportunities. His presentation covers overview of Cooperation in Reactor Design Evaluation and Licensing (CORDEL), key factors challenging standardization, advantage of modularisation and small reactors to component cost, and approach to international certification.

CORDEL aims to promote international standardisation of each vendor design and information sharing on operating experience and design improvements, and safety and economic best practices. CORDEL Working Group is composed of four Task Forces (codes & standards, design change management, licensing & permitting, and IAEA Safety Standards / Probabilistic Safety Goals) and three Ad-hoc Groups (digital I&C, SMRs, and results from Fukushima).

The social benefits of standardisation are the benefits of SMRs: Reduces licensing, construction and commissioning risks; enhance credibility with investors; leverage of resources across fleets in special tooling, share of spare parts, obsolescence issues; public confidence in regulatory decisions increases; peer review and international cooperation can address issues and problematic areas with wider knowledge and resources; and standardisation of components with wider markets.

He suggested the following step by step approach toward international design certification.

(Phase 1) Share design assessments/reviews: this is being done more and more by NEA/ MDEP
(Phase 2) Validate and accept design approvals of other countries: this is done de facto by newcomer countries and needs more specific guidance for application to SMR licensing.
(Phase 3) International Design Certification: in practice, some elements of phase 3 could be done immediately through joint design review and commitments to issue identical licences; in the long term, a treaty system could be installed.

A number of regulators in attendance pointed out to the audience that although the NEA's MDEP has made significant inroads in sharing design assessments, discussions on Phase 2 would only be possible if vendors are willing to be fully transparent on the design information they are submitting to regulators for certification or licensing reviews (currently this is not the case). Regulators pointed out that Phase 3 may take decades to achieve and expending energy on this effort distracts from the more immediate need to address pressing concerns such as developing appropriate codes and standards where convergence may be possible in the near term.

4. Proposal on SMR Regulator's Forum

Mr Magruder from NRC, USA, made a presentation on "Proposal of Regulator Forum for SMRs" at the perspective of the US regulator. In the outset of his proposal, he gave background on this proposal, informing that the setting up of this Forum was also proposed at the last consultancy meeting. The Chair, Mr Newland, reminded participants of the conclusion of this consultancy meeting that the meeting had not reached a consensus but decided that "the proposal continues to be open until the next INPRO Dialogue Forum in order to get more comments and opinions from participants and other Member States."

Based on the discussions at the last consultancy, he suggested the following guiding principles: (i) Initial membership is suggested to be MSs currently developing SMRs; (ii) the operation of the Forum must be MS driven (MS's ownership) and MS should bear the participation cost of the Forum but the IAEA could facilitate it with MS funding; (iii) the Forum has an willingness to openly share knowledge and experience; and (iv) the Forum could initially start as an working group through a consultancy meeting – initial focus on terms of reference.

Mr Gibbs added some complementary explanations: as Mr Lyons' remarks in the opening, the IAEA (NSNI) encourages the formation of the forum and help facilitate and promote such a forum; suggested to focus on how to implement including the way of operation and needed extrabudgetary funding.

Mr Drace: the Forum could be a mechanism for promoting interaction between designers and operators and regulators and between NENP (designers) and NSNI (regulators) with the IAEA (e.g. annual INPRO-GIF interface meeting including the organization of a technical workshop on licensing and safety issues for SFRs).

Some of participants' views: if set up, consider how to manage appropriately the Forum as there are a number of SMR technologies and designs; need to promote interactions with designers, vendors, TSOs, etc., considering negative aspects of MDEP's experience; needs to open to industry to get users' inputs; may be some burden on industry in phase but benefit to technology holders by harmonizing rules and setting common regulatory positions; and suggest to extend the scope of this Dialogue Forum to discuss cross-cutting issues.

VI. Future Actions on Licensing and Safety Issues for SMRs

The plenary began with presentation from 4 groups on their issues, followed by presentation from China on their ACP100 Design. Mr H Subki presented results of the questionnaires distributed to the participants prior to the meeting. Mr D Ingersoll acting as a rapporteur presented his observation of the plenary session, and Mr D Newland as the Chairman gave a summary report. The INPRO Group Leader Mr Z Drace presented INPRO future actions and suggestions prior to the conclusion of meeting by Director of NENP, Mr J.K. Park.

1. Report on the Breakout Session Results

1.1. Group 1: Considerations for SMR Designs

Ms K Söderholm, Leader of Group 1, reported the group discussion results focusing on discussed issues, method, major findings, and recommendations. The full final report is attached as Annex 5.

As reported in the plenary for the Breakout Session, the Group 1 discussion focused on the below key issues and the case studies were used to trigger the group discussion.

- Defence in depth in plant design
- Suitable DID approach to manage international standardization
- Operational Reliability of the Integral PWR's (iPWR) SMR designs
- I&C in SMRs and plant staffing
- Safety analyses challenges
- Fukushima lessons learned

In terms of the group discussion process, all group members reviewed the requirements in the IAEA Safety Standards SSR-2/1 (Safety of Nuclear Power Plants: Design) and identified 19 key design requirements that entailed additional discussion to assure that SMR features were adequately addressed. Also, each participant was given an opportunity to express their views concerning these topics with respect to SSR-2/1.

Major findings and considerations are:

- DID philosophy do not need any modification because of the difference of the approach from large NPP
- The modularity of SMR designs requires specific consideration, especially for modularity in construction and modularity for multi modules.
- Concept of "practical elimination" for plant event sequences that could result in high radiation doses or radioactive releases needs to be considered.
- Special considerations need for I&C (especially remote locations) and human factors (operator actions, multiple reactors in common control room)

- Issues on operational reliability of iPWR discussed were in-vessel control rod drive mechanisms and FOAK engineering features and their reliability.
- Need for knowledge sharing of new engineering features (for safety analyses and approval of the reliability, e.g. modelling and experimental data)

Regarding recommendations, the group had the opinion that the Safety Standards SSR-2/1 in most parts are consistent with SMR features and capabilities but it is recommended that the standard be kept technology neutral and their findings be conveyed to the group that is responsible to revise the safety standard. Additional meeting should be organized to discuss novel aspects of multi-module plants, e.g. operation, control room, I&C. The I&C for remotely controlled SMRs, including satellite links and cyber security, is recommended to be included in studies of IAEA's Nuclear Power Engineering Section on Instrumentation and Control Technologies.

The group also discussed the topic on public participation and made the following views and suggestions: (i) Strong safety case offered by SMRs should be communicated to the public in a simpler way; and (ii) Regulatory process must provide adequate protection of vendor and supplier intellectual property for full public participation and acceptance of SMR technology.

The group identified several cross cutting issues as follows:

- Multi-module designs, human factors, remote control, I&C
- Internal versus external hazards
- Emergency planning zone (exclusion zone)
- Physical security, transportation of fuelled reactor

1.2. Group 2: Siting Considerations for SMRs

Leader of Group 2, Mr Marcel de Vos, indicated that the group 2 discussions were highly successful particularly in light of the very diverse backgrounds of the attendees. SMRs could alter the traditional picture of a NPP site. There were 3 case studies examined, and siting conditions in these case studies were developed to challenge NS-R-3 siting requirements as well as the design and the ability to provide adequate emergency response in a timely manner.

The three case studies examined were: (i) Closer to dense population centres with stressed (e.g. inadequate) infrastructure, (ii) Adjacent to industrial facilities that present challenges to the SMR's safety case, and (iii) Very small facilities in remote regions with poor infrastructure and delay of emergency response. The group reviewed two IAEA Safety Standards against case studies: DS-433 *Safety Aspects in Siting for Nuclear Installations* and NS-R-3 *Site Evaluation for Nuclear Installations*.

There were 4 main discussion points followed by recommendations.

- *Determining source terms for non-water cooled SMRs or novel fuels*: There is recognition that source terms from marine based SMRs and non-water cooled designs need to be addressed. In this regard, the IAEA needs to investigate and address the issue in greater details with priority given to designs available for near term deployment. The country of origin of technology shall provide technical support in dealing with this issue.

- *Transportable Nuclear Power Plants (TNPP)*: The IAEA needs to provide guidance to Member States to clarify their own requirements that should address any difference between a TNPP and a fuel transport package. The IAEA also should facilitate a regulatory discussion to address the issue and also whether to integrate shipment route into site investigations as a basis for site acceptance or rejection. The country of origin of technology shall provide technical support in dealing with this issue.

- *IAEA Safety Standards DS-433 and NS-R-3*: both are in most part suitable as-written for all SMRs. Therefore, requirements and guidance can be applied in a graded manner, and some adjustments to guidance may be necessary for designs to be located below ground and for TNPP (including surface and subsurface marine-based). The IAEA was asked to confirm this point, and to examine IAEA Safety Guides NS-R-3 as a suite against the three case studies used to address below grade designs and TNPP designs.

- *Sites in regions lacking in essential infrastructure*: There is greater potential for SMR sites to be located where essential infrastructure is insufficient or does not exist. In this regard, site surveys and site characterization is needed to address safety and security issues and establish a plan for ensuring infrastructure in place. Guidance is needed on infrastructure considerations for reactor facilities sited in close proximity to hazardous industrial facilities. As NS-R-3 provides only high level guidance, more details and associated safety guides are needed to address the issue. Information should consider both policy-based infrastructure such as national emergency plans as well as physical infrastructure.

With respect to cross cutting issues, there were several cutting issues mentioned, namely 'practical elimination' for SMRs placed in regions with potential for more aggressive external events or other pressures, and graded approach for siting as a risk informed activity. More challenging site conditions present greater impacts on emergency planning with implications on staffing, and more pressure on design to compensate challenges to operation and emergency response.

The group identified 'siting' related concepts that require clarification for public understanding as follows: source term, core damage frequency (CDF), practical elimination, essential infrastructure, unacceptable potential effects of the nuclear installation on the regions (NS-R-3 § 2.25), inherently safe, and passive (safety) features. Clarification is also needed on the relationship between emergency planning and the term 'inherently safe' - this is an important consideration for both the site survey and site characterization steps. In this regard, the IAEA should consider adding this information to DS-433 and NS-R-3 to further clarify the guidance.

Floor Discussions

- On environmental aspect for TNPP compared to SMR in specific site, understanding of the meaning of siting for TNPP is required. The route in siting is still not clear. For transportability or reactor without fuel, there is no problem for it can fulfil requirements as fresh fuel package.
- For remote regions: Regulatory bodies will need to weigh reactor safety against safety issues that arise if access to the power is lost. For example, in remote northern regions, lack of power will put lives at risk.
- For efficiency purpose, siting and environmental evaluation for a site with a number of modules should be performed taking into account maximum capacity.
- On TNPP, the Russian Federation has been transporting reactor with no fuel. A factory fuelled reactor is discussed for distant future. It was noted that one vendor has proposed such (fuelled reactor) design. In this respect, France also commented on Flexblue design, i.e. transportation of fuelled reactor to the site.
- On essential infrastructure, the current writing should be examined that it includes not just infrastructure for SMRs but also around the site, for example near the refinery, and identify if gaps exist.
- Regarding public understanding of safety terms, one participant argued that wider audience should be informed and understood, but industry needs to be cautious in doing that. There must be agreed terms to be clarified by industry such as inherently safety, especially to the public.

1.3. Group 3: Application of graded approach in regulatory and licensing process for SMRs

Leader of Group 3, Mr A Ramakrishna presented application of graded approach to key discussion points: emergency planning and accident response, safety analysis (codes, methodology, and validation), I&C, plant staffing, licensing process, and public participation. The group examined two case studies: 200 MWe units in densely-populated Member State, and 10MWe Units in extremely remote region. Comparisons were made between the two case studies over the six issues to review application of graded approaches. Details (for details, see attached the final group report).

It was noted that the requirement of public participation cannot be graded, and there was question on the correctness of the term ‘inherently safe’.

The group recommended the IAEA to develop a guidance document on the application of the graded approach, a protocol for MS’s inspection on SMR manufacturing factory, and host web-based information on SMR designs, licensing and operation experience.

Floor Discussions

- Questions arose on whether PSAs are actually required of very small SMRs. Discussions seemed to indicate that the need for PSA can be determined by individual regulatory authorities. One participant asked how graded approach to safety could be defined - as a risk informed manner.
- Given the fact that each Member State has certain protocol, it is argued that protocol is needed because under contract or as regulatory when doing inspection. The protocol is useful especially when going into serial production. But in procurement guidelines in GSR 3, there is an obligations that supplier of contract will have access and inspection. So there should not be an issue.
- One participant had the opinion that public participation cannot be graded and asked whether the role of applicant or license was examined considering that public perception is sensitive. Basically it’s not looking at regulators, simply regulator process. However, France argued that PSA target risk can be graded based on factors such as local social and economic conditions.

1.4. Group 4: Legal and regulatory framework of SMRs

Leader of Group 4, Mr Stewart Magruder, reported the discussion results on identified 5 key issues and recommendations made in this group. Key issues include: plant staffing, transportation of fuelled NPPs, licensing process for multiples modules, identification of required changes to safety standards, and standardization of portion of design and safety classification.

Summary of finding and considerations for the five key issues are as follows:

(Plant staffing) It was concluded that number of operators relies on design features, and that training requirements need to be examined. A number of industry representatives indicated this needs to be addressed as well as part of discussions around “International Design Certification.”

(Transportation of fuelled NPP) Considerations should be given on industrial standards, designs with separate fuel or fuelled designs and on IAEA document “Regulations for the safe transport of nuclear material (TS-R-1).”

(Licensing process for multi modules) Some of the new designs are opting for sharing more safety systems, accordingly it was discussed whether sharing safety systems is an option but participants were reluctant towards this idea, pointing to the DID principle of independent safety systems. Licensing multiple modules for one site at the same time might be problematic, as the design of modules may change, resulting in different vintages of the same design on one site. There is a need to review the safety standards to see if there are clear requirements and guidance, and to determine whether related standards need revision.

(Identification of required changes to safety standards) Both IAEA documents (SSR-2/2 on Safety of Nuclear Power Plants: Commissioning and Operation and NS-G-2.14 on Conduct of Operations at Nuclear Power Plants) need to be reviewed (see below) need to be reviewed (see below).

(Standardization of portion of design and safety classification) It is important to business case for vendors but difficult with changing standards and requires shift in thinking on part of users.

(Cross-cutting issues) Consistent with the discussion at the consultancy meeting to plan the dialogue forum, the group identified the following issues as cross-cutting: application of graded approach; size of EPZ & siting; and design for inspection & testing.

(Public participation) Public may demand at least one operator to be present including for fully automated reactors. The IAEA needs to conduct a workshop of public acceptance for SMRs.

Major findings and recommendations are as follows.

- IAEA should consider reviewing safety standards for new SMRs for near-term commercial deployment, taking into account issues like licensing process, number of staffing, remote location, transportation of TNPP, etc.
- Designers, regulators and operators need to proactively cooperate with standards organizations with respect to technical standards for SMRs.
- There is a need to facilitate parallel considerations of design safety requirements by industry and licensing safety requirements by regulators.
- There is a need to update IAEA Glossary to reflect terminologies pertinent to SMRs, and evaluate whether SMRs need to be further classified into sub-groups. (Note) there was no consensus at the Forum that this is necessary and many felt that SMRs are simply smaller NPPs and classification is simply a "marketing exercise".
- IAEA needs to support discussion of potential international certification of designs, and roles of regulator and IAEA in facilitating deployment of SMRs, e.g. licensing, serialization.
- There is a need to review the IAEA Safety Standards regarding number of staffing, for example, NS-G-2.14, to determine whether changes are needed with regard to SMRs (e.g. consider defining a minimum number of operators for SMRs).
- IAEA needs to consider cooperation with OECD/NEA RISK WG on SMRs.

Floor Discussions

There was a question on multi-unit PSA and discussions how to approach and implement.

Regarding waste management, there are issues on international arrangement of retrieval of waste to country of origin depending on the contract. IAEA draft TNPP report incorporated reference cases and assumptions on such waste management. One advantage for SMRs is no decommissioning phase, but there is no difference with waste management from conventional NPP. Many countries prohibit retrieval, and change of national law is needed when retrieval is to be allowed.

The group did not discuss monitoring management of fleet with respect to regulatory program.

No conclusion on what the IAEA, NEA or Member States should do regarding International Design Certification. Member States did agree that this is a long term goal but there was no consensus on whether pursuing it at this time is a suitable use of valuable resources, particularly when there are a large number of embarking MSs that do not have well developed regulatory system.

(Note) *For details, see Annex 6: The Final Breakout Session Full Report. This report was prepared by consolidating each group report submitted by group leaders.*

2. Results of the Questionnaire Survey

The IAEA Secretariat requested all participants complete the Questionnaire two weeks before the forum to facilitate the conduct of the forum and to get information on the following items: MS status for SMR technology deployment; challenges in deploying SMR and siting for NPP and/or specific for SMR; countries preference in particular SMR design and technology; preparedness of countries in legal and regulatory framework to support SMRs licensing; and public response to potential SMR deployment. In the Questionnaire are also included the following technical topics: energy demand and share of nuclear energy, grid characteristics, benefits and impediments on introducing SMRs over large NPPs, modularization technology, the use of SMRs for non-electric application, infrastructure issues including site selection, SMR safety features and measures, and assurance of fuel supply. Mr Subki, NPTDS – IAEA, presented the summary of preliminary assessment of the participants' responses to the Questionnaire at the final session of the Forum.

Countries considering SMR technology deployment – domestically: The number of technology developers among 37 MSs responded is 13 countries. Among responding countries, 20 MSs are considering SMR deployment, 14 MSs are not considering, and 3 MSs are not decided. Looking at the status by region, Asia is the largest with 7 countries considering SMR deployment, followed by Africa (5), Europe (4), America (3), and middle-East (1).

Key challenges on licensing and safety in deploying SMR: legal and institutional frameworks, particularly for deployment in foreign market; lack of human resource, skills and capacity, and limited operating experience in advanced SMRs; low level of public acceptance and lack of persistent support from governments; long lead-time to prepare for and receive regulatory review; sufficient regulatory credit for inherent safety and security in the design; and review of code & standards that impact licensing.

Siting for NPP and/or specific for SMR: KLT-40S FNPP construction near completion; a site for SVBR-100 prepared (Russia); constructing HTR-PM in Shiadowan (China); completed site excavation for CAREM-25 (Argentina); envisioned deployment of mPower for TVA in Clinch River Site in 2022 (USA); conducted the study on deployment of SMRs in remote areas in the southern and northern territories (Canada); several candidate sites for SMRs in South East Asia with archipelago; and several local governments invite SMR construction (Korea).

Countries preference in particular SMR design and technology: Integral-PWR type SMRs with modularization (Argentina, China, France, India, Korea, Russia, Canada and USA); FNPP and LMFR-SVBR-100 (Russia); and embarking countries preferred proven-technology.

In summary, most of MSs responded currently do not provide a specific legal and regulatory framework for SMRs; demands from MS concerning SMRs vary significantly; there is a need to address capacity building for new-comers' regulatory authorities to cope with SMR licensing; and discussions mostly focus on water-cooled integral-PWR type SMRs for multi-modules plant.

3. Conclusions and Recommendations

3.1. Summary and findings by Rapporteur

Mr Ingersoll, Rapporteur of the plenary session, presented the accomplishment of the plenary sessions that had been taking place from Monday to Wednesday.

In his personal observations, beginning from the INPRO CUC project (2008-2009) with few SMRs that was still unfamiliar concept, to the extraordinary follow up meetings, many countries viewed that SMRs appear to be the solution as confirmed by this Dialogue Forum. However, there are still many questions and issues. The diversity of SMRs is overwhelming and a clear simple matrix is required for MSs to be able to evaluate and compare SMR designs and categorization can be based not just on power but also other aspects such as functionality, e.g. multi-modular, sub-categorization (iLWR, TNPP, micro). Participants expressed lots of interest in details of design and licensing and special interest in "modular" (multi-unit) plants.

The IAEA has done an exceptional job at facilitating the dialogue between technology holders and users, and the progress in dialogue seemed impressive. He pointed out that there are lots of issues and challenges to be addressed and the job is not over.

3.2. Summary and findings by Chairman

Mr Newland, Chairman, presented his personal observation, key conclusion and recommendations, highlighting the wells of information shared from the IAEA, regulators, TSOs, international organization, standards organization, agency staffs who provided the background and the activity of INPRO Group. The diverse participation has allowed exchange of opinion during the forum and throughout the breakout session. With so many designs, philosophy is needed to change the way of licensing. The issue that could not be accomplished during the Dialogue Forum is public participation, perhaps due to the greater challenge but it was noted that this aspect is very important, a pre-requisite to a successful implementation of the SMR project.

He touched a number of themes that cut across many of the breakout session discussions: licensing and safety breakout session top ten findings, sharing of information on SMR technologies, international licensing or certification, international cooperation, and finally, standards and guides. Mr Newland also mentioned that the idea for a forum for regulators of SMRs seemed to be a worthy initiative moving forward.

3.2.1. Key findings from breakout sessions

IAEA Safety Standards are deemed fundamentally sound but require some adjustments. The principle of defence-in-depth (DID) - the cornerstone of safety must not be changed. The principle of the EPZ should not be changed but it can be graded taking into account the design and the location. Standards are not clear to address multi modules and Transportable Nuclear Power Plants (TNPP) that require additional consideration. Some opportunities for SMR deployment will challenge what must be available in terms of the local or essential infrastructure. In fact, some SMR deployment scenarios require one to clarify what is meant by essential infrastructure in specific cases, e.g. for a very remote site, an airfield may be essential to emergency plan execution.

As a result, the forum recognized that the approach to emergency planning and response needs to be adjusted according to the type of design and the local situation. In some cases and with increasing use of automation, the notion that all of the operators have to be physically present at the plant needs to be studied further. Further development of engineering standards is critical so that regulators can do review efficiently. The engagement of industry and regulators with the public to assist its understanding must be done in a timely fashion by both proponents of these technologies, licence applicants and regulators. Countries embarking on nuclear power have special needs that require those countries with nuclear technology to assist in sharing knowledge and experience, e.g. through forums such as the IAEA Regulatory Cooperation Forum.

3.2.2. Key recommendations

(Sharing of information on SMR technologies) Given the number of technologies and their diversity, and the increasing interest from embarking countries, it is recommended that Member States identify their specific needs for information gathering and sharing and the IAEA explore whether it could act as a central repository for such information

(International licensing or certification) During the plenary presentations, panel discussions and breakout sessions, participants proposed the concept of international licensing and design certification. Therefore, it is recommended that proponents of such an approach need to develop a more substantive proposal with its concrete vision and regulators should consider the same issue to determine whether there are fundamental difficulties with such an approach.

(International cooperation) The INPRO Dialogue Forum is a proven means of cooperation among vendors, proponents, regulators and others and the Regulatory Cooperation Forum (RCF) is an important mechanism for more experienced countries to assist those regulators that have less experience. During the Forum, many countries have requested that a SMR Regulators' Forum be considered. Therefore, it is recommended that (i) the IAEA continue to actively engage all stakeholders on SMR activities both through INPRO and NSNI; (ii) the RCF is open to consideration of SMRs in embarking countries; and (iii) interested MSs, with assistance from the IAEA, take exploratory steps to establish a SMR Regulators' Forum. It was agreed that the IAEA (NSNI) working with the INPRO Group would conduct a consultancy meeting in early 2014 to bring together those regulators who had expressed interest during this Dialogue Forum and those countries who are involved in SMR designs to discuss in a more focused way the formation of such forum, including the development of a terms of reference.

(Standards and guides) It was concluded that, for those reviewed, the IAEA Safety Standards are to a large degree applicable to SMRs but in case of the Safety Guides a more detailed review is necessary to verify their applicability to SMRs. For industrial standards, further work is required to ensure that these are adequate and complete for SMRs. Therefore, it is recommended that (i) MSs include a General Conference Safety Resolution regarding the importance of the safety of SMRs and the need for safety standards and guides; and (ii) vendors and utilities engage with Standards Development Organisations to ensure that standards are ready prior to licensing.

On his final remark, Mr Newland praised the high degree of collaboration throughout the week, particularly during the breakout sessions. In order to maintain such collaboration, he maintained openness and transparency is a must in sharing knowledge, and emphasized the importance to use existing collaboration mechanisms rather than inventing one.

3.3. Future actions and suggestions from the INPRO perspective

Mr Drace, Head of INPRO Group, presented "Future Actions and Suggestions from the INPRO Perspective." He summarised that this Dialogue Forum achieved its objectives to discuss the key issues regarding licensing and safety issues of SMRs; participants to the Forum developed and prioritised a list of licensing and safety issues relevant to SMRs and provided diverse suggestions for the path forward. In this regard, he conveyed highly appreciation to all meeting officers, especially to group leaders and co-leaders for their great contributions and dedicated hard working.

He highlighted future actions envisaged by INPRO as follows:

- Case study for the deployment of factory fuelled SMRs (2014-2015)
- Limited scope of NESA for innovative reactors including SMRs (2014-2016)
- Revision of INPRO methodology (2014-2015)
- 7th Dialogue Forum on Sustainability of NES (November 2013)
- Dialogue Forum on demand driven innovative SMRs

He also made the following suggestions at the INPRO perspective:

- Redefine mandate of the existing IAEA TWGs incorporate innovative SMRs;
- Expand SMR related IAEA information and database by improving the existing ARIS;
- SMR Regulator's Forum needs to be independent from INPRO Dialogue Forum

3.4. Closing remarks

The meeting was closed by **Mr Jong Kyun PARK.** He delivered congratulations for successful completion of the sixth INPRO Dialogue Forum on Global Nuclear Energy Sustainability – addressing the Licensing and Safety Issues of SMR.

He pointed out that due to the outstanding leadership of Chairman Newland and Co-Chairman Juhn, it was possible to constructively discuss the identified key issues of design considerations, siting and infrastructure, application of graded approaches, legal and regulatory framework, and public participation in the SMR licensing process.

He expressed his expectations that this Forum has facilitated a common understanding of the needs and potential role of different stakeholders in countries considering SMR for their near term and future national energy mix by addressing key issues on licensing and safety of advanced SMR technologies; and this Forum has been an opportunity for Member States in developing and deploying SMRs as one of the viable options for reliable and competitive energy mix.

He confirmed that the Agency continues its various programs to support Member States build capacity for nuclear programs— through close collaboration between the Department of Nuclear Energy and the Department of Nuclear Safety and Security. He also convinced that this Forum could formulate recommendations and path forward to address the identified key issues and the IAEA will have a thorough review of the recommendations and take appropriate actions.

He pointed out that the idea of setting up a Forum of Regulators on SMR was discussed as an option to carry the issues forward but the setting up such a Forum is beyond the scope of this Dialogue Forum. Therefore, this issue has to be further discussed with the existing Regulators'

Cooperation Forum and the Agency's Department of Nuclear Safety and Security.

VII. Annexes

Annex 1: Terms of Reference of the 6th INPRO Dialogue Forum

1. Background

The Agency seeks to bring together technology holders and technology users to discuss and share information on desirable innovations, both technical and institutional, to ensure that nuclear energy is available to meet long-term global energy needs in a sustainable manner. The INPRO Dialogue Forum is one mechanism for technology holders and users to discuss such innovations.

The 56th IAEA general Conference resolution (GC(56)/RES/12) stressed the importance, when planning and deploying nuclear energy, including nuclear power and related fuel cycle activities, of ensuring the highest standards of safety and emergency preparedness and response, including incorporating the lessons learned from the Fukushima Daiichi accident.

In October 2011 an INPRO Dialogue Forum was held on Common User Considerations (CUC) for Small and Medium-sized Nuclear Power Reactors (SMRs) to discuss user considerations for SMRs in light of the conclusions reached in the CUC study and recent developments in SMR technologies.

The IAEA technical meeting, held in December 2011, on “Technology Assessment of SMRs for Near Term Deployment” concluded with respect to their safety and licensing aspects as follows: 1) Since many innovative SMRs contain a certain degree of ‘first-of-kind’ engineering systems and components, licensing and regulatory issues must be addressed; 2) Many newcomers are still in favour of ‘proven’ technology and want SMR technologies to be first deployed in the country of origin to minimize licensing and performance risks; 3) In the light of the Fukushima Daiichi Accident, the technology users paid particular attention to the implications of multi-module plants relating to extreme natural events that could potentially lead to severe accidents; and 4) The technology holders should incorporate lessons learned from the Fukushima Daiichi Accident into the design.

In December 2012, the INPRO Group in cooperation with NENP-NPTDS and NS-NSNI organized a Consultancy Meeting to prepare this Dialogue Forum and to discuss the possibility of setting up a “SMR Regulators Forum” in the IAEA Member States. At this Consultancy Meeting, participants discussed and identified specific topics and issues for this Dialogue Forum.

2. Participation

The meeting is open to 80 or more participants from Member States including Albania, Algeria, Argentina, Armenia, Bangladesh, Belarus, Belgium, Brazil, Bulgaria, Canada, Chile, China, Croatia, Czech Republic, Egypt, Finland, France, Germany, Hungary, India, Indonesia, Israel, Italy, Japan, Jordan, Kazakhstan, Kenya, Republic of Korea, Malaysia, Mexico, Morocco, Netherlands, Nigeria, Pakistan, Poland, Romania, Russian Federation, Saudi Arabia, Slovakia, South Africa, Spain, Sudan, Switzerland, Thailand, Tunisia, Turkey, Ukraine, United Arab Emirates, United Kingdom, United States of America, Uruguay, Vietnam, and the European Commission.

Participants may include representatives from: WENRA, OECD/NEA groups such as CNRA, CSNI and MDEP, technology developers (vendors/reactor designers, GIF, fuel cycle facility designers), utilities and utilities groups such as WANO, TSOs, key “code and standard” developers (e.g., ASME), and NEPIO representatives from embarking countries.

The meeting targets senior officers or technical experts from potential licensees and national regulators, in both developing and developed countries, engaged or interested in the development, deployment and licensing of sustainable nuclear energy systems, especially on innovative SMRs. The participants will be expected to actively participate in the breakout session, including presenting any evidence to support a point of view. Participants are strongly encouraged to review the background material prior to the meeting.

3. Programmatic Context

The meeting is being held under Subprogramme 1.1.4, "International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO)", of *The Agency's Programme and Budget 2012–2013* (IAEA document GC(55)/5 issued in August 2011).

4. Objectives and Outputs of the Meeting

The traditional objective of the INPRO Dialogue Forum is to bring together nuclear technology users and technology holders from all IAEA interested Member States to discuss issues related to sustainable nuclear energy development and deployment. This dialogue facilitates mutual understanding of the needs and potential roles of technology users and the possibilities and limitations of technology holders. To date, five INPRO Dialogue Forums have been held since 2010. For details, see www.iaea.org/INPRO.

This Dialogue Forum aims to discuss the following major issues regarding licensing and safety issues of Small and Medium sized Nuclear Power Reactors (SMRs): 1) considerations for SMR designs; 2) siting considerations of SMRs; 3) application of graded approach in regulatory and licensing process; 4) legal and regulatory framework of SMRs; and 5) public participation in SMR licensing process (see Annex: Scope and nature of the Meeting).

The primary audience for this forum will be nuclear regulators and operating organisations in the IAEA Member States that are potentially licensing or preparing to license SMRs. Other stakeholders such as technical support organizations, vendors, and codes and standards organizations are also encouraged to participate. All participants will discuss the common issues for deployment of SMRs. For those countries considering SMRs in their nuclear power development programme, it will provide licensing and regulatory knowledge and experience through its participants with an opportunity to discuss common safety issues with technology holders.

Participating Member States considering the use of SMR technology are expected to develop and prioritise a list of licensing and safety issues, develop an understanding of related work in other forums and a recommended path forward to resolve, and address the issues identified through participation in a working group.

5. Location

This Dialogue Forum will be held at IAEA Headquarters, Boardroom A, Building M, Vienna International Centre (VIC), Austria.

6. Meeting Officers

Scientific Secretaries:

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Scope and Nature of the Meeting

The workshop will consist of lectures and presentations by IAEA professional staffs, invited experts and representatives from Member States and International Organizations as follows:

The workshop will consist of lectures and presentations by IAEA professional staffs, invited experts and representatives from Member States and International Organizations as follows:

- IAEA presentations may include INPRO methodology to assess innovative nuclear energy systems; status and prospects for SMRs; IAEA Safety Standards on the licensing process and related safety assessment requirements for nuclear power plants; and common user considerations on safety for SMRs.
- Member States' presentations may include: experiences and preparations for SMR licensing and deployment (technology holders) and licensing safety issues for SMRs (technology users).
- Presentations by International Organizations and invited speakers may include; licensing and safety approaches, development of design criteria, codes and standards for new nuclear energy systems including SMRs and Generation IV reactors.

Prior to the workshop selected participants will be provided with a chance to supply information on:

- Their national vision and status of development, deployment and licensing of SMRs from the perspectives of technology holders.
- Licensing and safety issues for the deployment of SMR technologies from the perspectives of technology users.
- Policy and technical issues and user requirements with respect to the unique design features and deployment plans for SMRs.

These presentations will be followed by breakout sessions to facilitate in-depth discussion on the following topics and issues:

- (Group 1) Considerations for SMR designs: implementation of defence in depth; approaches to international standardization; I&C and plant staffing; safety analysis challenges; and Fukushima lessons learned.
- (Group 2) Siting considerations for SMRs: determining source terms for non-water cooled SMRs or novel fuels; siting considerations for fuelled transportable reactors; and sites in regions lacking in fundamental infrastructure (including extreme remote sites).
- (Group 3) Application of graded approach in regulatory and licensing process: flexibility in emergency planning requirements and accident response; licensing codes and methodologies; R&D programmes; and demonstration of innovative features.
- (Group 4) Legal and regulatory framework of SMRs: plant staffing; licensing process for multiple modules; standardization of portion of design and safety classification; identification of required changes to safety standards; and transportation of fuelled-NPPs (modules).
- (Group 5) Public participation in SMR licensing process: new nuclear fuel issues (e.g. uranium nitride); environmental impact; safety culture; transportation of fuelled-NPPs (modules); and spent fuel management.

This breakout session will be followed by a panel discussion toward innovative licensing approaches for SMRs and presentations of proposals toward future actions for licensing and safety issues for SMRs.

The final session will consist of presentations summarizing the conclusions and recommendations from representatives from technology developers and potential users with a summation and concluding remarks by the Chairperson.

Annex 2: Agenda

INPRO — International Project on Innovative Nuclear Reactors and Fuel Cycles — IAEA

INPRO Dialogue Forum on Global Nuclear Energy Sustainability:

Licensing and Safety Issues for Small- and Medium-sized Reactors (SMRs)

29 July – 2 August 2013, IAEA Headquarters, Vienna, AUSTRIA
IAEA Board Room A (M-0237), Board Room C

AGENDA

Monday, 29 July 2013 *(Meeting Room: **Board Room A**, M Building)*

Time	Session and Topic	Presenters
08:00	Registration (Vienna International Centre, Gate 1)	All
	Session 1: Opening and Introduction	
09:30	**Opening** ➢ Welcome and opening remarks ➢ Opening remarks ➢ Chairperson's remarks ➢ Co-Chairman's remarks ➢ Program overview and objectives ➢ Approval of the Agenda	 J.K. Park (DIR-NENP) J.E Lyons (DIR-NSNI) David Newland (Canada) Poong-Eil Juhn (Korea) P.H. Park (IAEA) Chairperson
10:30	Group photo and coffee break	
11:00	**Introductory Presentations** ➢ INPRO activities in support of transition to sustainable nuclear energy systems ➢ Summary of results of the preparation consultancy meeting ➢ Status of global SMR development and prospects for deployment ➢ Licensing process considerations for SMRs ➢ Design review process for nuclear installations	 Z. Drace (Head-INPRO) S. Magruder (USA) H. Subki (IAEA) R. Gibbs (IAEA) J. Yllera (IAEA)
12:30	Lunch break	
	Session 2: Experiences and Preparations for SMR Licensing and Deployment	
14:00	**Member State Presentations** ➢ CNSC perspectives on reviewing foreign designs - Applicability to SMRs ➢ FLEXBLUE: a subsea reactor project and considerations for its licensing ➢ Nuclear regulation for SMRs in India – Current perspectives ➢ SMR development and challenges for design assessment in Japan ➢ Licensing review of SMART for standard design approval ➢ Safety provisions for KLT-40S reactor plant floating power unit ➢ The DOE program to support the development of SMRs in the U.S ➢ The US NRC efforts to prepare for licensing SMRs	 M. deVos (Canada) C. Lecomte (France) A. Ramakrishna (India) T. Mochida (Japan) M.J. Jhung (ROK) I. Bylov (Russia) T. Beville/ S. Magruder (US)
16:00	Coffee break	
16:30	**Panel Discussions: Licensing and safety issues for SMRs** ➢ Moderator: Mr David Newland ➢ Panelists: Mr David Newland (Canada), Mr Roger Seban (France), Mr Marco Ricotti (Italy), Mr Kamal Araj (Jordan), Mr Shang-Hi Rhee (Korea), Mr Igor Bylov (Russia) ➢ Suggested topics ✓ Challenges and issues for SMR early deployment and licensing ✓ Lessons learned from the Fukushima accident for SMRs ✓ International cooperation on SMR licensing and safety ✓ Expectations and suggestions for this Forum	
18:30	**Welcome reception (1st floor, M building)**	**All**

Tuesday, 30 July 2013

Time	Session and Topic	Presenters
	Session 3: Breakout Session for Licensing and Safety Issues for SMRs (Meeting Room: **Board Room A**, M Building)	
09:00	**Plenary for Introduction of Breakout Session** ➢ Organization overview of breakout session ➢ Introduction of group leadership (leader, co-leader, facilitator, etc.) ➢ Issue briefings by group ➢ INPRO Methodology and SMR: review and recommendations for Track 2 revisions ➢ INPRO activities in support of global deployment of SMRs: collaborative project RISC and TNPPs	K. Qureshi (IAEA) Chairman Group leaders A. Korinny (IAEA) V. Kuznetsov (IAEA)
10:30	Coffee break (Participants move to the designated group session meeting rooms)	
	(Note) **Breakout session meeting rooms by groups** Group 1: Considerations for SMR designs **(F0817)** Group 2: Siting considerations of SMRs **(F0814)** Group 3: Application of graded approach in regulatory and licensing process **(A0478)** Group 4: Legal and regulatory framework of SMRs **(F0822)** Group 5: Public participation in the SMR licensing process **(B0486)** (**This session was cancelled**)	
11:00	**Breakout session: Introduction and session setting** ***Session overview and process outline by group leader*** ***Introductory presentations by IAEA*** ➢ Group 1: Defence in depth for nuclear power plants (Mr Javier Yllera) ➢ Group 2: IAEA safety requirements and evaluation process for siting nuclear installation (Mr Sujit Samaddar) ➢ Group 3: Application of graded approach in licensing process (Mr Deshraju Venkat Rao) ➢ Group 4: 1) Major findings of the INPRO activity on legal and institutional issues of transportable NPPs (Mr Zoran Drace); 2) Establishment of a regulatory framework for safety - GSR Part 1 (Mr Marie Cletienne) ***Presentations by invited speakers*** ➢ Group 4: Issues of insurance of civil liability for nuclear damage for low power NPP (Mr Vladimir Demin, Russia)	Group leaders
12:30	Lunch break	
14:00	**Breakout session: Group discussion**	
15:30	Coffee break	
16:00	**Breakout session: Group discussion**	
18:00	Adjourn (Breakout session will continue at 09:00 am on Wednesday at the designated group session meeting rooms)	

Wednesday, 31 July 2013

Time	Session and Topic	Presenters
09:00	**Breakout session: Group discussion**	
10:30	Coffee break	
11:00	**Breakout session: Group discussion**	
12:30	Lunch break (Plenary meeting will reconvene at 14:00 pm at Board Room A)	
	Session 4: Plenary for Breakout Session Progress Report and International Organizations (Meeting Room: **Board Room C**, C Building)	
14:00	**Report on the progress status of group sessions** Group 1: Considerations for SMR designs Group 2: Siting considerations of SMRs Group 3: Application of graded approach in regulatory and licensing process Group 4: Legal and regulatory framework of SMRs	K. Soderholm M. de Vos A. Ramakhrisna S. Magruder
15:30	Coffee break	
16:00	**Presentations by international organizations** ➢ ASME nuclear codes and standards: Overview ➢ OECD/NEA study on the economics and market of SMRs ➢ WENRA and its expectations on the safety of new NPPs ➢ Opportunities and obstacles for SMRs: the WNA CORDEL perspective	K. Ennis (ASME) V. Sozoniuk (NEA) D. Müller-Ecker (WENRA) A. Wasylyk (WNA)
17:20	**Proposal on SMR's Regulator's Forum** ➢ Proposal to establish an SMR Regulator's Forum ➢ Open discussion	S. Magruder (USA) All
18:00	Adjourn (Breakout session will continue at 09:00 am on Thursday at the designated group session meeting rooms)	

Thursday, 1 August 2013

Time	Session and Topic	Presenters
	Session 5: Breakout Session (continued)	
09:00	**Breakout session: Group discussion**	
10:30	Coffee break	
11:00	**Breakout session: Group discussion**	
12:30	Lunch break	
14:00	**Breakout session: Finalization of session discussions** *(Prepare a draft group report including summary of discussions, conclusions and recommendations)*	
15:30	Coffee break	
16:00	**Breakout session: Finalization of session discussions** *(Complete a draft group report and prepare a power point presentation)*	
18:00	Adjourn (Plenary meeting will reconvene at 09:00 am on Friday at Board Room A)	
(**Note** – After the session, **a leadership meeting will be held at 18:10, F0822** to discuss breakout session reports and prepare the final session among chairman, co-chairman, plenary rapporteurs, group leaders and co-leaders,		

facilitators and rapporteurs)

Friday, 2 August 2012 *(Meeting Room: **Board Room C**, C Building)*

Time	Session and Topic	Presenters
Session 6: Future Actions on Licensing and Safety Issues for SMRs		
09:00	**Report on the breakout session results** Group 1: Considerations for SMR designs Group 2: Siting considerations of SMRs Group 3: Application of graded approach in regulatory and licensing process Group 4: Legal and regulatory framework of SMRs	K. Soderholm M. deVos A. Ramakhrisna S. Magruder
10:30	Coffee break	
11:00	➢ Safety features and licensing of ACP100 design ➢ The results of the questionnaire survey	F. Zhong (China) H. Subki (IAEA)
11:30	**Conclusion** ➢ Summary and findings by Rapporteur ➢ Meeting summary by Chairman ➢ Future actions and suggestions from the INPRO perspective ➢ Closing remarks (DIR-NENP)	D. Ingersoll (USA) D. Newland (Canada) Z. Drace (GH-INPRO) J.K. Park (DIR-NENP)
12:30	Adjourn	

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INPRO International Project on Innovative Nuclear Reactors and Fuel Cycles

IAEA

INPRO Dialogue Forum on Global Nuclear Energy Sustainability:

Licensing and Safety Issues for Small- and Medium-sized Reactors (SMRs)

29 July – 2 August 2013, IAEA Headquarters, Vienna, AUSTRIA
IAEA Board Room A (M-0237)

Opening Address

Mr Jong Kyun PARK

Director, Division of Nuclear Power
IAEA Department of Nuclear Energy

Distinguished representatives, participants, dear colleagues, ladies and gentlemen,

On behalf of the International Atomic Energy Agency, I would like to welcome you all to the sixth INPRO Dialogue Forum on Licensing and Safety Issues for Small- and Medium-sized Reactors, in short SMRs.

This Forum offers a platform for Member States to discuss issues of sustainable development and deployment of nuclear energy. It facilitates a common understanding of the needs and potential role of different stakeholders in countries considering nuclear power for their national energy mix; and it addresses opportunities and challenges of countries which are developing and applying advanced technologies.

We are now witnessing a global interest in SMRs. So it is timely that this Forum addresses licensing and safety issues for SMRs.

SMRs can offer important advantages for nuclear newcomer countries, particularly to those with small electric grids, with less-developed infrastructure, and limited investment capabilities. Countries with existing nuclear power programmes may consider SMRs for specialized applications, for example, deployment in remote areas, process heat applications and desalination.

There are, however, some challenges to be addressed relevant to the regulatory framework, associated with the advanced specificity and unique features of SMRs that were not incorporated in conventional large-sized reactors, as well as their broader options of utilization, including deployment in remote areas and its utilization with non-electric applications.

Many embarking countries have expressed interest in SMRs, but are still in favour of 'proven' technology; so they want SMR technology to be first deployed in the country of origin to minimize licencing and performance risks. Member States also have expressed their wish that technology developers, nuclear regulatory authorities, and operating organizations primarily responsible for reactor safety, incorporate the lessons learned from the Fukushima Daiichi accident into the operating plants as well as in new nuclear power plants including SMRs.

Advanced SMRs, particularly those integral pressurized water reactors with modularization technology are not yet commercially available even though several countries are moving in this direction.

This is where the Agency -- with the continued support from the Member States -- can play an important role in supporting technology developers and potential users to address technology requirements of SMRs.

I am pleased that over 100 experts and representatives from **37** Member States and 5 International Organizations are attending this forum to discuss licensing and safety issues of SMRs.

You will primarily take into account considerations for the design, siting, application of graded approaches, legal and regulatory framework, and public participation in the SMR licensing process.

We expect that this Forum will provide valuable feedback for Member States' regulatory bodies. At the same time, several countries which develop different types of SMRs will benefit from the exchange of knowledge and experience among Member States. Also, the results of this workshop will provide important input for future Agency's activities in this area.

This Dialogue Forum is jointly organized by the Agency's Department of Nuclear Safety and Security, and the Department of Nuclear Energy. I believe that it is essential for us to work closely together in helping Member States develop nuclear energy programmes and this is one of the excellent examples of close cooperation between the two Departments.

The IAEA studies in the past decade have revealed that SMRs can play an important role in the global sustainable energy development as part of an optimal energy mix. Therefore, the Agency continues its various programmes. This includes formulating a roadmap for technology development, reviewing newcomer countries' requirements including regulatory infrastructure, and defining performance indicators for operation. Technical meetings, workshops and dialogue forums are effective means to achieve this goal.

I wish to thank the Agency's Department of Nuclear Safety and Security for initiating to conduct this forum and for their support.

I thank the Scientific Secretaries: Mr Russell GIBBS from the Department of Nuclear Safety and Security, and Mr Pill-Hwan PARK and Mr Hadid SUBKI from the Department of Nuclear Energy and their hard-working team for arranging this important and well attended Dialogue Forum on SMRs.

On behalf of the IAEA, I wish to thank the governments of the **Republic of Korea** and **the United States of America** for their generous **Extra-Budgetary contribution** for **Peaceful Uses Initiatives --**, without their support, this Dialogue Forum would have not been possible.

I also thank all participants, presenters, and particularly, the **Leaders** and **Co-Leaders** of the five break-out sessions for their leadership in this important activity.

Finally, based on the recommendation from the Scientific Secretaries, I would like to propose **Mr David NEWLAND** from **Canada** as chairman and **Mr Poong-Eil JUHN** from **the Republic of Korea** as co-chairman for this Dialogue Forum.

I would like to ask **Mr Newland** and **Mr Juhn:** would you kindly accept this proposal?

Thank you for your kind acceptance.

Now, I would like to ask all participants: would you approve the chairmanship of Mr Newland and Mr Juhn?

Thank you for your approval.

I wish you all a very productive and exciting week here in Vienna, and now, I declare this Dialogue Forum open. Next, I'd like to turn the meeting over to Mr Newland and Mr Juhn. Thank you both for taking on this leadership role.

Opening Address

Mr. James E. Lyons

Director for the Division of Nuclear Installation Safety

IAEA Department of Nuclear Safety and Security

The Agency is very pleased to see such a large turnout for this Dialogue Forum whose focus is on licensing and safety of SMRs. This shows that there is great interest in the development of deployment of SMRs which helps us to better focus our efforts in areas where we can most effectively support our Member States.

In my division, we work hard to help our Member States build capacity for nuclear installation safety. We do this primarily through the development of IAEA Safety Standards, through peer reviews such as the Integrated Regulatory Review Service and Operational Safety Review Team, through advisory services and through education and training activities.

We have developed a Technical Series Catalogue for Nuclear Installation Safety – a document that outlines many of these support activities. A limited number of copies have been made available for this Dialogue Forum and we hope you find the catalogue useful.

As Mr Park indicated, it is essential that our two departments work together as effectively and efficiently as possible, along with the financial support provided through our Technical Cooperation Programme, in helping our Member States ensure the safe and secure use of nuclear energy. And we see this Dialogue Forum, because of its focus is on licensing and safety of SMRs, as an excellent opportunity for this needed collaboration.

From a safety perspective, it is essential that the IAEA Safety Standards are used. The Safety Fundamentals, Safety Requirements and Safety Guides together provide internationally accepted approaches in achieving high levels of nuclear and radiation safety. And we strongly encourage that as you have discussions this week that you refer to them as needed noting that we will have Agency staff available to assist you in this regard. Also, if you believe changes might be needed to the Safety Standards, we encourage you to raise these points during your discussions.

Some believe that the nearer term future of nuclear energy may rest with SMRs. We hear that because the designs are considered more inherently safe with the use of more passive safety systems and lower source terms that SMRS may be more desirable for countries embarking on nuclear power and those countries considering expansion of their existing nuclear programmes. The SMR concept that uses the more innovative designs, in particular, appear to present the potential to make the siting, construction and operation less complicated than the more traditional designs operating today. But there are concerns being raised as to whether different approaches to licensing might be needed because of these more innovative features.

For example: have the issues of first-of-kind engineering features adopted in integral-PWR SMR designs with modular technology been thoroughly addressed? Is it appropriate from a safety perspective to reduce the size of the emergency preparedness exclusion area? Can SMRs be designed and operated in a way that reduces traditional security requirements? Should SMRs be deployed in areas of higher density population? And what about control room staffing? Are fewer operators needed for a multiple-modules SMR plant with one control room? Reflecting upon the use of graded approaches to safety, some have argued that the SMR probabilistic safety assessments may yield core damage frequencies that are several orders of magnitude lower than the current operating fleet. Is this realistic? And what about the public's acceptance of such new and innovative designs? These are just a few of the questions being raised and there are many more that I am confident that you address this week during the five break-out sessions. Who has the answers to all these questions?

We are hopeful that during your breakout sessions you will identify key issues that need follow-up. With the issues identified with the leadership of the session leaders and co-leaders, we hope that you can formulate recommendations and path forward to address the identified issues in this Dialogue Forum.

I am pleased to inform you that the Agency has the capability to facilitate the path forward for these issues. But it is you, our Member States that must be fully committed to address the issues.

We understand that the idea of a forum of regulators has been raised as a way to move the issues forward. We would encourage the formation of such as forum and we stand by to help facilitate and promote such a forum. If you desire the Agency to take on this role, we would need to have more dialogue on the additional human resources needed for this support.

We have taken on this role a number of times and a recent example is the Regulatory Cooperation Forum – a forum of senior regulators who aim is to help embarking countries develop effectively independent and robust regulators of nuclear power. But we see this particular application to be similar to the Multinational Design Evaluation Programme, or MDEP. We look forward to your ideas this week on how such a forum might be developed.

I would also like to express my sincere thanks for the excellent work done last December during the preparatory Consultancy Meeting - a meeting that played a key role in formulating this Dialogue Forum, the preparations made by the Scientific Secretaries and their team members, the hard work done by the session leaders and co-leaders in preparing the material for break-out sessions and finally your presence here today. We believe that the stage is set for an outstanding opportunity to make a difference in how SMRs might become a viable option for safer and secure nuclear power.

Thank you for your attention and best wishes for a successful meeting this week.

Annex 5: Group Formation for Breakout Session

INPRO
International Project on Innovative Nuclear Reactors and Fuel Cycles

IAEA

INPRO Dialogue Forum on Global Nuclear Energy Sustainability:

Licensing and Safety Issues for Small- and Medium-sized Reactors (SMRs)

29 July – 2 August 2013, IAEA Headquarters, Vienna, AUSTRIA
IAEA Board Room A (M-0237)

Assignment of Participants into the Five (5) Topical Groups

Group 1
Considerations for SMR designs

Location:
Building **F** – Room **F 0817**

No.	Country/ Affiliation	Name of Participants	No.	Country/ Affiliation	Name of Participants
1	Albania	Mr Milo KUNESHKA	14	Russia	Mr Igor BYLOV
2	Algeria	Mr Hocine BENKHARFIA	15	Russia	Mr Yuri FADEEV
3	Canada	Mr David POOLE	16	Singapore	Mr Ziyu John CHONG
4	China	Mr Fajie ZHONG	17	Thailand	Mr Phongphaeth PENGVANICH
5	Egypt	Mr Mahmoud GAD	18	Tunisia	Mr Hafedh BELMABROUK
6	**Finland**	**Ms Kristinna SÖDERHOLM***	19	USA	Mr Timothy BEVILLE
7	France	Mr Roger SEBAN	20	USA	Mr Dan INGERSOLL
8	Germany	Mr Justus OLDENBURG	21	USA	Mr Robert SISK
9	**Italy**	**Mr Marco RICOTTI***	22	USA	Mr Darrell GARDNER
10	Japan	Mr Takaaki MOCHIDA	**23**	IAEA/NENP/NPTDS	**Mr Hadid SUBKI** ***
11	Korea	Mr Poong-Eil JUHN	24	IAEA/NSNI/SAS	Mr Javier YLLERA **
12	Korea	Mr Keun-Bae PARK	25	IAEA/NSNS/PS	Mr Manfred ALEX **
13	Romania	Mr Rizea ADRIAN	26	IAEA/NENP/NPTDS	Mr Nils HANEKLAUS @

Notes:

* Group's Leader and Co-Leader
** Facilitator(s)
***** Scientific Secretary of the Forum**
@ Rapporteur

Group 2
Siting considerations of SMRs

Location:
Building **F** – Room **F 0814**

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2	Armenia	Mr Aram GEVORGYAN	13	Russia	Mr Yuri CHEREPNIN
3	Canada	Mr David NEWLAND	14	Singapore	Mr Seng Soon Bernard NEE
4	**Canada**	**Mr Marcel de VOS ***	15	Singapore	Mr Patrick Peng-Kang FOO
5	France	Mr Christophe HERER	16	Thailand	Mr Vutthi BHANTHUMNAVIN
6	Hungary	**Ms Z. HODOSSYNE HAUSZMANN**	17	USA	Ms Anna BRADFORD
7	Hungary	Mr Nemeth GABOR	18	IAEA/NENP/INPRO	Mr Vladimir KUZNETSOV **
8	**Indonesia**	**Mr Ferhat AZIZ ***	19	IAEA/NENP/INPRO	Mr Kamran QURESHI **
9	Jordan	Mr Kamal ARAJ	20	IAEA/NENP/NPTDS	Mr H. HIDAYATULLAH **
10	Korea	Mr Shang-Hi RHEE	21	IAEA/NENP/INPRO	Mr Benyamin DABBS @
11	Pakistan	Mr Nasir Hayat HENGRA			

Notes:

* Group's Leader and Co-Leader
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Group 3
Application of Graded Approach in Regulatory and Licensing Process

Location:
Building **A** – Room **A 0478**

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2	Canada	Mr David J. WINFIELD	12	Poland	Mr Michal KOC
3	Chile	**Mr Cristian Pedro SEPÚLVEDA**	13	Russia	Mr Mikhail LANKIN
4	China	Mr Bin XU	14	Russia	Mr Vladimir ARONCHIK
5	Egypt	Mr Sayed EL-MONGY	15	USA	Mr Jay Harrison THOMAS
6	Finland	Mr Antt DAAVITTILA	16	USA	Mr Richard BLACK
7	**India**	**Mr A. RAMAKRISHNA ***	17	Vietnam	Mr Quang Tuyen DOAN
8	Indonesia	Mr Helen RAFLIS	18	**WENRA/Germany**	Mr Dieter MÜLLER-ECKER
9	Japan	Mr Kazumasa HIOKI	19	**IAEA/NSNI/RRS**	Mr Deshraju Venkat RAO **
10	Korea	Mr Keun-Bae OH	20	**IAEA/NENP/NPTDS**	Mr S. SUSYADI @

Notes:

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@ Rapporteur

Group 4
Legal and regulatory framework of SMRs

Location:
Building **F** – Room **F 0822**

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2	Armenia	Mr Ashot MARTIROSYAN	22	Russia	Mr Vladimir DEMIN
3	Bangladesh	Mr Golam MAHBUB	23	Singapore	Mr Alvin CHEW
4	Bangladesh	Mr Mahabubur RAHMAN	24	South Africa	Mr Andre BOTHA
5	Bulgaria	Mr Pavlin GRUDEV	25	Spain	Mr Palmiro VILLALIBRE
6	Canada	Mr Frances HILDERMAN	26	United Kingdom	Mr John Rhys JONES
7	Egypt	Mr Galal Eldin ORABI	27	Ukraine	Mr Oleg GODUN
8	France	Ms Catherine LECOMTE	28	USA	Ms Carol MOYER
9	France	Mr Jorge Luis HERNANDEZ	29	USA	Mr Dan STOUT
10	Germany	Mr Bejoy SAHA	30	USA	Ms Danielle GOODMAN
11	India	Mr Jose JOSEPH	31	USA	Mr Jim KINSEY
12	Indonesia	Mr Budi ROHMAN	32	USA	Mr Pareez GOLUB
13	Kenya	Mr Collins Gordon JUMA	33	OECD/NEA	Mr Vladislav SOZONIUK
14	Korea	Mr Kwang Won LEE	34	**USA**	**Mr Stewart MAGRUDER ***
15	**Korea**	**Mr Myung Jo JHUNG ***	35	ASME / USA	Mr Kevin Patrick ENNIS
16	Korea	Mr Si-Hwan KIM	**36**	IAEA/NSNI/RAS	**Mr Russell A. GIBBS** ***
17	Malaysia	Mr Ibrahim MUHAMAD	37	IAEA/NENP/INPRO	Mr Zoran DRACE **
18	Pakistan	Mr Mohammad IQBAL	38	IAEA/NENP/INPRO	Ms Christina JOHARI **/@
19	Polandia	Mr Andrej CHWAS	39	IAEA/NENP/INPRO	Mr Rafael TUCCI @
20	Polandia	Mr Kajetan ROZYCKI	40	IAEA/NSNI/RAS	*A Rapporteur/Intern from NSNI* @

Notes:

* Group's Leader and Co-Leader
** Facilitator(s)
***** Scientific Secretary of the Forum**
@ Rapporteur

Group 5
Public participation in the SMR licensing process

Location:
Building **B** – Room **B 0486**

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2	Korea	Mr Peoung-Uk KIM	12	WNA	Mr Andrew WASYLYK
3	**Malaysia**	**Mr Muhammad RAWI**	**13**	**IAEA/NENP/INPRO**	**Mr Phil-Hwan PARK *****
4	Russia	Mr Alexander VASILYEV	14	**IAEA/NSNI**	Mr Jean-Rene JUBIN **
5	Russia	Mr Alexey PROSHIN	15	**IAEA/NENP/NPES**	Mr Brian R. MOLLOY **
6	Singapore	Mr Koh HUI-SHAN	16	**IAEA/NENP/NPES**	Ms Brenda PAGANNONE **
7	Thailand	**Ms Duchduen BHANTHUMNAVIN**	17	**IAEA/NENP/INPRO**	Ms Tsvetelina MILIOVSKA **/@
8	UAE	Mr Hamad Al Kaabi	18	**IAEA/NENP/INPRO**	Mr Byungho JUNG @
9	Ukraine	Ms Olga MALIARUK	19	**IAEA/NENP/INPRO**	Ms Alexandra MORSCHER
10	USA	Mr Matthew BOWEN			

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* Group's Leader and Co-Leader
** Facilitator(s)
***** Scientific Secretary of the Forum**
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Annex 6: The Final Group Report

Final Report for the Breakout Session

6th INPRO Dialogue Forum on Global Nuclear Energy Sustainability: Licensing and Safety Issues for SMRs

A. Group 1: Considerations for SMR Designs

B. Group 2: Siting and Siting Considerations of SMRs

C. Group 3: Application of Graded Approach for SMRs

D. Group 4: Legal and Regulatory Framework of SMRs

A. Group 1: Considerations for SMR designs

1. Introduction

This document reflects the considerations by Group 1 of the IAEA-INPRO Dialogue Forum: IAEA Specific Safety Requirements (SSR-2/1) needs to be updated, to include SMR specific features; it appears that no deep modifications of SSR 2/1 are needed.

This work has been launched at the IAEA-INPRO Dialogue Forum and will continue in the next future: further and revised comments and contributions from the MS on the Safety Requirements listed in SSR 2/1 will be collected and implemented in this draft document by IAEA/INPRO.

The document reports in the left column the declaration of the Safety Requirements (in the working version, updated by IAEA after Fukushima), in the right column the comments and suggestions provided by the participating Member States in the Group 1 of the 6th INPRO Dialogue Forum.

2. Suggested Modifications to Selected 14 Specific Safety Requirements from the SSR-2/1 to incorporate Specificities of SMRs:

- Requirement 11: Provision for Construction (4.19)
- Requirement 17: Internal and external hazards (5.16 – 5.22)
- Requirement 23: Reliability of items important to safety (5.37 – 5.38)
- Requirement 32: [Human factors] Design for optimal operator performance (5.53 – 5.62)
- Requirement 35: Nuclear power plants used for cogeneration of heat and power, heat generation or desalination
- Requirement 43: Performance of fuel elements and assemblies
- Requirement 47: Design of specific plant systems - Design of reactor coolant system (6.13 – 6.16)
- Requirement 53: Heat transfer to an ultimate heat sink
- Requirement 54: Containment system for the reactor
- Requirement 57: Access to the Containment
- Requirement 65: [Instrumentation and Control System] Control room (6.39 – 6.40)
- Requirement 66: [Instrumentation and Control System] Supplementary control room (6.41)
- Requirement 68: Emergency power supply (6.43 – 6.45)
- Requirement 77: Steam supply system, feedwater system and turbine generators (6.56 – 6.58)

TABLE 1: *Comments and Suggestions from the Participating Member States in Group 1 to the IAEA Specific Safety Requirements* ***(No. SSR-2/1) -*** *Safety of Nuclear Power Plants: Design*

Requirement No. in SSR-2/1	Current Entry in SSR-2/1	Suggested Modification(s)
General Comments		Many newcomer countries are interested to consider SMR in the future, although most of the advanced SMRs concept is not yet in operation. Member States needs support and facilitation in identifying available SMR types and designs and capable to perform an assessment of reliability, safety, economy, and environmental aspects, in order to convince stakeholders, and decision makers. The need to provide clear definition of "modularity", both in the sense of modular/integrated primary system, modular construction and multiple modules deployment.

Requirement No. in SSR-2/1	Current Entry in SSR-2/1	Suggested Modification(s)
		The forum focused on integral type PWRs. Specific standard may be required for GEN4 reactors and advanced SMRs. Some Member States suggested that a separate document may be developed of for SMRs specific safety requirement document (No. SSR----)
Requirement 11: Provision for Construction (4.19)	*Items important to safety for a nuclear power plant shall be designed so that they can be manufactured, constructed, assembled, installed and erected in accordance with established processes that ensure the achievement of the design specifications and the required level of safety.* 4.19. In the provision for construction and operation, due account shall be taken of relevant experience that has been gained in the construction of other similar plants and their associated structures, systems and components. Where best practices from other relevant industries are adopted, such practices shall be shown to be appropriate to the specific nuclear application.	• (4.19) After words "…due account shall be taken" insert phrase "if possible" • Comment: in many cases, advanced SMRs designs will not be able to get relevant experience, because most concepts are not yet in operation. • Add (4.19a): If modular construction is adopted, the modules shall also be fabricated and assembled in accordance with process that assure achievement of both design and safety requirements.
Requirement 17: Internal and external hazards (5.16 – 5.22)	**Internal hazards** 5.16. The design shall take due account of internal hazards such as fire, explosion, flooding, missile generation, collapse of structures and falling objects, pipe whip, jet impact and release of fluid from failed systems or from other installations on the site. Appropriate features for prevention and mitigation shall be provided to ensure that safety is not compromised. **External hazards** 5.17. The design shall include due consideration of those natural and human induced external events (i.e. events of origin external to the plant) that have been identified in the site evaluation process. Natural external events shall be addressed, including meteorological, hydrological, geological	• <u>Comment</u>: In requirement 17, the IAEA should determine the difference between "internal" and "external" hazards as: hazards internal to unit or external to unit because site for SMRs can comprise multiple units. • For the TNPP or under-sea module, measures should be considered against anticipated terrorist attacks; • (5.16) Add after words "…internal hazards" a comment in parenthesis: "(i.e. events of origin internal to plant units)" • (5.16a) The design of a multi-module facility shall take into account that internal hazard may occur due to adverse interactions between the reactor module during all plant states (normal and accidental condition). Special consideration shall be given to the following phases: ✓ Refuelling of one module ✓ Scheduled and non-scheduled maintenance work at one module ✓ Addition of reactor module to the reactor facility ✓ Decommissioning of a module • (5.17) The end of the requirement 5.17 beginning from words "in the short term" mark as a separate requirement as this requirement is applicable as to internal as to external events.

Requirement No. in SSR-2/1	Current Entry in SSR-2/1	Suggested Modification(s)
	and seismic events. Human induced external events arising from nearby industries and transport routes shall be addressed. In the short term, the safety of the plant shall not be permitted to be dependent on the availability of off-site services such as electricity supply and fire fighting services. The design shall take due account of site specific conditions to determine the maximum delay time by which off-site services need to be available. 5.18. Items important to safety shall be designed and located to minimize, consistent with other safety requirements, the likelihood of external events and their possible harmful consequences. 5.20. The design shall be such as to ensure that items important to safety are capable of withstanding the effects of external events considered in the design, and if not, other features such as passive barriers shall be provided to protect the plant and to ensure that the required safety function will be performed. 5.21. The seismic design of the plant shall provide for a sufficient safety margin to protect against seismic events and to avoid cliff edge effects.	• (5.17) On page 21, under External Hazards, I would like to suggest including tsunami as one of natural external events. Why? Because tsunami was main natural external hazard when Fukushima NPP accident occurred in March 2011. • (5.18) Write the requirement as following: “5.18 Items important to safety shall be designed and located to minimize, consistent with other requirements the consequences of internal and external events harmful consequences” • (5.20) There is a need to precise this requirement the term “passive barriers” as there are terms “passive systems”, “passive components” as systems or components that don’t require supply of energy. What are “passive barriers”? Physical safety barriers? • (5.21) There is no need to mark only “seismic events” I suggest next version of requirement: “5.21 the design of the plant shall provide for a sufficient safety margin to protect against internal and external hazards to avoid cliff edge effects”.
Requirement 23: Reliability of items important to safety (5.37 – 5.38)	*The reliability of items important to safety shall be commensurate with their safety significance.* 5.37. The design of items important to safety shall be such as to ensure that the equipment can be qualified, procured, installed, commissioned, operated and maintained to be capable of withstanding, with sufficient reliability and effectiveness, all conditions specified in the design basis for the items.	• (5.37) The term “sufficient reliability” is quiet uncertain. The requirement to reliability of items important to safety and determined by requirements to reliability of safety systems. • Reliability and availability of passive safety systems and natural circulation process may need their own requirement to emphasise their incremental uses in new designs. For instance, the failure mode of the natural circulation system process, operational margin, etc.
Requirement 32: [Human factors] Design for optimal operator performance (5.53 – 5.62)	*Systematic consideration of human factors, including the human–machine interface, shall be included at an early stage in the design process for a nuclear power plant and shall be continued throughout the entire design process.* 5.53. The design for a nuclear power plant shall specify the minimum number of operating personnel required to	• Design for optimal operator performance shall be considered in all the stages of SMR development, from design, construction, operation, maintenance, and decommissioning. • In paragraph 5.54 on Page. 30, I recommend to add as follows: “……in the process to the future operation, maintenance and decommissioning of the plant” • (5.53) Specifically for a multi-module facility, the scope of simultaneous

Requirement No. in SSR-2/1	Current Entry in SSR-2/1	Suggested Modification(s)
	perform all the simultaneous operations necessary to bring the plant into a safe state. 5.54. Operating personnel who have gained operating experience in similar plants shall, as far as is practicable, be actively involved in the design process conducted by the design organization, in order to ensure that consideration is given as early as possible in the process to the future operation and maintenance of equipment.	operator's action shall take into account that in accidental conditions multiple module may be affected and therefore need to be controlled.
Requirement 35: Nuclear power plants used for cogeneration of heat and power, heat generation or desalination	*Nuclear power plants coupled with heat utilization units (such as for district heating) and/or water desalination units shall be designed to prevent processes that transport radionuclides from the nuclear plant to the desalination unit or the district heating unit under conditions of operational states and in accident conditions.*	• Add *"including internal and external hazards"* • Requirement 35 should be made clearer: co-generation should be also much more flexible. Convert among district heating, and/or electricity or water desalination, i.e. Nuclear power plants use for district heating in winter, for electricity for summer. This may be involved with design technology, depend technology.
Requirement 43: Performance of fuel elements and assemblies	*Fuel elements and assemblies for the nuclear power plant shall be designed to maintain their structural integrity, and to withstand satisfactorily the anticipated radiation levels and other conditions in the reactor core, in combination with all the processes of deterioration that could occur in operational states.* 6.3. Fuel elements and fuel assemblies shall be capable of withstanding the loads and stresses associated with fuel handling.	(6.3) says that "fuel in withstanding the loads in with fuel handling. Does this "fuel handling" include "reactor transportation" of "pre-fuel loaded" SMR? We need some description to ensure the integrity of fuels after reactor/fuel is transported.
Requirement 47: [Design of Specific Plant Systems] Design of reactor coolant system (6.13 – 6.16)	The components of the reactor coolant systems for the nuclear power plant shall be designed and constructed so that the risk of faults due to inadequate quality of materials, inadequate design standards, insufficient capability for inspection or inadequate quality of manufacture is minimized. 6.14. The design of the reactor coolant pressure boundary shall be such that flaws are very unlikely to be initiated, and any flaws that are initiated would propagate in a regime of high resistance to unstable fracture and to rapid crack propagation, thereby permitting the timely detection of flaws. 6.16. The design of the components contained inside the reactor coolant pressure boundary, such as pump impellers and valve parts, shall be such as to minimize the likelihood of failure	• (6.16) After words "shall be such as" write "to prevent failure and consequential damage…". The term "likelihood" is quiet uncertain. • It is suggested that iPWR specific features should be added into the requirements. Examples: Steam generator cartridges inside the reactor vessels; horizontally mounted canned motor recirculation pumps; In-vessel control rod drive mechanisms; rational start-up procedure for

Requirement No. in SSR-2/1	Current Entry in SSR-2/1	Suggested Modification(s)
	and consequential damage to other components of the primary coolant system that are important to safety, in all operational states and in design basis accident conditions, with due allowance made for deterioration that might occur in service.	natural circulation iPWRs. • Inherent safety should be discussed. • This requirement needs to be updated for integrated SMR where the reactor coolant systems are integrated in the reactor vessel. In the case requirement should identify key design and construction features and raises adequate provisions. • SMR must be capable of adding reactor module within a common building to satisfy the increasing energy demand for electricity if needed.
Requirement 53: Heat transfer to an ultimate heat sink	*Systems shall be provided to transfer residual heat from items important to safety at the nuclear power plant to an ultimate heat sink. This function shall be carried out with very high levels of reliability for all plant states.*	• In order to connect to ultimate heat sink for residual heat, "system" is not enough. So, I would like to suggest to add as follow: "Systems, structures and/or components" shall be provided to transfer ….." on P. 40. • To change words "with very high levels of reliability" to "with adequate level of reliability". Comment: Designer can prove only level of reliability for active systems. Reliability of passive systems (e.g. for heat removal) is a subject to research. • Should either delete the phrase "…carried out with very high levels of reliability…" or define high levels of reliability in terms of some quantity. But it may not be desirable to provide more specificity; it is explicit that all requirements qualified in the document should be designed with a high reliability. • Add more explanation about heat transfer to external heat sink and give some examples of system designed to this task.
Requirement 54: Containment system for the reactor	*A containment system shall be provided to ensure, or to contribute to, the fulfilment of the following safety functions at the nuclear power plant: (i) confinement of radioactive substances in operational states and in accident conditions, (ii) protection of the reactor against natural external events and human induced events and (iii) radiation shielding in operational states and in accident conditions.*	• For the multi-module plant, each module shall be provided with separate containment system, to prevent propagation of accident to nearby modules. • So far, we have had 3 severe accidents: (1) TMI in 1979, (2) Chernobyl in 1986, and (3) Fukushima in 2011. In TMI accident case, there was no radiation released to the environment, due to containment maintained integrity. But in the cases of Chernobyl and Fukushima accidents, radiations were released to the environment, because containment integrity was not maintained when hydrogen explosion happened. So, I would like to suggest as follow on P. 41: "….. in operational states and in accident conditions, in particular, hydrogen explosion". • DELETE "(iii) radiation shielding …. conditions". Not appropriate for steel

Requirement No. in SSR-2/1	Current Entry in SSR-2/1	Suggested Modification(s)
		containment vessels and not a functional requirement. • Quiet disputable is the (iii) item. It is applicable only for concrete containments and not for metal ones as many SMRs have. Perhaps this point adds: "if there are no other systems to provide radiation shielding". • Most of the integrated SMR have a metallic containment. Provision (iii) of requirement 57 cannot be fulfilled of course metallic requirement is the third barrier but "…radiation shielding in operational state and in accident condition" should be modified to take into account radiation protection by other means. • Requirement (iii) should be removed are written in such way to accommodate metallic containment designs. That explicit shielding function may be replaced or retained by giving qualification that may reduce the effect.
Requirement 57: Access to the Containment	*Access by operating personnel to the containment at a nuclear power plant shall be through airlocks equipped with doors that are interlocked to ensure that at least one of the doors is closed during reactor power operation and in accident conditions.* 6.25. Where provision is made for entry of operating personnel for surveillance purposes, provision for ensuring protection and safety for operating personnel shall be specified in the design. Where equipment airlocks are provided, provision for ensuring protection and safety for operating personnel shall be specified in the design. 6.26. Containment openings for the movement of equipment or material through the containment shall be designed to be closed quickly and reliably in the event that isolation of the containment is required.	• This requirement assumes large traditional containment – not appropriate for many SMRs (no containment access during operation). Also, it is not appropriate for steel containment vessels. Qualify: "If operations staffs are to have access to ….." • "Access by operating personnel to the containment at a nuclear power plant shall be through (suitable) airlocks": it should not be required for some advanced SMRs or new reactor designs that do not foresee access to the containment during operation or for surveillance." • It seems that 6.25 and 6.26 do not need to be updated.
Requirement 65: [Instrumentation and Control System] Control room (6.39 – 6.40) **Requirement 66: [Instrumentation and Control System] Supplementary**	*Requirement 65: Control room* *A control room shall be provided at the nuclear power plant from which the plant can be safely operated in all operational states, either automatically or manually, and from which measures can be taken to maintain the plant in a safe state or to bring it back into a safe state after anticipated operational occurrences and accident conditions.* 6.39. Appropriate measures shall be	• Control room design for the multi-module plant should consider expandability to accommodate the addition of modules in the early stage of the first module construction • Remove the words "at the nuclear power plant" and replace with "for" the nuclear power plant". • Provision for "remote" control room and its communication & I&C safety issues should be addressed separately. I suggest against

Requirement No. in SSR-2/1	Current Entry in SSR-2/1	Suggested Modification(s)
control room (6.41)	taken, including the provision of barriers between the control room at the nuclear power plant and the external environment, and adequate information shall be provided for the protection of occupants of the control room against hazards such as high radiation levels resulting from accident conditions, release of radioactive material, fire, or explosive or toxic gases. 6.40. Special attention shall be paid to identifying those events, both internal and external to the control room, that could challenge its continued operation, and the design shall provide for reasonably practicable measures to minimize the consequences of such events. *Requirement 66: Supplementary control room* *Instrumentation and control equipment shall be kept available, preferably at a single location (a supplementary control room) that is physically, electrically and functionally separate from the control room at the nuclear power plant. The supplementary control room shall be so equipped that the reactor can be placed and maintained in a shutdown state, residual heat can be removed, and essential plant variables can be monitored if there is a loss of ability to perform these essential safety functions in the control room.* 6.41. The requirements of para. 6.39 for taking appropriate measures and providing adequate information for the protection of occupants against hazards also apply for the supplementary control room at the nuclear power plant.	& protection. Changing "at" to "for". • Original: A control room shall be provided at the Nuclear Power Plant. New: A control room shall be provided for the Nuclear Power Plant. Comment: SMRs located in remote regions may be highly automated and controlled over a multiple-redundant highly secure link from a control room located at the Licensee facility; this change would allow remote siting of control rooms. • Original: functionally separate from the control room at the Nuclear Power Plant; • New: functionally separate from the control room for the Nuclear Power Plant. Comment: This change would avoid conflict with the suggested change for Requirement 65. • Remove the words “at the nuclear power plant” and replace with “for the nuclear power plant”
Requirement 68: Emergency power supply (6.43 – 6.45)	*The emergency power supply at the nuclear power plant shall be capable of supplying the necessary power in anticipated operational occurrences and accident conditions, in the event of the loss of off-site power.* 6.43. In the design basis for the emergency power supply at the nuclear power plant, due account shall be taken of the postulated initiating events and the associated safety functions to be performed, to determine the requirements for capability, availability, duration of the required power supply, capacity and continuity. 6.44. The combined means to provide emergency power (such as water, steam	• Any new changes to emergency power supply requirements should not mandate a separate power supply without consideration of the coping time that can be demonstrated by the design without this reliance. New plant designs may demonstrate very long coping times (e.g. longer than 72 hours) and have sufficient time to provide supplemental power supplies. The requirement could be written to demonstrate sufficient coping time for design extension events through existing equipment of supplemental equipment (i.e. requirement should be performance based and not prescriptive for solution) • (6.44) Remove the Requirement: The design shall include a “dedicated power

Requirement No. in SSR-2/1	Current Entry in SSR-2/1	Suggested Modification(s)
	or gas turbines, diesel engines or batteries) shall have a reliability and type that are consistent with all the requirements of the safety systems to be supplied with power, and their functional capability shall be testable.	source" to supply necessary power extension some flexibility should be allowed to accommodate "passive" and advanced designs • The words "in the event of the loss of off-site power" change to "in base of external and internal events". Comment: off-site power may not be applicable to some SMR designs.
Requirement 77: **Steam supply system, feedwater system and turbine generators (6.56 – 6.58)**	*The design of the steam supply system, feedwater system and turbine generators for the nuclear power plant shall be such as to ensure that the appropriate design limits of the reactor coolant pressure boundary are not exceeded in operational states or in accident conditions.* 6.58. The turbine generators shall be provided with appropriate protection such as overspeed protection and vibration protection, and measures shall be taken to minimize the possible effects of turbine generated missiles on items important to safety.	• This requirement assumes that the "serviced load" of the reactor is a turbine generator. The load serviced by the reactor may be process heating loads. Suggest the requirement be clarified to include consideration of other serviced loads such that those loads also do not negatively affect reactor design limits. (Examples of serviced loads are in Requirement 35) • Words "design limits of the reactor coolant pressure boundary" change to "design limits of the reactor plant…" • (6.58) Any energy cogeneration system installed at the plant shall not cause unstable plant operation or breach of nuclear boundaries under any operational or accident conditions of the cogeneration system. Comment: Many SMRs may generate forms of energy other than electricity. • Please also note that requirement 77 does not always include non-power generation paths such as heat generation or desalination i.e. high pressure water supply system, which is different from "steam supply system" in requirement 77.
Non SSR-2/1 item: **Public Participation, Input for Group-5**		• Public participation and understanding of the licensing process is very important to adoption and acceptance of SMR technology. It is important that the process provides for sufficient public participation while providing protection of manufacturer/supplier intellectual property. • Requirement stated in ultimately for the purpose of protection the public. Therefore licensing process of the SMR which consider the assembly of the component that have been design according to the requirement. It should contain easy word to understand by the people of public.

3. Summary of Discussions

3.1. Key Findings from the Breakout Sessions

- IAEA Safety Standards are fundamentally sound but require adjustment

- The fundamental cornerstone of safety defence-in-depth must not be changed
- Multi-module plants require additional consideration
- Transportable Nuclear Power Plants (TNPPs) require additional consideration
- SMR deployment and local infrastructure considerations
- Approach to emergency planning and response
- Approach to overall staff complement: operators, support and security
- Further development of engineering standards needed
- The industry and regulators have not yet truly engaged with the public to assist its understanding
- Embarking countries have particular needs

3.2. Sharing of information on SMR technologies

- During the plenary discussions of the forum and the breakout sessions there were a number of requests for a more central sharing of information on SMRs
- Recommendation: MS to identify the type of information needed
- Recommendation: IAEA to explore whether it can act as a central repository

3.3. International licensing or certification

- During the plenary presentations, panel discussions and breakout sessions, participants proposed the concept of international licensing and design certification
- Recommendation: Proponents of such an approach elaborate a more detailed vision
- Recommendation: Regulators consider whether there is any fundamental difficulty with such an approach

  International Cooperation
- The INPRO Dialogue Forum is a proven means of cooperation among vendors, proponents and regulators
- The Regulatory Cooperation Forum (RCF) is an important venue to assist regulators of embarking countries
- A number of countries have requested that a "SMR Regulators' Forum" be considered
- Recommendation: IAEA continue to actively continue engagement on SMR activities – both through INPRO and the Division of Nuclear Safety Installations
- Recommendation: The RCF ensures it is open to consideration of SMRs in embarking countries
- Recommendation: Interested MS with assistance from the IAEA take exploratory steps to establish a "SMR Regulators' Forum"

3.4. Standards and Guides

- IAEA Safety Standards requirements are to a large degree applicable to SMRs
- IAEA Safety Guides – applicability requires verification
- Industrial standards – incomplete or applicability unclear or yet to be determined
- Recommendation: MS to include a General Conference Safety Resolution regarding the importance of the safety of SMRs and the need for safety standards and guides
- Recommendation: Vendors/utilities engage with Standard development organisations to ensure that standards are ready prior to licensing

3.5. Final remarks

- Excellent collaboration by all
- Openness and transparency in sharing knowledge and experience will be needed
- Use of existing collaboration mechanisms, if possible.

3.6. Major findings and considerations

- Defence in Depth philosophy do not need any modification

- The multi-module SMR designs require specific consideration
- I&C (especially remote locations) and human factors (operator actions and multiple reactors in common control room)
- Knowledge sharing of new engineering features (for safety analyses and approval of the reliability, e.g. modelling and experimental data)

4. Recommendations

IAEA Safety Standard SSR-2/1 (Safety of Nuclear Power Plants: Design) in most parts are consistent with SMR features and capabilities, however based on the group discussion we recommend as follows:

- The standard should be kept technology neutral;
- Our comments to facilitate the development and deployment of SMRs will be provided to the group that is responsible to revise this safety standard.

Meetings should be organized by IAEA to discuss novel aspects of multi-module plants (e.g. operational, control room, I&C, etc.).
I&C for remotely controlled SMRs, including satellite links and cyber security is recommended to be included in studies of IAEA's Nuclear Power Engineering section on Instrumentation and Control Technologies.

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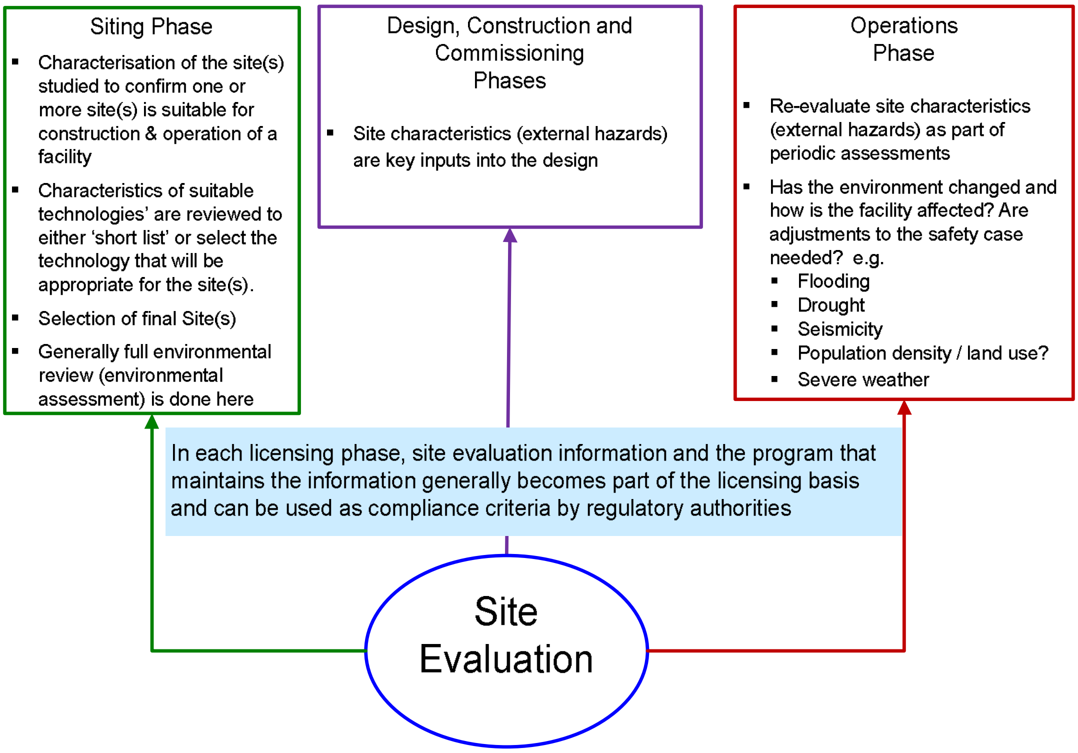
B. Group 2 – Siting and Siting Considerations for SMRs

1. Introduction

As discussed in IAEA Safety Requirements Document NS-R-3, *Site Evaluation for Nuclear Installations*, siting considerations and site evaluation are key in establishing and maintaining a strong safety case for a facility over its full life cycle.

Figure 1: *How Site Evaluation Information is Used in the Various Licensing Phases*



The public in any member state will have expectations that Small and Medium Sized Reactors[1] (SMRs) will offer a level of safety that equals or even surpasses that found in both existing and new large Nuclear Power Plants (NPPs). These designs will also be expected to address the same siting requirements as their larger cousins, albeit taking into account their smaller size and touted lower risks associated with these designs.

Depending on how SMRs are used and where they are planned to be located, site choices may place additional challenges on some aspects of the facility's defence in depth and overall safety approach. This discussion topic was developed to identify and discuss some of the key areas that will challenge SMRs and to recommend siting technical and discussion areas that will need further examination by both member states and the IAEA.

There are two very distinct groups of SMRs emerging that have varying application and potential for siting in different parts of the world:

1.1. **First Group**: Reactor facilities that are simply smaller versions of existing NPP designs.

These designs may be constructed in a modular fashion, contain passive features, and even be situated below-grade but are otherwise very similar in operational characteristics to traditional NPPs and are fuelled / refuelled on-site. Some designs may be so-called "Generation IV" designs employing less traditional core cooling concepts such as gas-cooled, liquid metal cooled. Larger marine-based designs

[1] including those designs which are intended to be modular

(ship or barge) would also fit in this category. Siting Issues for this class of facilities tend to be centered on the following:

- Because they may be sited in locations that would not be considered for NPPs (closer to cities, near industrial complexes, or in extreme remote locations etc.). There is a desire for additional flexibility in setting and satisfying emergency planning requirements (i.e. using a risk-informed approach rather than more traditional deterministic means) – this would involve discussions about areas such as how source term calculations influence decision-making for emergency planning zones.
- There are many new countries with small grids who may consider building these facilities rather than NPPs. These countries in particular would have to address sites lacking in infrastructure (i.e. how can a site be rendered suitable where basic infrastructure does not exist yet?).
- Spent fuel management on site at SMR facilities may be of concern to the public (this issue becomes more dominant the smaller the reactor facility is).
- Applicability of NS-R-3 site evaluation requirements and guidance to marine-based facilities (submersible or surface-based) and whether any gaps in requirements and guidance exist that need to be addressed.

1.2. **Second Group**: Reactor facilities that are significantly smaller (approx. 2 to 100 MWe)

The reactor module itself would likely be fabricated/ assembled, fuelled and sealed at reactor vendor's manufacturing and assembly 'factory', and shipped to and from a site in its fuelled state. Although a few designs may be more traditional water-cooled designs, the majority are likely to be so-called "Generation IV" designs employing more novel core-cooling concepts such as gas-cooled, liquid metal cooled. Smaller marine-based designs (ship or barge) would also fit in this category. These facilities share the above issues but are also challenged by the following:

- Because these reactors are transported fully fuelled, how does the transport route fit into the siting process? How does one examine potential environmental impacts along the route of travel in an objective and scientific manner?
- How will issues around crossing international borders be addressed? (particularly when crossing through a number of countries along the route)

2. Group Formation

The participants who attended Group 2 brought diverse backgrounds to the discussion including:

- Member state government representatives from embarking countries with expertise in energy policy and an interest in exploring deployment of SMRs (including a representative of the OECD Nuclear Energy Agency);
- Nations involved in siting with issues they need to resolve (not necessarily for SMRs);
- An experienced member state TSO representative with experience in site characterisation;
- Representatives of both experienced and embarking country regulators with varying levels of experience in siting work;
- IAEA experts with significant experience in siting.

One interesting observation of the cross-section of attendees in this discussion group is that they represented countries exploring a number of possible siting extremes for SMRs:

- In extreme remote regions
- In countries with potential for multiple extreme external hazards
- In very close proximity to large population centres where mass evacuation in an emergency is not an option
- In countries with poor to non-existent existing local infrastructure to support a nuclear facility project

Because of the broad experience base, the group focused on discussing the key issues for this topic at the level of requirements and guidance contained in IAEA NS-R-3 *Site Evaluation for Nuclear Installations.*

3. Key Issues

Using a single group discussion format, the Topic Lead, Co-Lead and IAEA staff members acted as facilitators in guiding the group to explore the following siting issues against three case studies discussed in Section 5.

- Determining source terms for non-water cooled SMRs or novel fuels: Discussion on the impacts of source terms on size of emergency planning zones for SMRs
- Siting considerations for fuelled transportable reactors (including marine applications): Discuss whether the existing requirements and guidance contained in IAEA NS-R-3 *Site Evaluation for Nuclear Installations* and supporting topical safety guides are sufficient to address this class of reactor facilities?; addressing special emergency planning needs; transportation issues including crossing jurisdictional boundaries and handling of used fuel; and characterising potential environmental impacts during transport
- Sites in regions lacking in fundamental infrastructure (including extreme remote sites): Addressing emergency planning needs; impacts on security; and what is the role of design in this case?

Prior to beginning the discussions on the siting issues, and to addressing the varying degrees of participant experience in siting and site characterisation, context was provided to establish a common understanding of: what exactly is site characterization and site selection?; what is the role of siting work in the safety case of a reactor facility?; and what is the role of design when deciding whether a site is suitable for construction and operation of a reactor facility?

An IAEA technical facilitator knowledgeable in siting issues reviewed existing IAEA site evaluation information and changes in progress as a result of the Fukushima Daiichi accident.

The three case studies were then reviewed by the group to illustrate and discuss how different types of SMRs can affect how siting requirements are interpreted. The discussion group then reviewed two key documents used in siting:

- DS-433 *Safety Aspects in Siting for Nuclear Installations* – which , when published by the IAEA will be used to establish a process to initially investigate candidate sites and narrow down choices to one or more final sites to be investigated in greater detail.
- NS-R-3 *Site Evaluation for Nuclear Installations* (and supporting safety guides) – used to establish site suitability as inputs to the facility safety case over the life of the facility

Discussions then proceeded on each of the issues using the three case studies as reference points. The primary focus of the discussions was on identifying where gaps in IAEA requirements and guidance (in DS-433 and NS-R-3) may exist for SMRs, and the roles member state government agencies as well as industry (utilities and vendors) can play in identifying and resolving gaps in national regulatory frameworks. Also discussed were potential and practical paths forward to be addressed by both the IAEA and member states.

4. Discussion Results

4.1. Issue 1: Determining source terms for non-water cooled SMRs or novel fuels

Source terms for a number of SMR designs will be different from those more traditionally understood to be dominant for existing fleet reactors. This issue was raised because there is a need to discuss the how these different source terms are calculated and how they may affect emergency planning issues (including how they affect emergency planning and/or exclusion zone sizing). In addition, there was a need identified to discuss whether a need exists to update current IAEA information and/or guidance around the calculation of source terms.

It was quickly decided that the discussion group did not have the in-depth expertise to hold meaningful technical discussions in this area. Senior regulators that were present led a discussion that explained to attendees the meaning of *source term* and some of the issues being faced by SMR proponents faced with calculating source terms for specific designs:

- Industry proponents are of the position that existing assumptions on source terms are too conservative for SMRs and do not take into account the design claim that fuel melt may be physically impossible for designs.
- The regulatory view is that regardless of whether fuel melt is possible, there is a need to calculate source terms, based on the simple assumption that fuel melt does occur.
- As a result, a number of SMR vendors are considering mechanistic (facility specific) source term calculations while modifying the assumptions used with existing LWRs
- Source terms from non-water cooled technologies may be different and have different characteristics. There was recognition by the discussion group that existing atmospheric and water dispersion models should be re-examined with this knowledge in-mind. This is particularly true when considering submersible or surface-based marine SMRs.

Recommendations are given in Section 6.2.

4.2. Issue 2: Siting considerations for fuelled transportable reactors and marine-based reactor facilities (also known as Transportable Nuclear Power Plants, TNPPs)

Two types of TNPP facilities were considered in these discussions:

- Marine based power plant (see case study 2) – refuelled at one or more ‘home bases’ (generally either factory-of-origin or a designated central refuelling and maintenance facility)
- Small, sealed land-based design shipped to its site by water, overland and/or air. (see case study 3) – There would be no on-site refuelling: A depleted reactor module replaced with new one and would be shipped back to the vendor “factory” for refit or decommissioning.

Group discussions for this issue centred on where DS-433 and NS-R-3 addresses or does not adequately address specific siting issues for these particular types of reactor facilities. A line-by-line review of NS-R-3 was done to identify any high level gaps in requirements and guidance; however, there was insufficient time to review the guidance documents that support NS-R-3. An overview of DS-433 was given by IAEA staff to allow asking questions about how it is applied.

Case Study #2 was important to the discussions because the floating power plant example used in the study was sited adjacent to a facility (refinery, liquefied natural gas processing terminal and shipping port) that likely presents greater external hazards to the site than the power plant itself. In addition, the facilities the plant serves can play a large role in the emergency planning strategies used for the greater site. The case illustrated that proponents must take a holistic view to siting particularly when siting SMRs closer to population centres and industrial projects.

Case Study #3 (many tiny power plants over a large region) illustrated the considerations of siting in a region with little or no suitable infrastructure in place (discussed further in Issue #3).

On the whole, the group agreed that existing DS-433 and NS-R-3 requirements already address the needs of TNPPs but differences may arise when interpreting the NS-R-3 supporting guides.

- In NS-R-3, there is a need to amend requirements on characterization of water-based events to include “rapid changes in water level” (not covered by storm surge). In addition, characterization of potential changes in water table level needs to be reflected for TNPPs to be located in subsurface silos or buildings.
- There is a need for a regulatory discussion (in the context of DS-433 and NS-R-3) on whether the shipment route of a TNPP needs to be part of the site investigations for the power plant site (can the shipping route and method be a basis for site acceptance or rejection).
- The IAEA and member states considering these types of facilities should examine their emergency planning requirements to confirm TNPP considerations are addressed.

- TNPPs sited next to industrial facilities need to also characterize effects of potential external and human induced hazards on the industrial facilities and how they might affect the safety of the TNPP facility. Some of these effects may be direct (potential for seismic events, explosions, fires etc.) and others might be indirect (redirect emergency response assets that would otherwise support the TNPP in an emergency).
- There were some discussions at the discussion forum that a TNPP is in fact synonymous with a fuel transport package. There is a need to better understand this conclusion in terms of small sealed SMRs with reactivity devices and in-core instrumentation in-situ during transport. It would be useful for IAEA to publish a paper discussing this understanding in more detail.

Recommendations are given in Sections 6.1 and 6.3.

4.3. Issue 3: Sites in regions lacking in fundamental infrastructure (including extreme remote sites)

Compared to traditional NPP sites, there is greater potential for SMRs to be sited in countries or regions inside a country where basic infrastructure to support facility operation or emergency planning is insufficient or does not exist (e.g. roads, hospitals, local emergency response capabilities). This is particularly true in very remote regions such as in the far north or in areas of very low population density where a project such as a mine needs to establish stand-alone power infrastructure. There is likely also the need to install infrastructure to perform site evaluation in advance of the site being officially selected.

Even if SMR designs are made more inherently safe, adequate infrastructure for emergency planning needs to exist from a defence-in-depth perspective to respond to plant emergencies as well as from a public confidence perspective. Discussions revolved around which additional areas may need to be addressed in requirements such as those contained in NS-R-3 to address this issue. Specific sub-issues and concerns discussed and addressed included: Addressing emergency planning needs; impacts on security; and what is the role of design versus emergency planning? How can additional design reduce the need for extensive emergency planning and security?

In order to better understand the concept of 'essential infrastructure' the discussion group was split into three groups to report on what the term meant in each case. It was noted that there were some similarities and differences between what represented essential infrastructure in each case.

Similarities found were in areas such as (not a complete list):

- Need for land use planning policies and controls over population inhabiting the regions around the site
- Need for adequate emergency response strategies and plans (including evacuation locations)
- Site characterization infrastructure needed in place over the life of the facility
- Public engagement programs
- Access to adequate medical care
- Physical access to the site (whether by land, water or air)
- On-site security and emergency response capabilities
- Access to backup power, fuel and water

Differences in what is considered to be essential infrastructure emerged when looking at site specific characteristics. For SMRs located on more traditional sites, the idea of essential infrastructure is already well understood. In more remote sites, however, infrastructure outside the nuclear facility site becomes more important in supporting safe site operation such as:

- State of local roads between a site and nearby emergency response resources;
- Airfields (for parts, evacuation, supplies and delivery of emergency response);
- Employee housing;
- Local emergency shelters (where mass evacuation is not possible);
- Offsite medical facilities where on-site hospitals do not exist;
- Offsite emergency response support centres

Discussions recognized that site surveys and site characterization need to identify the essential infrastructure necessary for safety and security and establish a plan to ensure the infrastructure is in place for when it is needed. A review of DS-433 and NS-R-3 concluded that only very high level guidance is provided in this area and more detailed requirements and guidance needs to be documented. In particular, guidance is needed on infrastructure considerations for reactor facilities sited in close proximity to hazardous industrial facilities (e.g. emergency plans should be combined/closely coordinated, and to consider coincident events between the two facilities).

Recommendations are given in Section 6.4.

5. Cross Cutting Issues

Group 2 found the following areas to be cross cutting-across all of the topics at this Discussion Forum.

5.1. Defence in depth

More challenging siting conditions put additional pressures on emergency planning unless the design can adapt to these conditions easily. When considering design standardization, SMR vendors need to be cognizant of the broader potential siting challenges specific SMR designs may be required to address.

There is an expectation by many stakeholders that the role of “practically eliminated” in design will be more dominant SMRs. This is particularly true in cases where SMRs will be sited in either extreme remote sites or regions of higher population density where mass evacuation is neither practical nor possibly desired.

5.2. Emergency planning

In addition to stronger expectations of the use of “practically eliminated” in design activities to reduce or preclude the need for evacuation, group discussions showed that some misconceptions exist for SMRs around the need for emergency planning. Some government decision makers had the impression that SMRs will not require any emergency planning because the designs are ‘inherently safe’. It is important to impress on the fact that emergency planning is an integral part of a defence in depth approach and will be expected for all siting situations regardless of the site location or safety claims of the design being sited there.

5.3. Graded approach

Siting is a risk-informed activity with the understanding that it informs the design and the safety case of the facility. Generally, discussions showed that SMR proponents are planning to apply risk informed approaches for siting activities for SMRs. In terms of siting, concepts such as preclusion of fuel melt as well as inherent safety and passive features may be used to propose reduced size of study regions when performing site investigations.

5.4. Facility staffing

Although SMR designers may specifically design a generic SMR for a specific number of key operations, maintenance and security and emergency support staff, the three case studies illustrated how site-specific challenges can and will influence numbers and types of staffs needed to support safe conduct of site activities.

6. Case Studies

In order to facilitate and stimulate focused discussions, three case studies were provided as briefing material to prepare attendees. The case studies are provided in Sections 6.1-6.3. Each case study was meant to illustrate:

- Different real world siting challenges that face member states for different SMR applications;
- How SMRs could alter the traditional picture of a nuclear plant site

Conditions in case studies were designed to review existing siting requirements and to see if any adjustments are needed to accommodate issues that arise in the case studies.

The following considerations and assumptions were expected to be considered by the discussion team members when examining all of the case studies.

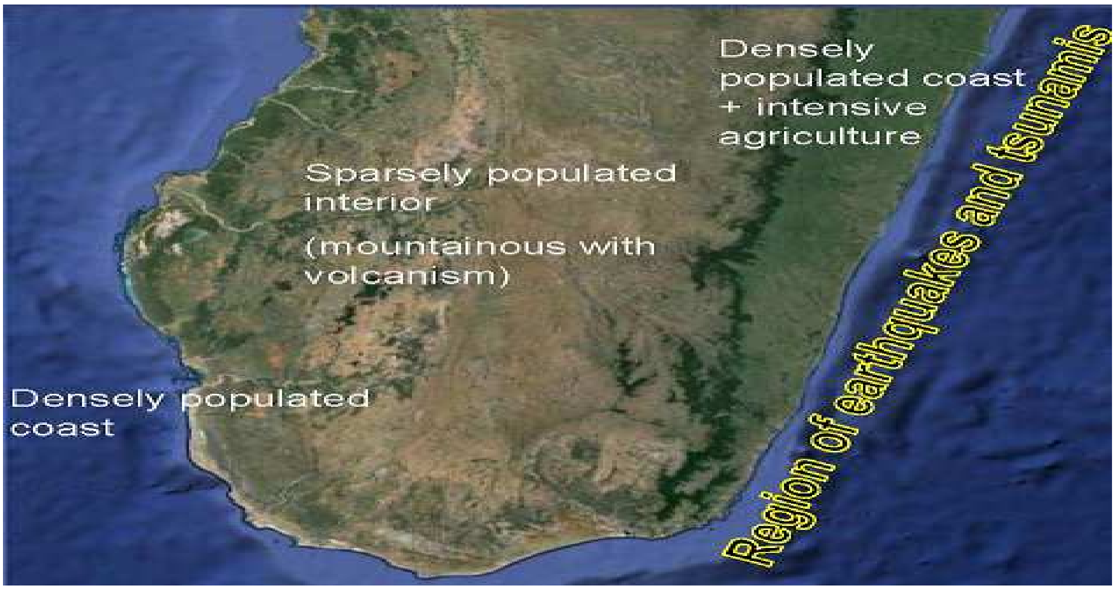
- The case study member state has no current domestic experience with nuclear power.
- The case study member state's regulatory body and regulatory framework is at an early stage of development. As a result, the regulator and the utility are working with the country-of-origin's regulatory body and vendors / 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 case study member state will be relying heavily on the IAEA's safety and security framework documents as part of their overall regulatory strategy.
- The case study 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 case study member state and significant threats to nuclear facilities cannot be discounted.

Additional member state attributes were assigned in each case study to introduce different challenges to siting.

6.1. Case 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.

Figure 2: *Pictorial Representation of Hypothetical Case 1 Member State*



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.

6.2. Case 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; and 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.

Figure 3: *Pictorial Representation of Hypothetical Case 2 Member State*

Additional Member State attributes for this case study:

- Population density of the member state on 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 is 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.

6.3. Case 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 not serviced 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.

Figure 4: *Pictorial Representation of Hypothetical Case 3 Member State*

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.

7. Major Findings and Recommendations

7.1. Adequacy of DS-433 and NS-R-3 when applied to SMRs

DS-433 and NS-R-3 are, for the most part, suitable as-written for all SMRs. Existing requirements and guidance can be applied in a graded manner.

The discussion group did note in its review, that in NS-R-3, there is a need to amend requirements on characterization of water-based events to include "rapid changes in water level" (this issue is not covered under the term "storm surge". In addition, characterization of potential changes in water table level needs to be reflected for those TNPPs (such as very small sealed reactor designs) to be located in subsurface silos or buildings.

Adjustments to guidance may be necessary for designs to be located below ground and Transportable Nuclear Power Plants (including surface and subsurface marine-based) because existing guidance was likely not written with this in-mind.

Recommendation: IAEA needs to confirm the above conclusions and examine the NS-R-3 safety guides as a suite against the 3 case studies used (and others if necessary) to address below grade designs, and TNPP designs (including surface and subsurface marine-based).

7.2. Issue 1: Determining source terms for non-water cooled SMRs or novel fuels

There is recognition that source terms from marine-based SMRs and non-water cooled designs need to be addressed.

Recommendation: IAEA needs to investigate and address this issue in greater detail with priority given to the designs available for near-term deployment. Countries-of-origin of technology should be requested to provide technical support.

The concept of *source term* is very difficult to explain in lay-terms and yet it is a key to public discussions around nuclear safety approaches in design.

Recommendation: Member state industry and regulators should collaborate to find ways to communicate more clearly what source terms are and what they mean.

7.3. Issue 2: Siting considerations for fuelled transportable reactors and marine-based reactor facilities (also known as Transportable Nuclear Power Plants, TNPPs)

There is a need for a regulatory discussion (in the context of DS-433 and NS-R-3) on whether the shipment route of a TNPP needs to be part of the site investigations for the power plant site. In other words, can the shipping route and method be included in a basis for site acceptance or rejection? This is particularly a key for designs that will be shipped as fueled and sealed modules to the site and returned to the factory or a disposal site when depleted.

TNPPs sited next to industrial facilities need to also characterize effects of potential external and human induced hazards on the industrial facilities and how they might affect the safety of the TNPP facility. There is a need to reinforce the fact that emergency plans for to be carefully coordinated between the power plant and the industrial operations to ensure they are holistically sufficient.

Recommendation:

- IAEA to facilitate a future discussion, perhaps when considering an update to NS-R-3, to explore how a shipping route factors into site investigations.
- Member states considering the deployment of such technologies prepare to discuss their approaches and views in an international context. As part of these preparations, member states considering these types of facilities should examine their emergency planning requirements to confirm TNPP considerations are addressed when placed in close proximity to industrial facilities.

There were some discussions at the discussion forum that a TNPP is in fact synonymous with a fuel transport package. There is a need to better understand this conclusion in terms of small sealed SMRs with reactivity devices and in-core instrumentation in-situ during transport. It would be useful for IAEA to publish a paper discussing this understanding in more detail.

Recommendation: IAEA needs to facilitate a regulatory discussion to understand and document similarities and differences between a TNPP fuel module and a fuel transport package/.

7.4. Issue 3: Sites in regions lacking in fundamental infrastructure (including extreme remote sites)

Compared to traditional NPP sites, there is greater potential for SMRs to be sited in countries or regions inside a country where basic infrastructure to support facility operation or emergency planning is insufficient. This is particularly true in very remote regions such as in the far north or in areas of very low population density where a project such as a mine needs to establish stand-alone power infrastructure.

Differences in what is considered to be essential infrastructure emerged when looking at site specific characteristics. For SMRs that would be located on more traditional (i.e. NPP) sites, the idea of essential infrastructure is already well understood. In more remote sites, however, infrastructure outside the nuclear facility site becomes more important in supporting safe site operation such as:

- State of local roads between a site and nearby emergency response resources
- Airfields (for parts, evacuation, supplies and delivery of emergency response),
- Employee housing,
- Local emergency shelters (where mass evacuation is not possible)
- Offsite medical facilities where on-site hospitals do not exist
- Offsite emergency response support centres

Discussions recognized that site surveys and site characterization need to identify the essential infrastructure necessary for safety and security and establish a plan to ensure the infrastructure is in place for when it is needed. A review of DS-433 and NS-R-3 concluded that only very high level guidance is provided in this area and more detailed requirements and guidance needs to be documented. In particular, guidance is needed on infrastructure considerations for reactor facilities sited in close proximity to hazardous industrial facilities (e.g. emergency plans should be combined/closely coordinated, and to consider coincident events between the two facilities).

Recommendation: IAEA needs to consider adding information to DS-433, NS-R-3 and associated safety guides to address what essential infrastructure is and that it should be considered during the siting process to ensure it is in place in anticipation of when it will be needed to support facility operation or emergency planning. Information should consider both policy-based infrastructure such as national emergency plans as well as physical infrastructure.

C. Group 3: Application of Graded Approach in Regulatory and Licensing Process for SMRs

1. Introduction

A consultancy meeting was held on 17–19 December 2012 to prepare for the INPRO Dialogue Forum on Licensing and Safety Issues for Small- and Medium-sized Reactors (SMRs). The consultancy concluded that the Dialogue Forum should discuss the following major issues regarding the licensing and safety of SMRs: (i) Considerations for SMR designs; (ii) Siting considerations for SMRs; (iii) Application of graded approach in regulatory and licensing process; (iv) Legal and regulatory framework for SMRs; and (v) Public participation in SMR licensing process.

The consultancy determined that, in addition to plenary sessions involving all participants, the Dialogue Forum would include five parallel breakout sessions corresponding to the identified major issues. Each participant in the Dialogue Forum would be assigned to a group discussing one of the major issues.

Dr A. Ramakrishna from Atomic Energy Regulatory Board of India, Dr James Walker from Atomic Energy of Canada Limited, and Mr Shri Desiraju V. Rao from IAEA were identified as the Group Leader, Co-Group leader, and IAEA facilitator respectively for Group 3.

Prior to the Dialogue Forum, the leader, co-leader, and facilitator prepared a Briefing Handout [1] for participants in the forum. The Briefing Handout described the issues to be discussed by Group 3 during the forum, provided a brief description of each issue, described the proposed organization of the group's activities during the forum, and provided case studies for use in Group 3's discussions. The Briefing Handout was distributed to all participants prior to the forum.

1.1. Issues for discussion

The topics for discussion by Group 3 during the Dialogue Forum were:

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

1.2. Description of issues

1.2.1. Application of graded approach to emergency planning and accident response

<u>Concept and background</u>

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-in-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 mock-up 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, inherent safety features, and effective emergency response plan.

1.2.2. Demonstration of innovative features

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 defence 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?

1.2.3. Research and development programmes

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.

1.2.4. Safety analysis — Codes and Methodology

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 analysing 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)

1.2.5. Instrumentation and Controls – Increased use of automation and plant staffing

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 off site. 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?

1.2.6. Licensing process for multiple modules

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

1.3. Case studies

In order to facilitate focused discussions, three potential case studies were provided. Each case study was 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's regulatory body and regulatory framework are under development. 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 implementing a national regulatory framework, the member state will also be relying 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.

1.3.1. CASE 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.

1.3.2. Case 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 is 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.

1.3.3. Case 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 not serviced 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 off-site 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 off-site 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.

2. Formation of Group 3

The breakout sessions commenced on Day 2 of the Dialogue Forum (Tuesday, 30 July 2013). The following persons expressed an interest in the application of the graded approach in the regulatory and licensing process for SMRs, and were assigned to Group 3:

James Walker (Canada)
David J. Winfield (Canada)
Cristian Pedro Sepulveda (Chile)
Bin Xu (China)
Sayed El-Mongy (Egypt)
Antti Daavittila (Finland)
A. Ramakrishna (India)
Kuen-Bae Oh (Korea)
Nasiru-Deen Bello (Nigeria)
Vagif Abdulkadyrov (Russia)
John Rhys Jones (UK)
Richard Black (USA)
Jay Harrison Thomas (USA)
Quang Tuyen Doan (Vietnam)
Dieter Müller-Ecker (WENRA)
Deshraju V. Rao (IAEA)
S. Susyadi (IAEA)

The group established itself under the following officers:

A. Ramakrishna (India), Topic Lead
J.R. Walker (Canada), Topic Co-Lead
D.V. Rao (IAEA), Facilitator
S. Susyadi (IAEA), Rapporteur

The group received two presentations on the graded approach [2, 3], and a presentation on a proposal for the group's activities during the breakout sessions [4].

The group reviewed the Participants' Briefing Handout, the issues developed during the consultancy, and the three case studies. The group also reviewed the definition of the graded approach from the IAEA's safety glossary [5]:

- For a system of control, such as a regulatory system or a safety system, a process or method in which the stringency of the control measures and conditions to be applied is commensurate, to the extent practicable, with the likelihood and possible consequences of, and the level of risk associated with, a loss of control.
- An application of safety requirements that is commensurate with the characteristics of the practice or source and with the magnitude and likelihood of the exposures.

To more closely address the interests of Member States, the group consolidated the issues into the following list:

- Emergency Planning and Accident Response
- Safety Analysis – Codes, Methodology, Validation
  - ✓ Innovative Features/R&D Programmes
  - ✓ PSA & Deterministic Analysis
- Instrumentation & Controls
- Plant Staffing
- Licensing Process
  - ✓ Multiple Modules
  - ✓ SMRs licensed in a different member state

Subsequently, Public Participation was added at the request of the Chair of the Dialogue Forum.

Additionally, the group determined that it would be more effective to concentrate on only two of the three possible case studies. So that the cases could be studied to the necessary detail, it was resolved that the group would confine its attentions to:

- Case Study 1: 200MWe Units in a densely-populated Member State; and
- Case Study 3: 10MWe Units in an extremely remote region of a Member State.

During the group's deliberations, additional context was provided through presentations on SMRs and on the graded approach from both India [6] and Russia [7].

The group prepared presentations describing the mid-week progress [8], and the final outcome [9].

The results of the group's deliberations, and recommendations, are provided below.

3. Results of Group 3 Deliberations

Item	Case 1: 200MWe; dense population; significant hazards	Case 3: 10MWe, micro-NPP; extremely remote region
Emergency Planning and Accident Response	Response to emergencies can be graded based on potential source terms and other identified on-site and off-site consequential hazards. The size of the Emergency Planning Zone can be graded based on the potential source term and dose rates. The grading of the Exclusion Zone may be based on security threats. The category for nuclear- and radiation-related threats can be graded based on the 5 categories of threat described in IAEA Safety Standard Series "Preparedness and Response for a Nuclear or Radiological Emergency" GSR part 2, Table 1. Category I: *Facilities, such as nuclear power plants, for which on-site event (including very low probability events) are postulated that could give rise to severe deterministic health effect off the site, or for which such events have occurred in similar facilities.* The infrastructure, measures, and notification requirements for emergency response can be graded based on existing local, regional and national off-site capabilities.	Off-site hazard is not applicable. Source term is extremely small and it is likely that passive features may significantly reduce on-site hazards. It is likely that it will not be required to define an EPZ, based on postulated off-site dose. The exclusion zone is less likely to be required, based on local security threats. The category for nuclear and radiation related threat can be graded based on the 5 categories of threat described in IAEA Safety Standard Series "Preparedness and Response for a Nuclear or Radiological Emergency" GSR part 2, Table 1. Category II or III. Emergency response is likely to be limited to any required notification, sheltering, and iodine intake, if necessary.
Safety Analysis – Codes, Methodology, Validation: Innovative Features/ R&D Programmes PSA & Deterministic Analysis	The regulatory authority must review and evaluate the full Safety Analysis Report. The scope and depth of the safety analysis review and audit can be graded based on prior regulatory approval, reduced risk, PSA results, deterministic review, proven design, safety margins, and previous operating experience. Full in-depth review/audit should be based on identified dominant risk factors. Full in-depth review/audit should be conducted on those innovative features that are important to safety, and should be supported by an extensive R&D program that might include prototype testing. The PSA target risk can be graded based on factors such as local social-economic factors and the potential economic impacts of the proposed facility.	The number of postulated events that can be excluded from the safety analysis will be significantly increased because of the reduced hazards and likelihood of occurrence. Hence, the scope and depth of safety analysis review and audit can be graded accordingly. The need for PSA can be determined by regulatory authority.

I&C	I&C design complexity and requirements for qualification can be graded based on independence, diversity, redundancy, safety classification, and demonstrated experience on the use of innovative monitoring and control systems.	Remote monitoring and control may require more rigorous attention in proportion to the claims made on the system with regard to safety.
Plant Staffing	The number of operators in the control room can be graded based on the design of single/multi-unit control room operations. The number of staff (maintenance, operation) can be graded based on reactor design, reactor operation mode, security threats, economic considerations, maintenance strategy, emergency planning, and location. Staffing can be graded based on simulator training.	Operation staff may be located remotely from the reactor site, provided that the plant is sufficiently resistant to all hazards, and is adequately reliable. On-site staff will have the same considerations as case 1.
Licensing Process Multiple Modules; SMRs licensed in a different member state	<u>Multiple modules</u>: The multi-module licensing process could be based on a licence modification method as additional modules are added. The licensing process could be graded based upon the intended purpose of additional modules, the module deployment strategy, and the Member State's regulations and resources. <u>SMRs licensed in different member state</u>: Grading could be based on standardization within the factory fabrication, and Customer State regulatory inspection within the factory. Grading could be based on prior approval of design certification, increased use of approved international standards in SMR design, and feedback from operational experience.	<u>Multiple modules:</u> Consideration for grading is the same as case 1. <u>SMRs licensed in different member state:</u> Consideration for grading is the same as case 1.
Public Participation	The requirement of public participation cannot be graded, and is part of site acceptance process. The extent of public participation can be based on regulatory practices in Member State and on local conditions and support. The regulatory body should be able to justify its graded licensing approach.	Consideration for grading is the same as case 1.

4. Recommendations

Group 3 derived the following recommendations for the IAEA's consideration:

- The IAEA should develop a guidance document explaining the graded approach to the application of safety and licensing requirements of SMRs.
- The IAEA should develop a protocol for customer state regulatory inspection within SMR manufacturer's factory
- The IAEA should host web-based information for Member States regarding SMR designs, licensing and operating experiences.

REFERENCES

[1] Participants' Briefing Handout, Discussion Group 3: Application of Graded Approach in Regulatory and Licensing Process, INPRO Dialogue Forum on Global Nuclear Energy Sustainability: Licensing and Safety Issues for Small and Medium-sized Reactors (SMRs), 29 July – 2 August 2013, IAEA Headquarters, Vienna, Austria

[2] D.V. Rao (IAEA), The Use of a Graded Approach in the Application of Safety Requirements, Discussion Group 3: Application of Graded Approach in Regulatory and Licensing Process, INPRO Dialogue Forum on Global Nuclear Energy Sustainability: Licensing and Safety Issues for Small and Medium-sized Reactors (SMRs), 29 July – 2 August 2013, IAEA Headquarters, Vienna, Austria

[3] J.R. Walker (Canada), A. Ramakrishna (India), D.V. Rao (IAEA), Graded Approach, Discussion Group 3: Application of Graded Approach in Regulatory and Licensing Process, INPRO Dialogue Forum on Global Nuclear Energy Sustainability: Licensing and Safety Issues for Small and Medium-sized Reactors (SMRs), 29 July – 2 August 2013, IAEA Headquarters, Vienna, Austria

[4] A. Ramakrishna (India), J.R. Walker (Canada), D.V. Rao (IAEA), Conduct of Discussion Group 3: Application of Graded Approach in Regulatory and Licensing Process, Discussion Group 3: Application of Graded Approach in Regulatory and Licensing Process, INPRO Dialogue Forum on Global Nuclear Energy Sustainability: Licensing and Safety Issues for Small and Medium-sized Reactors (SMRs), 29 July – 2 August 2013, IAEA Headquarters, Vienna, Austria

[5] IAEA Safety Glossary, Terminology Used in Nuclear Safety and Radiation Protection, IAEA, Vienna, 2007

[6] A. Ramakrishna (India), Grading Approach in Licensing Process for SMR – Indian Experience, Discussion Group 3: Application of Graded Approach in Regulatory and Licensing Process, INPRO Dialogue Forum on Global Nuclear Energy Sustainability: Licensing and Safety Issues for Small and Medium-sized Reactors (SMRs), 29 July – 2 August 2013, IAEA Headquarters, Vienna, Austria

[7] V. Abdulkadyrov (Russia), Some aspects of SMR Licensing, Discussion Group 3: Application of Graded Approach in Regulatory and Licensing Process, INPRO Dialogue Forum on Global Nuclear Energy Sustainability: Licensing and Safety Issues for Small and Medium-sized Reactors (SMRs), 29 July – 2 August 2013, IAEA Headquarters, Vienna, Austria

[8] J.R. Walker (Canada), Group 3 (Graded Approach) Status 2013-07-31, INPRO Dialogue Forum on Global Nuclear Energy Sustainability: Licensing and Safety Issues for Small and Medium-sized Reactors (SMRs), 29 July – 2 August 2013, IAEA Headquarters, Vienna, Austria

[9] A. Ramakrishna (India) and J.R. Walker (Canada), Group 3 Report on Application of Graded Approach in Regulatory and Licensing Process for SMRs, INPRO Dialogue Forum on Global Nuclear Energy Sustainability: Licensing and Safety Issues for Small and Medium-sized Reactors (SMRs), 29 July – 2 August 2013, IAEA Headquarters, Vienna, Austria

D. Group 4: Legal and Regulatory Framework of SMRs

1. Introduction

A consultancy meeting was held on 17–19 December 2012 to prepare for the INPRO Dialogue Forum on Licensing and Safety Issues for Small- and Medium-sized Reactors (SMRs). The consultancy concluded that the Dialogue Forum should discuss the following major issues regarding the licensing and safety of SMRs: (i) Considerations for SMR designs; (ii) Siting considerations for SMRs; (iii) Application of graded approach in regulatory and licensing process; (iv) Legal and regulatory framework for SMRs; and (v) Public participation in SMR licensing process.

The consultancy determined that, in addition to plenary sessions involving all participants, the Dialogue Forum would include five parallel breakout sessions corresponding to the identified major issues. Each participant in the Dialogue Forum would be assigned to a group discussing one of the major issues.

Mr. Stewart Magruder from the U.S. Nuclear Regulatory Commission, Mr. Myung Jo Jhung from the Korea Institute of Nuclear Safety, and Mr. Russell Gibbs from IAEA were identified as the Group Leader, Co-Group leader, and IAEA facilitator respectively for Group 4.

Prior to the Dialogue Forum, the leader, co-leader, and facilitator prepared a Briefing Handout for participants in the forum. The Briefing Handout described the issues to be discussed by Group 4 during the forum, provided a brief description of each issue, described the proposed organization of the group's activities during the forum, and provided case studies for use in Group 4's discussions. The Briefing Handout was distributed to all participants prior to the forum.

2. Formation of Group 4

The breakout sessions commenced on Day 2 of the Dialogue Forum (Tuesday, 30 July 2013). The following persons expressed an interest in the application of the graded approach in the regulatory and licensing process for SMRs, and were assigned to Group 3:

Ashot Martirosyan (Armenia)
Mahabubur Rahman (Bangladesh)
Pavlin Grudev (Bulgaria)
Galel Orabi (Egypt)
Catherine Lecomte (France)
Jorge Luis Hernandez (France)
Jose Joseph (India)
Collins Gordon Juma (Kenya)
Matthew Bowen (USA)
Kwang Won Lee (Korea)
Si-Hwan Kim (Korea)
Mohammad Iqbal (Pakistan)
Kajetan Rozycki (Poland)
Kevin Ennis (ASME/USA)
Russell Gibbs (IAEA)
Christina Johari (IAEA)
Viacheslav Kuznetsov (Russia)
Marie Cletienne (IAEA)
Vladimir Demin (Russia)
Alvin Chew (Singapore)
Palmiro Villalibre (Spain)
Oleg Godun (Ukraine)
Carol Moyer (USA)
Danielle Goodman (USA)
Budi Rohman (Indonesia)
Jim Kinsey (USA)
Pareez Golub (USA)
Myung Jo Jhung (Korea)
Ibrahim Muhamad (Malyaysia)
Andrej Chwas (Poland)
Stewart Magruder (USA)
Vladislav Sozoniuk (OECD/NEA)
Zoran Drace (IAEA)
Andre Gioia (IAEA)
Brigitte Skarbo (IAEA)

The group established itself under the following officers:

- S. Magruder (USA), Topic Lead
- M.J. Jhung (Korea), Topic Co-Lead
- R. Gibbs (IAEA), Facilitator
- C. Johari (IAEA), Rapporteur

- B. Skarbo (IAEA), Rapporteur

The group received presentations on the following topics during the breakout session:

- Establishment of a Regulatory Framework for Safety - GSR Part 1 – IAEA/NSNI
- Legal and Institutional Issues of TNPPs – IAEA/INPRO
- Insurance of Civil Liability for Nuclear damage - Russian Federation
- Legal Issues of TNPPs – IAEA/OLA

The group reviewed the Participants' Briefing Handout, the issues developed during the consultancy, and the proposed case studies. The group also discussed other issues to be considered during the breakout session.

In order to more closely address the interests of Member States, the group consolidated the issues into the following list:

Original topics from consultancy meeting:

- Plant staffing
- Transportation of fuelled NPPs
- Licensing process for multiple modules
- Identification of required changes to safety standards
- Standardization of portion of design and safety classification

New suggested topics:

- First-of-a-kind-design issues
- Inspectability and testing issues intervals
- I&C – the "black box phenomena" size of exclusion area, can it be reduced for SMRs?
- Does the term SMRs have too big of a range? Is there need for splitting them up in two or more categories – SMRs and very small reactors?
- Remotely operated SMRs
- Cyber security
- Reactor lifetime versus terminal license (independent of technology)

Subsequently, Public Participation was added at the request of the Chair of the Dialogue Forum.

The group prepared presentations for the plenary sessions describing the mid-week progress, and the final outcome.

3. Key Issues and Discussions

Presentation by Marie Cletienne: Establishment of a Regulatory Framework for Safety - GSR part 1

The group benefitted from a short presentation about the formal process for developing IAEA safety standards. The message was that it is a rigorous process ensuring high quality documents that in the end reflect the international consensus on what constitutes high level of safety. A summary of the presentation is as follows.

- Hierarchy: Safety fundamentals, Safety Requirements, Safety Guides

- Legal status: The standards are not legally binding for MS, but binding for IAEA staff going on a mission, and when a MS makes a binding agreement with the IAEA; the standards can be used by the MS in various ways – partly, full adaptation, references.

- GSR Part 1: There are 36 requirements for of the governmental, legal and regulatory framework for safety; divided into three parts: (i) Responsibilities and Functions of the Government, (ii) Global safety regime, (iii) Responsibilities and Functions of the Regulatory Body. On point (iii), specific requirements include:
    - ✓ Requirement 23: Authorization of facilities and activities by regulatory body is a pre-requisite

- ✓ Requirement 24: Demonstration of safety for the authorization of facilities and activities which may be important to innovative concept
- ✓ Requirement 21: Liaison between the regulatory body and authorized parties
- ✓ Requirement 22: Stability of regulatory control
- ✓ Requirement 36: Communication and consultation with interested parties

***Presentation by Zoran Drace**: Legal and Institutional Issues of TNPPs*

INPRO finalized working on a publication on TNNPs (In May 2013 IAEA Publication Committee approved the final report: NE Series No. NG-T-3.5 "Legal and Institutional Issues of Transportable NPPs") to examine legal and institutional issues regarding ownership and contract related to deployment, with focus on export deployment and also implications of TNPP options. The TNPP is defined as physically transportable but not producing energy during transportation in order to differentiate TNPP from, for example, nuclear submarines. There are 2 technical options: (i) fuelled and tested TNPP from suppliers, (ii) pre-tested and fuelled TNPP on site (Both with Balance of Plants constructed on site).

There are 3 scenarios considered:

- Supplier is operator, Host State is regulator
- Host state is operator and regulator, Supplier takes back TNPP and the fuel
- Supplier is operator and regulator (Impossible case?)

Legal basis for innovative SMRs is analysed explicitly. It is still considered as missing, and it was discussed whether current standards can be applied. Safety standards should move in parallel with innovative technology.

For transportation of fuelled and tested TNPP from suppliers, a consensus is needed among the 3 parties involved (supplier country, host country, countries in international waters) on whether the TNPP should be considered as an operable reactor or a package of fresh fuel. The decision is to be based on assessment of technical measures. Current regulation and standards would apply if it is viewed as a fuel package, but these would not apply if it is viewed as an operable reactor.

On safeguards, nothing is distinctive regarding characteristics of construction and operation. However, when exported to non-weapon state, then agreement should be established with the IAEA for verification during construction.

On security, existing norms and recommendations are of a generic nature - by the States Parties (IAEA member states in the case of IAEA security recommendations) not to impede technological innovations of any kind. It was concluded that the application of the existing legally binding and non-legally binding physical protection norms and recommendations remains valid to address the known concerns in the case of a transport of a TNPP. Given the novelty of this option, existing recommendations should perhaps be more stringently applied until more specific, experienced based, norms and best-practices are established

Resolution for near term includes (i) countries be parties to international conventions on safety, security and liability, (ii) countries enter into treaties and conventions, and (iii) safety, security, and environment requirements be developed. International certification of design and licensing of equipment and components might greatly facilitate international transactions.

In the discussion, it was agreed that TNPP is a subset of SMRS which requires an additional, not a separate, consideration. For fuelled reactors, there has to be a guarantee that the reactor will not become critical. The draft TNPP, after undergoing reviews for several years, is ready to print in a few months. The draft was made available to the participants and can be used under discretion for comments to improve the publication.

***Presentation by V.F. Demin**: Issues of insurance of civil liability for nuclear damage for low power nuclear power plants*

Analysis was performed to assess safety changes and (partly) economics, mostly on justification of approach to insurance and quantity of compensation for nuclear damage. Evaluation was performed on consequences of accidents, estimating maximum possible damage, formulation of insurance policy and possible insurance expenditures. A barge floated type NPP (called FNU RITM-200M) was used with specific features / extra test considerations: capability to withstand seismic, tsunami, properties of self-protection, defence in depth, emergency shutdown, emergency cooling, safety management system, beyond design basis accidents, and so on. Also, consideration of external impacts such as fire, explosion and helicopter drop was provided. The heavy consequence is LOCA with melting core having a frequency of 10-7 per reactor year. The dose is very low, that serious post-accident measures such as evacuation are not necessary. Damage is estimated to be 0.001 lower than that of large NPP, and amounted to no more than 10 million dollars. Operation is insured as civil liability.

Given the very low probability of severe accidents and the absence of statistics, it is not possible to calculate premium for nuclear insurance. So, the practice is to harmonize among insurer, insurant interest and expert reports. Minimum amount of insurance is approx. 200 million dollars to third party damage, and excess damage is covered by the State. This shows that high level of safety of FNU can fundamentally change insurance.

Thus, there is a need to establish SMR or low power reactors with high level of safety, to provide insurance. The recommendation is to initiate development of amendments to national and international legislation for establishing lower minimal limit of operator responsibility for nuclear damage.

Russian Federation has reference in terms of experience in safety, accident, back end and green decision (floating SMR), and offers solution for countries that want to start NPP immediately, considering the less time while waiting for construction of land-based reactors. The group considered to use this as a sample case.

In the discussion, it was pointed out the difficulty to generate the frequency value. But operating experience is required to come up with numbers, thus requirements used must be defined along with how the logics was developed. Perhaps there is a need for international review and calculations for scenarios, prior to licensing.

Presentation by Mr Andre Gioia*: Legal issues of TNPPs*

During the second day of the breakout sessions, the group was fortunate to receive a presentation from the IAEA/OLA. This prompted good discussion regarding TNPPs. A summary of the presentation and the discussion is in the following.

OLA has not yet come to any definitive conclusions to the answers to the legal issues of fuelled TNPPs, but has identified the potential legal issues. The draft publication by INPRO is considered a very good starting point for covering major issues on transportation of fuelled TNPPs. OLA has reviewed this document for clearance, and the legal issues around TNPPs are presented quite clearly related to the national law and the perspective of the Agency with respect to international legal framework.

Although the secretariat might have a view on whether something might apply to different conventions, the IAEA is not a party to any convention, so it is up to the contracting parties to deal with the issues.

A main legal question is whether TNPPs can be covered within the conventional legal framework, and if so to what extent.

A broader interpretation of the Vienna Convention covers Civil Liability for Nuclear Damage could exclude TNNPs from the convention entirely, making it necessary to develop additional jurisdiction.

The IAEA does not have an official view on how the exclusion should be interpreted, but the advisory body to the IAEA/DG/OLA has a view the exclusion has to be interpreted strictly and therefore should not be applied to TNNP, i.e. the Vienna Convention does apply to TNPPs, both during transport and power production. The advisory's opinion does not necessarily reflect the view of the IAEA.

Regardless of the convention, the contracting parties are to decide upon any disputes depending on the harmonization of the convention with own national jurisdictions. There is a settlement process brought before court of justice that results in a binding decision, but the states can choose to opt out as states are sovereign and cannot be subjected to international law.

Physical protection is not a major issue with respect to the convention of physical protection for international transportable material, and such will cover TNPP.

Presentation by Mr Jim Kinsey*: Multiple Module Licensing – Licensing and Safety Issues for Small- and Medium-Sized Reactors (SMRs)*

The process developed by Idaho National Laboratory (INL) on how to license multiple modules of HTGR was presented. Lots of inputs from different stakeholders have been taken into account. The INL has had a dialogue with the US NRC and the preliminary conclusion is that the proposal is reasonable, although it will not be accepted and approved until design details are reviewed. Within the next one month, the US NRC will issue a letter to DOE with evaluation of the proposal.

A principle behind this type of licensing is that it is irrelevant how many units are placed on one site; what is relevant is the total radiation dose received by the public. The designers have to prove that the dose for the many reactors they plan to build will not exceed the maximum dose limit. Top level regulatory criteria for the public are used based on: (i) generic, technological neutral and independent of plant site, (ii) quantitative - easily measured, and (iii) direct statements of acceptable consequences of risks to the public. The four top level regulatory criteria for the public: (i) annualized offsite dose guidelines, (ii) accident off site doses, (iii) protective action guides for offsite doses, and (iv) individual fatality risks.

A map of zones for different criteria was shown with the nearest exclusion area boundary (EAB) of 400 meter for GCR (Gas-Cooled Reactors) with multiple units. The other zones follow the practice of typical LWRs. One of the objectives of the designers of GCRs has been to collapse the different dose limits of the design so that all releases would stop at the fence of the plant. This would allow reduction of the emergency zone – which again provides possibilities for building SMRs closer to densely populated areas or next to a chemical processing plant, delivering steam to it. Note, however, that the limit to the reduction is not governed by dose only but also by other factors such as security, severe weather, and evacuation plan.

Following this, the approach has been changed to looking at dose per reactor year to dose per plant year – looking at any releases that can occur on the whole plant including multi-module events – this thereby determines how many modules can be built on a site . The analysis includes all external events, from a steam generator tube rupture that will affect only one module to a tsunami that is likely to affect all and there are different consequences.

There should be a PSA for the whole site. In the current licensing structure of the US NRC PSA is used as more of a piece of information, to provide additional insights, but if this proposal will be adopted PSA will have more legal standing / attention.

It was commented that PSA might need re-evaluation to accommodate differences in design due to time span between building different modules.

It was questioned whether Safety Standards would have to be modified to allow for possibility of no containment building. (The US NRC reported that a change of regulation regarding containments would have to be revised, although there could be exemption for the first unit).

The importance of whether one can reduce the boundaries was noted, as it can change many important aspects such as the ones just exemplified above. Criteria should be determined in order to decide upon such reduction, and this may be a task for the IAEA. Again it was mentioned that there are likely to be major differences within the SMR category, due to the large span in size. It was also noted that the question of changing EZ is also an issue for TNPPs.

It was requested to have more information on this type of analysis, also in simpler forms so it can be used to inform the public. Idaho Lab will provide a report by the end of September 2013.

3.1. Issue 1: Plant staffing

The group discussed whether fewer operators are needed for SMRs than for NPPs. The main argument is that SMRs have more automation with gaps and less severe consequences hence allowing less staffing. It was suggested that for the purpose of the discussion, it should be assumed that these are new technologies that are allowing for more reaction time, less complicated interfaces. Still, many in the group seemed to agree that some minimum number of staffing is needed. It is emphasized that staffing is based on engineering design, not reactor power, and one participant mentioned it may also be site specific. Designers need to show the regulator (in the US) which staffing is required for SMRs, including the case of event response. In a steady state operation, such as Flexblue with remote operation, staffing cannot be excluded permanently; there should be periodic check-up. In case of multiple modules for the same external common events, staffing is required to attend to each of the modules.

In addition, issue of staffing for security in case of breach was brought up, as regulated in the US.

It was discussed whether qualification of SMR operators should be different from large conventional NPPs, whether there are unique traits to SMR creating special demands on the operator. An example of a challenge with innovative technologies from Pakistan is that in their national regulation the operator of the plans should have experience from the operation of a similar plant.

It was also pointed out that, although some regulations have regulations mostly for control room operators, there are arguments for thinking about staffing numbers also for other employee groups at the SMR.

Suggested recommendations:

Generically, plant staffing is design specific and should be a task analysis – Human factor analysis and man machine interface evaluation as well as grace period are required to determine the minimum number of operators needed for a specific design, which should be part of the licensing. It was suggested to include/clarify/stress this in Safety Standards (also need to check whether/ to what extent it is already covered).

It was also suggested to review the safety standards guiding and requirements regarding number of staffing to determine if they are specific about number of operators and therefore might need to be revised. One should consider defining a minimum amount of operators. This is not included in the Requirements ("shall" statements), as the requirement is very general and would apply also to SMRs (see below). The guide, however, states the following: NS-G-2.14, 3.7: "Irrespective of the reactor type and organizational structure, at least one authorized reactor operator should be present at the controls in the main control room at all times while the reactor is in operation." This is written with an assumption that there is one control room per reactor, and as this may not be the case for SMR this is one reason to consider changing it.

SSR-2 should be checked to see the number of operator per control room when reactor is operating, and if there is no experience, then how to set the criteria in the Guidance.

It was also mentioned that the number of operators is depending on the culture of the country, and it will not be the same all over. One might therefore only be able to make estimation on the percentage. It was stated that the IAEA guidance document should acknowledge that there are differences, but at least point to a minimum, and if there is ability and will to have additional staff it is good, at least to a certain extent.

IAEA publications – relevant requirements and guidance to consider revision of:

- Safety of Nuclear Power Plants: Commissioning and Operation for protecting people and the environment No. SSR-2/2
    - ✓ Requirement 4: Staffing of the operating organization. The operating organization shall be staffed with competent managers and sufficient qualified personnel for the safe operation of the plant.
- NS-G-2.14

- ✓ 2.25. Operations personnel should not normally interchange components or carry out maintenance.
- ✓ 3.4 The number of operators on each shift and their responsibilities should be determined on the basis of the complexity of the plant, its level of automation and its organizational structure
- ✓ 3.5 The main responsibilities of the control room operators are to operate the plant and the plant systems in accordance with the design intent and operating procedures and to maintain the reactor and other plant systems within the established operational limits and conditions. (...)
- ✓ 3.6 The field operators who are assigned to control operational activities outside the control room should be made responsible for monitoring the performance and status of equipment in the field and for recognizing any deviations from normal conditions. They should also respond properly to plant conditions with the goal of preventing unanticipated transient operational states or at least mitigating their consequences.
- ✓ 3.7 Irrespective of the reactor type and organizational structure, at least one authorized reactor operator should be present at the controls in the main control room at all times while the reactor is in operation.

3.2. Issue 2: Transportation of fuelled NPPs

Issue on containers and qualification/validation for transportation was brought up. A process qualifying new containers to transport ready fuelled reactors is already established. But vendors are considering transporting the whole module with fuel.

It was argued that there is a fundamental difference between transporting a fuelled reactor and only fuel, and additional safety issues during transportation of fuelled reactors must be considered to assure no criticality throughout transportation and mechanical robustness.

There is a lack of standards for transportation requirements and there are other standards involved such as for transportation to verify the condition of the reactor once arriving at the site, and they may all differ. This could represent a very large area of standards writing. Development of standards is like a chicken/egg discussion, i.e. how the TNPP should be designed so that it can meet the transportation requirements, or how the requirements should be written so it can meet the design demands. Participants argued that requirements have to be developed in parallel with the technological development, but in practice there may be challenges in particular to safety.

It was recommended to further follow up the topic of standards and guidance and facilitate international exchange among countries with existing nuclear programs on how to develop standards.

A proposed path forward for fuel reactors and shipping containers are presented for the different scenarios for TNPPs, with regard to licensing requirements for shipping containers and licensed shipping containers. It was suggested that an INPRO WG is created to look at both aspects for the case of fuelled TNPPs.

It was suggested to consider whether TS-R-1 should be modified to include transportation of TNPPs, and to use technology neutral. Additional standards can be added to the existing ones in particular for the case of small sized reactors.

After the OLA presentation, it was suggested that the legal liability issues might better be left to the lawyers. A proposal on how to separate different scenarios for transportation of fuel for SMRs is provided below:

- Option 1: Transporting fuel separated from core

		Licensing requirements for shipping container?	Licensed shipping containers?
FUEL TYPE	Classical design	YES	YES
	New design	To be confirmed	**?** (→ Licensing requirements should be reviewed with regard to new types of

			fuels)

- Option 2: Transporting fuelled core

Licensing requirements for the shipping container	Licensed shipping container
NO (→ Need to develop licensing requirements for the shipping container)	NO (→ Need to develop licensing for shipping containers)

For the second part of the table, it was suggested that an INPRO WG should be created to look at both aspects of fuelled core transportation. In addition, it was argued that complete guidance on how to transport fuelled reactors is needed.

There is also a need to distinguish between transportation of different sizes of SMRs – a fuelled 700 MW reactor cannot be transported in a single container.

There was a discussion on commissioning of fuelled reactor whether it is done prior to transportation or after arriving at the site, and which tests can be done the factory and at the site. France explained that Flexblue modules are assembled at the factory and take into account accidents in transportation, shut down system, analysis of safety features, emergency – cannot only review the concept of a pure passive shelter – that can contribute to the transportation. This includes environment, maritime situation, seismic conditions etc. apart from a pure containment.

3.3. Issue 3: Licensing process for multiple modules

The meaning of "module" was discussed; whether there is a difference between a module and a reactor. It was suggested that a module is a reactor, a nuclear steam supply system. A module is independent and closed, can be stopped, fixed or mounted later on. Modules may share not only the same secondary system, e.g. steam turbine, but also the same primary system, e.g. diesel generators.

Some of the new designs are opting for sharing more safety systems, accordingly it was discussed whether sharing safety systems is an option. Participants were reluctant towards this idea, pointing to the DID principle of independent safety systems for each level for each unit. Licensing multiple modules for one site at the same time might be problematic, as the design of SMRs is rapidly changing, and although all modules would be licensed, they would normally not be constructed simultaneously, due to economic and other considerations. This may lead to regulators requiring re-licensing for new modules.

It was recommended to review the safety standards to find out if there are clear requirements and guidance, and to determine whether standard regarding multiple module SMRs need revision.

The process developed by Idaho National Laboratory (INL) on how to license multiple modules of HTGR was described. A principle behind this type of licensing is that it is irrelevant how many units are placed on one site; what is relevant is the total radiation dose received by the public. Hence, a PSA for the whole site is deemed necessary. There was a discussion on exclusion zone and potential reduction of zones due to the advances in fuel technology, changes of standards to eliminate containment building, and differences of requirements and licensing of power reactors if used as research reactor versus power reactors.

Other issues raised in the group were requirements and licensing for two identical power reactors in which one is used as a research reactor and the other as a power reactor, whether the same licensing process would apply and whether licensing of research reactors is less rigorous.

Licensing of multiple modules for the same site:

Multiple modules on the same site were described as a practical approach, as there is money and time to save by having a large site licensed for many modules, due to the long licensing process. It was also mentioned that being able to build multiple modules on a site over time opens for a smaller investment upfront, which is an important benefit for newcomers/countries with limited funds.

The main question discussed was whether licensing multiple modules for one site should be done at the same time. On separate licensing for the site and multiple modules of the same design at the same site, some regimes have integrated systems, but it was questioned how this will look like in regimes without having integrated systems. MSs have experience in building NPPs with more than one unit on the site. Pakistan has two units constructed within a 10-year span, which did not require a separate licensing. France has NPP with many units and each unit has separate licensing. India also has several sites with multiple units. The experience was that it takes time to construct more units at the same time given the amount of work required for site evaluation and clearance, as well as the necessary infrastructure, logistics, staffing and transport. But the units are independent in every aspect, especially safety system, i.e. no sharing of safety system, and the unit was licensed separately. The common US practice is to first licence the site of multiple modules, and then issue a license for each individual module when built. This way, it will be evaluated how many modules the sites has capacity for in total before any licensing is done and this also ensures that there are no problems due to changes in technology.

The majority of the group seemed to agree that the US practise would be advisable also for SMRs, as many participants argued that licensing several modules at the same time would be problematic, as the design of SMRs is rapidly changing, and although all modules would be licensed, they would normally not be constructed simultaneously, due to economic and other considerations. (It was mentioned that there are many cases where a site is licensed for several reactors, and then the operator decided to construct fewer.) This would mean that some of the modules might be built several years after they are licenced, and if there are any changes in the technology, even just slight, the license may have to be renewed. Many different scenarios were drawn up by the participants to illustrate the complexity, for example, the regulator might require a licensee to change the design when building a new module due to safer designs available on the market. Mr Ennis proposed to consult with regulators for cases where one module is not exactly the same as / slightly different than the older design, i.e. “how close is close enough”; to ask the designer so that even trivial changes can be discussed with the regulator to see if re-certification is needed.

3.4. Issue 4: Required changes to Safety Standards?

This topic was covered throughout the sessions. In general, it was recommended to review the safety standards to establish what is relevant to SMRs specifically, and if there is a need to change these or develop new standards. It was mentioned that one thing that might change the requirements is the TNPPs: “Emergency planning for a fixed site is one thing, when it moves around it is a whole other issue”.

It was emphasised that there would be a strong benefit if the SMR standards can be harmonized, as the market will be international and suppliers will benefit considerably. SMRs might be more viable than large NPPs despite the great challenges. Vendors, operators and regulators should work in parallel with regards to developing design and standards.

3.5. **Other issues discussed**

Life extension

The issue of life extension, in case of multiple module SMRs, was discussed, and it was noted to take into account evolution of technology, whether new improvement will jeopardize the old module, i.e. life extension of the first module may not fulfil the requirements posed by the new module.

Maximum number of modules

Regarding criteria for maximum number of modules allowed in one site, the group noted that under some regulations the operator has to prove that the number of modules placed on one site is safe. The regulator should indicate whether to approve, or require a PSA, independent or the total, from the operator.

Public participation

Public participation was also discussed briefly.

- Is it the task of regulators to inform the public about the risks of nuclear power generation to the public?
- It was argued that there is a need to consider who is conveying information on safety, security, risks, environmental aspects etc. to the public, and that one should include research institutions, academia, the press etc. in interactions the with the public.
- It was also argued that the extent of public participation in the licensing process is up to public hearings.
- With regards to number of staff – it was argued that the public would demand at least one operator running any nuclear power plants, including fully automated SMRs. However, it was also argued that this may not be an issue that the public gets directly involved in.
- Public acceptance for reactors with longer life time was also discussed; it was argued that they need to involve academia, international reviews to increase safety.

4. Cross-cutting Issues

Consistent with the discussion at the consultancy meeting to plan the dialogue forum, the group identified the following issues as cross-cutting:

- Application of graded approach
- Size of EPZ & siting
- Design for inspection & testing

5. Case Studies

Though case studies were not formally introduced to the group, the questions documented in the Briefing Handout were used during the discussion of staffing requirements for SMRs and TNPPs.

6. Major Findings and Recommendations

- IAEA should consider reviewing IAEA Safety Standards regarding new SMR technologies and approaches that have potential for commercial deployment in the short-medium term with regards to licensing process, number of staffing, remote operation, TNPP transportation, etc.
- Designers, regulators and operators need to proactively cooperate with standards organizations with respect to technical standards for SMRs.
- There is a need to facilitate parallel considerations of design safety requirements by industry and licensing safety requirements by regulators.
- There is a need to update IAEA Glossary on SMRs, and evaluate classifications of SMRs.
- IAEA needs to support discussion of potential international certification of designs, and roles of regulator and IAEA in facilitating deployment of SMRs, e.g. licensing, serialization.
- There is a need to review the IAEA Safety Standards regarding number of staffing, for example, NS-G-2.14, to determine whether changes are needed with regard to SMRs (e.g. consider defining a minimum number of operators for SMRs).
- IAEA needs to consider cooperation with OECD/NEA RISK WG on SMRs.

INPRO Dialogue Forum on Global Nuclear Energy Sustainability:

Licensing and Safety Issues for Small- and Medium-sized Reactors (SMRs)

29 July – 2 August 2013, IAEA Headquarters, Vienna, AUSTRIA
IAEA Board Room A (M-0237), Board Room C

Closing Remarks

Mr Jong Kyun PARK

Director, Division of Nuclear Power
IAEA Department of Nuclear Energy

Good afternoon, Ladies and Gentlemen,

Congratulations for successful completion of the sixth INPRO Dialogue Forum on Global Nuclear Energy Sustainability – addressing the Licensing and Safety Issues of SMR. I hope all of you enjoyed your stay in Vienna even though the weather was a bit hot.

I am so delighted that this Dialogue Forum was satisfactorily completed today through the effective cooperation between the Department of Nuclear Energy and the Department of Nuclear Safety and Security.

On behalf of the International Atomic Energy Agency, I would first like to express my sincere appreciations to Mr David NEWLAND and Mr Poong-Eil JUHN for their excellent chairmanship in bringing this Dialogue Forum to a complete success.

Through their outstanding leadership, we were able to constructively discuss the identified key issues of design considerations, siting and infrastructure, application of graded approaches, legal and regulatory framework, and public participation in the SMR licensing process.

I hope that this Dialogue Forum has facilitated a common understanding of the needs and potential role of different stakeholders in countries considering SMR for their near term and future national energy mix; by addressing the associated issues on licensing and safety of advanced SMR technologies. And I believe that this Dialogue Forum has been a remarkable opportunity for Member States in developing and deploying SMRs as one of the viable options for reliable and economically competitive energy supply.

The Agency continues its various programmes to support Member States build capacity for nuclear power programmes— through close collaboration between the Department of Nuclear Energy and the Department of Nuclear Safety and Security by providing platforms for Member States to discuss issues of sustainable development and deployment of nuclear energy.

We are all pleased that this Dialogue Forum could formulate recommendations and path forward to address the identified key issues through the intensive breakout sessions. The IAEA will have a thorough review of the recommendations and take appropriate actions if needed.

I was reported that the idea of setting up a Forum of Regulators on SMR was discussed during the Dialogue Forum as an option to carry the issues forward. However, the establishment of such a Forum is beyond the scope of this Dialogue Forum and I believe that this issue has to be further discussed with the existing Regulators' Cooperation Forum and the Agency's Department of Nuclear Safety and Security.

Before concluding my remarks, I would like to extend my gratitude to all participants, presenters and particularly, the Leaders and Co-Leaders of the five break-out sessions for their superb leadership.

We are all thankful for the remarkable work done in conducting this Dialogue Forum and the preparations made by the Scientific Secretaries and their team members from the two Departments.

I wish all of you have safe trip back home.

Now, I would like to declare this Dialogue Forum CLOSED. Thank you.