Workshop on

New Challenges Facing Nuclear Regulators

Sponsored by

The Infrastructure Development Working Group (IDWG)

28-29 May 2018

Boulogne-Billancourt, France

IFNEC

INTERNATIONAL FRAMEWORK FOR NUCLEAR ENERGY COOPERATION

THE INTERNATIONAL FRAMEWORK FOR NUCLEAR ENERGY COOPERATION

The International Framework for Nuclear Energy Cooperation provides a forum for cooperation among participating states to explore mutually beneficial approaches to ensure the use of nuclear energy for peaceful purposes proceeds in a manner that is efficient and meets the highest standards of safety, security and non-proliferation.

The 34 IFNEC member countries are: Argentina, Armenia, Australia, Bahrain, Bulgaria, Canada, China, Estonia, France, Germany, Ghana, Hungary, Italy, Japan, Jordan, Kazakhstan, Kenya, Korea, Kuwait, Lithuania, Morocco, the Netherlands, Niger, Oman, Poland, Romania, Russia, Senegal, Sierra Leone, Slovenia, Ukraine, the United Arab Emirates, the United Kingdom and the United States.

The 31 Observer countries are: Algeria, Bangladesh, Belgium, Brazil, Chile, the Czech Republic, Egypt, Finland, Georgia, Greece, Indonesia, Latvia, Malaysia, Mexico, Moldova, Mongolia, Nigeria, Philippines, Qatar, Saudi Arabia, Singapore, Slovak Republic, South Africa, Spain, Sweden, Switzerland, Tanzania, Tunisia, Turkey, Uganda and Vietnam.

NUCLEAR ENERGY AGENCY

The OECD Nuclear Energy Agency (NEA) was established on 1 February 1958. Current NEA membership consists of 33 countries: Argentina, Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Luxembourg, Mexico, the Netherlands, Norway, Poland, Portugal, Korea, Romania, Russia, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The European Commission and the International Atomic Energy Agency also take part in the work of the Agency.

The mission of the NEA is:

- to assist its member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally sound and economical use of nuclear energy for peaceful purposes;
- to provide authoritative assessments and to forge common understandings on key issues as input to government decisions on nuclear energy policy and to broader OECD analyses in areas such as energy and the sustainable development of low-carbon economies.

Specific areas of competence of the NEA include the safety and regulation of nuclear activities, radioactive waste management and decommissioning, radiological protection, nuclear science, economic and technical analyses of the nuclear fuel cycle, nuclear law and liability, and public information. The NEA Data Bank provides nuclear data and computer program services for participating countries.

The Nuclear Energy Agency serves as technical secretariat to IFNEC.

Foreword

The objectives of this workshop on *New Challenges Facing Nuclear Regulators* were to share information on the following themes.

Regulatory Approaches for New Large Reactors by Established Regulators

With the advent of Generation III/III+ reactors, long-established regulators face the challenge of evaluating enhanced safety features, including a higher degree of passive safety, and other new design features developed in response to the Fukushima Daiichi nuclear accident.

Regulatory Approaches by New Regulators

Regulators in emerging countries must deal with the same issues as they build up their capacity and expertise, and new laws and regulations are put in place.

Challenges in Regulating Small Modular Reactors

Both established and new regulators have to address new issues presented by Small Modular Reactors (SMRs), for example, reduced emergency planning zones, entirely passive cooling and control room staffing.

The workshop included presentations and participation by high-level experts and nuclear safety regulators representing:

Argentina
Canada
China
France
Ghana
Italy
Japan
Kenya
Poland
Republic of Korea
Russian Federation
Slovenia
United Arab Emirates
United Kingdom
United States
Chile
Egypt
Georgia
Indonesia
Euratom
IAEA
OECD/NEA

The presentations from the workshop can be downloaded from the IFNEC website: www.ifnec.org/

Infrastructure Development Working Group co-chairs

John Mathieson of the United Kingdom Nuclear Decommissioning Authority and Alex Burkart of the United States Department of State

AGENDA
WORKSHOP ON NEW CHALLENGES FACING NUCLEAR REGULATORS

May 28-29, 2018
OECD Boulogne,
46 Quai Alphonse Le Gallo,
Boulogne-Billancourt, France

Day One

9:00-9:15 am — **Introduction to the Meeting, Review of the Agenda, and Introduction of Participants**
IDWG Co-Chairs: John Mathieson and Alex Burkart
- Welcome – IDWG Co-Chairs and NEA Host
- Introductions
- Review of Agenda

9:15 am-12:45 pm — **Regulatory Approaches for New Large Reactors by Established Regulators**

9:15-9:45 am — The Multinational Design Evaluation Program (MDEP)
Ho Nieh, Head of the Division of Nuclear Safety Technology and Regulation, OECD Nuclear Energy Agency

9:45-10:15 am — Safety Approach and Safety Assessment of the Hualong One and the CAP 1400
Xin Tianmin, Vice President, Hualong Pressurized Water Reactor Technology Corporation, Ltd.; Shi Wei, Assistant Chief Engineer, Shanghai Nuclear Engineering Research and Design Institute Corporation, China

10:15-10:45 am — Regulating the Hualong One as a Customer
Nestor Masriera, President, Nuclear Regulatory Authority (ARN), Argentina

11:15-11:45 am — Assessing the Safety of New Reactors in France - EPR and ATMEA1
Karine Herviou, Director of Systems, New Reactors and Safety Approaches, Nuclear Safety Pole, Institute for Radiological Protection and Nuclear Safety (IRSN), France

11:45 am-12:15 pm — Licensing for APR1400 in Korea
Youngdoo Kang, Project Manager, Division of Reactor Licensing, Korea Institute of Nuclear Safety (KINS)

12:15-12:45 pm — Russian Regulatory Approaches for VVER-1200 Designs
Denis Rogatov, Lead engineer, NPP Safety Division, Scientific and Engineering Centre for Nuclear and Radiation Safety (SEC NRS), Russian Federation

2:00-3:30 pm — **Regulatory Approaches for New Large Reactors by Established Regulators (continued)**

2:00-2:30 pm	The UK Generic Design Assessment *Diego Lisbona, Nuclear Safety Inspector, UK Office of Nuclear Regulation (ONR)*
2:30-3:00 pm	Design Certification of Light Water Reactors in the United States *Anna Bradford, Deputy Director, Division of New Reactor Licensing, US Nuclear Regulatory Commission (USNRC)*
3:00-3:30 pm	On the Road Towards International Standardization *Donald Hoffman, Vice Chair CORDEL, President and CEO of EXCEL Services Corporation*
4:00-5:00 pm	Discussion
5:00 pm	**Adjournment**

Day Two

9:00-11:00 am Challenges Facing New Regulators

9:00-9:30 am — Preparing for Regulatory Oversight
Stewart Magruder, Senior Nuclear Safety Officer, International Atomic Energy Agency (IAEA)

9:30-10:00 am — Steps towards a Nuclear Power Program in Kenya
Erastus Gatebe, Chairman, Kenya Radiation Protection Board

10:00-10:30 am — Progress of the UAE Nuclear Power Program. Regulator's Perspective
Haitham Alsenaani, Senior Operational Safety Specialist, Federal Authority for Nuclear Regulation, United Arab Emirates (UAE)

11:00-11:30 am — Discussion

11:30-5:00 pm — Challenges in Regulating SMRs

11:30 am-12:00 pm — Common Issues in Safety, Licensing and Regulatory Frameworks for SMR Deployment
Stewart Magruder, Senior Nuclear Safety Officer, IAEA

12:00 -12:30 pm — Readiness for Regulating Small Modular Reactors
Hugh Robertson, Director General, Canadian Nuclear Safety Commission

1:30-2:00 pm — Regulating the Argentine CAREM Reactor
Nestor Masriera, President, ARN, Argentina

2:00-2:30 pm — Licensing for SMART in Korea
Seunghun Yoo, Senior Researcher, Dept. of Reactor Licensing Project Management, KINS

2:30-3:00 pm — Licensing of Floating Power Unit "Academician Lomonosov"
Alexey Ferapontov, Deputy Chairman, Rostechnadzor, Russian Federation

3:30-4:00 pm — Preparing for Regulating Advanced Nuclear Technologies (ANTs)
Elspeth McGregor, Associate in New Reactors Division, ONR, United Kingdom

4:00-4:30 pm — Design Certification of the NuScale Small Modular Reactor
Anna Bradford, Deputy Director, Division of New Reactor Licensing, USNRC

4:30-5:00 pm — Discussion

5:00 pm — Closing Remarks

Summary Report

Workshop Organization and Approach

The workshop consisted of three separate sessions addressing:

1. Regulatory Approaches for New Large Reactors by Established Regulators
2. Challenges Facing New Regulators
3. Challenges in Regulating SMRs

In addition to representatives from national nuclear safety regulatory authorities, the IAEA, the WNA, and the NEA also presented and participated.

This report provides a summary of the presentations in each of the three sessions. For those wishing to go beyond the summary, the PowerPoint presentations used by each of the participants can be found on the IFNEC website.

This report makes the outcomes of the workshop more generally accessible to all IFNEC members whether they were able to attend or not. The workshop was sponsored by the Infrastructure Development Working Group.

SESSION 1

Regulatory Approaches for New Large Reactors by Established Regulators

This session included ten presentations summarized below

A. The Multinational Design Evaluation Programme (MDEP): Accomplishments and Future Opportunities

Ho Nieh, Head of the Division of Nuclear Safety Technology and Regulation, Nuclear Energy Agency – OECD

MDEP was established in 2006 by the NEA as a forum for regulatory authorities to share information, discuss issues, understand differences and share questions for more informed and harmonized regulatory decisions.

MDEP is comprised of 16 national regulatory authorities with the NEA serving as the technical secretariat. The IAEA participates in issue-specific working groups.

Accomplishments from the MDEP work were discussed that included Steering Technical Committee common positions, and design-specific and issue-specific working groups, common positions and technical reports.

Benefits from this work included:

- increased cooperation in design evaluations
- increased communications

- greater quality of national safety assessments
- greater harmonization of regulatory reviews

Challenges and potential opportunities for MDEP going forward were also discussed.

B. Safety Approach and Safety Assessment of the Hualong One (HPR1000) Rector

Tianmin Xin, Vice President, Hualong Pressurized Water Reactor Technology Corporation, Ltd., China

For the Hualong One reactor project, since the Fukushima Daiichi accident, new requirements have resulted in new safety approaches and design features that have increased safety, reliability, and economic efficiency. Details of the new approaches and features being applied were presented.

Feedback from the Fukushima Daiichi accident has resulted in:

- diversity of power supply;
- anti-flooding design;
- establishment of emergency water supply;
- improved spent fuel pool cooling and monitoring; and
- improved radiation monitoring and emergency response.

Safety evaluations and assessments have been revised and improved with a focus on specific important issues on Preliminary Safety Analysis Report review.

C. Safety Approach and Safety Assessment of the CAP 1400 Reactor

Shi Wei, Assistant Chief Engineer, Shanghai Nuclear Engineering Research and Design Institute Corporation, China

Features of the CAP 1400 reactor:

- AP 1000 passive safety concepts;
- more reactor power:
  - 4040 MWt
  - 1500 MWe;
- equipment localization greater than 85%;
- lower CDF and LRF;
- increased safety margins;
  - 10% at least;
- meets the requirements of newest codes and standards.

Several safety enhancements:

- including Fukushima Daiichi accident improvements;
- enhancement of several accident prevention measures including hydrogen control.

The CAP 1400 design has undergone extensive safety reviews and validation testing over an 18-month period based on experience with the AP 1000 design.

D. Regulating the Hualong I as a Customer

Nestor Masriera, President, Nuclear Regulatory Authority (ARN), Argentina

It can be instructive to understand that, from a simplified view, there are two "models"/approaches to regulating NPPs:

Safety Goal Oriented Approach: A top-down process from Safety Objectives – safety analysis – engineering requirements for systems, structures and components (SSCs).

Prescriptive Approach: Of regulations, safety standards - industrial C&S – procedures – guides

The Hualong I - HPR 1000 – is and will be a turnkey supply project in which Argentina will follow the Prescriptive Approach.

For an "ideal" foreign supplier turnkey project:

- The supplier will provide the "hardware" and the construction, plus project management, licensing documents preparation, etc.
- Everything will be properly documented: there are clear, complete, classified descriptions of systems (and structures and components), there are sets of technical and quality specifications for every SSC.
- There will be industrial standards covering aspects of process, mechanics, instrumentation and control (I&C), electricity, etc.
- There will be rules for design, fabrication, assembling, and testing.
- There will be rules for commissioning, operating, handling, maintaining, etc.

If the customer country adheres to a prescriptive approach to regulating the project, the supplier will serve as the "design authority," and the design will have a safety assessment completed by the national regulatory body of the supplier country.

The local regulatory body generally relies on the regulatory experience of the supplier country and that regulator's design accreditation/certification is not repeated nor reviewed by the local regulator.

The safety regulation of the plant does not end in licensing. The licensing basis (the basis of the demonstration of safety) has to be maintained throughout the life of a plant. Modifications and updates will need to be performed by a design authority.

As the regulator for the customer, having a turnkey plant and using the prescriptive approach can work well, but only if in the supplier country maintains a healthy/growing nuclear industry that can continue to serve as the design authority.

E. Assessing the Safety of New Reactors in France - EPR and ATMEA1

Karine Herviou, Director of Systems, New Reactors and Safety Approaches, Nuclear Safety Pole, Institute for Radiological Protection and Nuclear Safety (IRSN), France

Several improvements have been identified to enhance the safety of Gen III PWRs. These include:

- use of a large operating experience on PWR plants, notably French and German units (periodic safety reviews, events analysis for French PWRs);
- use of the results of in-depth studies performed on French nuclear existing reactors, particularly Probabilistic Safety Assessment studies; and
- use of knowledge progress from R&D, in particular the R&D on melt core accident that have been undertaken after the TMI 2 accident.

The basic objectives are reinforcement of defense in depth and enhancements to the robustness of the safety case.

Safety goals for the next generation of PWRs:

- Reduce individual and collective doses for the workers during normal operation and abnormal occurrences, which are largely linked to maintenance and in-service inspection activities.
- Reduce the number of significant incidents, which involves seeking improvements in the equipment and systems used in normal operation, with a view to reducing the frequencies of transients and incidents and hence to limiting the possibilities of accident situations developing from such events.
- Reduce the global core melt frequency. Implementation of improvements in the defense in depth of such plants should lead to the achievement of a global frequency of core melt of less than ten to the minus five per plant operating year. Uncertainties and all types of failures and hazards must be taken into account.
- A significant reduction of potential radioactive releases due to all conceivable accidents:
    - for accident situations without core melt, there shall be no necessity of protective measures for people living in the vicinity of the damaged plant (no evacuation, no sheltering);
    - for accident situations with core melt that would lead to large early releases have to be "practically eliminated": if they cannot be considered as physically impossible, design provisions have to be taken to design them out. This objective applies notably to high-pressure core melt sequences;
    - low pressure core melt sequences have to be dealt with so that the associated maximum conceivable releases would necessitate only very limited protective measures in area and in time for the public.

Challenges:

- Need to develop and maintain very high level competences and skills in different technical domains in order to be able to deeply assess the design of the plant and accidental studies.
- Need to anticipate the potential impact of design options on the plant safety during operation.
- Need to carefully follow up the construction activities and the manufacturing of its components to assess the plant safety.

F. Licensing for APR 1400 in Korea

Youngdoo Kang, Project Manager, Division of Reactor Licensing, Korea Institute of Nuclear Safety (KINS)

Licensing Status of APR 1400:

- Shin-Kori 4 : the Nuclear Safety and Security Commission will start deliberation for an operation license;
- Shin-Hanul 1&2: pre-operational inspection is being carried out;
- Shin-Kori 5&6: pre-operational inspection is ongoing.

Major design changes in comparison with SHN 1&2:

- consideration of an intentional large commercial aircraft impact;
- installation of an alternate alternating current diesel generator for each unit;
- increase of the safety grade battery capacity (from 8 hours to 24 hours);

- installation of four Emergency Reactor Depressurization Valves against severe accidents.

Concerns:

- confirm safety requirements in light of safety related phenomenon from Fukushima Daiichi accident, there are 33 action items for APR 1400;
- need to develop new regulatory requirements for advanced technologies;
- common cause failure for software based systems;
- safety-security interface;
- commissioning test and oversight;
- first of a kind (FOAK) testing;
- dealing with the deficiencies resulting from improper implementation or human errors during commissioning phase;
- public concerns regarding nuclear energy;
- record-breaking earthquake near NPPs, 2016;
- new energy policy – shift from coal and nuclear towards renewable and natural gas energy.

G. Russian Regulatory Approaches for VVER-1200 Designs

Denis Rogatov, Lead engineer, NPP Safety Division, Scientific and Engineering, Centre for Nuclear and Radiation Safety (SEC NRS), Russian Federation

Federal Safety Rules and Regulations were presented and discussed relating to:

- assessment and selection of site for NPO location;
- NPP safety targets;
- defense in depth.

Requirements based on Fukushima Daiichi lessons learned:

- independence of the DiD levels from each other, as far as this practically possible *(especially for Level 3&4);*
- prevention of a barrier damage due to the damage of other barriers as well as several barriers damage resulting from the similar impact.

Measures aimed at excluding the "Cliff-edge effect" *(Level 1):*

- design and safety substantiation;
- safety related systems and safety systems;
- regulatory approaches to evaluation of the passive heat removal system;
- design-basis accidents and beyond-design-basis accidents (BDBA);
- special technical means used for BDBA managements;
- probabilistic safety assessment (PSA) and safety assessment report (SAR)

The status of current national NPP construction projects was also presented.

H. The UK Generic Design Assessment (GDA)

Diego Lisbona, Nuclear Safety Inspector, UK Office of Nuclear Regulation (ONR)

In the United Kingdom there are three elements of new build, General Design Assessment (GDA), Nuclear Site Licensing, and Construction.

GDA is an upfront, step-wise assessment of a generic reactor design undertaken by joint regulators (ONR / Environment Agency [EA] / Natural Resources Wales [NRW]):

- Usually, GDA does not consider a specific build location or a specific operating organization.
- GDA is performed prior to investment decisions.
- The aim and advantage is identifying and resolving key issues and design changes long before build– reducing construction cost and time risks.
- Openness, transparency and public input are very important in GDA – building public confidence.
- GDA is not a formal regulatory / legislative requirement, but remains a Government expectation.
- The typical timeline for the GDA process covers 52-57 months.
- A successful outcome of the process is a Design Assessment Certification from ONR and Statement of Design Acceptability from EA/NRW.

ONR's Regulatory Philosophy

- Goal setting – (mostly) non-prescriptive.
- Underpinned by a risk-informed framework (Tolerability of Risk, TOR).
- Aimed at developing and sustaining an open and effective dialogue with regulated parties - a positive and enabling approach to the review and approval of activities.
- The key pillar of the regulatory work is ensuring that risks are reduced As Low As Reasonably Practicable (ALARP).

The status of the Hitachi/GE ABWR GDA, and the General Nuclear Systems/CGN/EDF HPR1000 GDA was presented.

I. Design Certification of Light Water Reactors in the United States

Anna Bradford, Deputy Director, Division of New Reactor Licensing, U.S. Nuclear Regulatory Commission (USNRC)

The USNRC Design Certification (DC) process:

- Allows an applicant to obtain preapproval of a standard nuclear plant design.
- Facilitates standardization.
- A greater degree of design detail provides greater regulatory finality within certification.
- Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC).
- 15-year duration.

The NRC has reviewed and issued DCs for five reactor designs (two of which have expired) and one amended design:

- ABWR (General Electric (GE) Nuclear Energy)
- AP 1000 (Westinghouse Electric Company)
- ESBWR (GE-Hitachi Nuclear Energy)

- ABWR Amendment (South Texas Project Nuclear Operating Company)
- APR 1400 (Korea Electric Power Corporation and Korea Hydro & Nuclear Power Co., Ltd.)

The NRC encountered various licensing challenges when reviewing the applications of the AP 1000, ESBWR and APR1400, and some of these were revealed in this discussion.

J. On the Road Towards International Standardization

Donald Hoffman, Vice Chair CORDEL, President and CEO of EXCEL Services Corporation

Cooperation in Reactor Design, Evaluation & Licensing (CORDEL), sponsored by the World Nuclear Association (WNA):

- Every reactor vendor offers one or more standard designs (EPR, AP1000, ESBWR, AES2006, APR1400, etc.). These "standardized" designs are presently adapted to comply with the national safety standards in each country where they are built.
- If the regulatory requirements in all countries were harmonized, the design could go through the licensing process without adaptions or changes (other than those dictated by site-specific circumstances) and would therefore be internationally standardized design.

A standardized design approval process and worldwide nuclear power plant designs would boost investment attractiveness and predictability of nuclear new build worldwide, both in established nuclear countries and in emerging nuclear countries. In addition, safety would be improved though more efficient sharing of operating experience, enabling more cost effective licensing and safety analysis and providing more effective nuclear power plant monitoring.

CORDELL Mission: Promote the standardization of nuclear reactor designs

- CORDEL Working Group established in 2007

Main objectives are to promote:

- International standardization of reactor designs
- International harmonization of regulatory requirements
- International design approval/certification

Six Task Forces:

- Design Change Management [WANO, IAEA]
- Codes and Standards [MDEP, SDOs]
- Digital I&C [MDEP, IAEA, IEC]
- Nuclear Safety Standards [IAEA, ENISS, EUR, WANO]
- Small Modular Reactors [IAEA, NEA]
- Licensing & Permitting [MDEP, IAEA, NEA]

Membership:

- Almost all major vendors and many utilities interested in new build, service companies, etc.

CORDELL is working to establish a new strategic plan for the next five years.

SESSION 2

Challenges Facing New Regulators

This session included three presentations summarized below

K. Preparing for Regulatory Oversight: Establishing the Safety Infrastructure for a Nuclear Power Program

Stewart Magruder, Senior Nuclear Safety Officer, International Atomic Energy Agency (IAEA)

In the last decade an increasing number of countries having no or little experience in building, operating or regulating nuclear facilities are considering the introduction of nuclear power. For these countries there is a need to establish an appropriate and comprehensive national safety infrastructure in compliance with the IAEA safety standards for ensuring safety and gaining public trust at national and international level.

To address this issue the IAEA has published a Safety Guide, SSG-16, *Establishing the Safety Infrastructure for a Nuclear Power Program*. The Guide sets forth a phased approach for establishing the necessary infrastructure. Included is a self-assessment, Integrated Review of Infrastructure for Safety (IRIS).

The intent of the IRIS self-assessment:

- assess the current situation and progress made to build up the safety infrastructure for a nuclear power program;
- create a common understanding among stakeholders of the progress made in the development of the safety infrastructure;
- identify gaps between the current situation and expected status of the national safety infrastructure, and list areas where improvement is needed;
- take appropriate actions to strengthen the current safety infrastructure if necessary, in order to comply with IAEA standards;
- prepare an action plan for an implementation strategy.

The self-assessment process is resource intensive and requires a strong commitment by both the Government and the Regulatory Body.

SSG-16 is currently being revised.

L. Steps Towards a Nuclear Power Program in Kenya

Erastus Gatebe, Chairman, Kenya Radiation Protection Board

Kenya is among the African IAEA member states that have made a policy decision to go nuclear. However, a knowledgeable decision is pending but efforts towards this is/are being made.

The Radiation Protection Board was established in 1986 through the Radiation Protection Act, CAP 243 Laws of Kenya.

Kenya Regulatory Capacity:

- Already, Kenya has a trained manpower base of about 50, half of which are experienced but may require regulatory training for nuclear power.
- Therefore, there is a need to strengthen national capacity for planning, developing, managing and regulating an infrastructure for new or expanding nuclear power programs.
- Towards capacity building, Kenya has made arrangements, including MoUs, with local and foreign institutions of higher learning for manpower training in preparation for a nuclear power program.
- Among the institutions are the University of Nairobi, KINS and KINGS in Korea as well as institutions in China.

In its steps toward a nuclear power program, Kenya:

- has completed a Pre-Feasibility Report;
- had the IAEA conduct a Phase I Integrated Nuclear Infrastructure Review (INIR) with a final report in April 2016 finding that Kenya has made significant progress in its preparations to make a knowledgeable decision about introducing nuclear power;
- is undertaking an study of its electricity grid;
- completed a preliminary draft report assessing the various nuclear technology options available in the world against the country conditions;
- is prepared to conduct strategic Environmental Assessments;
- finalized the Nuclear & Radiation Safety Bill (2017) & Nuclear Policy through stakeholders and public workshops; and
- signed MoUs for capacity building and technical support with the Slovak Republic, the People's Republic of China, the Republic of Korea, and the Russian Federation.

M. Progress of the UAE Nuclear Power Program: Regulator's Perspective

Haitham Alsenaani, Senior Operational Safety Specialist, Federal Authority for Nuclear Regulation, UAE

The Nuclear Law established the Federal Authority for Nuclear Regulation (FANR) as an independent legal personality with "full legal competence and financial and administrative independence."

FANR Substantial Accomplishments

- Organizational Formation;
- Publication of 21 Regulations and 13 Regulatory Guides;
- Development of Safety Assessment and Inspection Procedures and Instructions;
- Issuing Construction Licenses for Four Reactors;
- Establishing and Implementing Inspection Oversight of NPP Construction;
- Resident Inspectors Office;
- HQ Team Inspections.

Key Enablers for these Accomplishments:

- Clear Policy Direction and Commitment of National Government;
- Leveraging Experienced International Experts in Staffing;
- Standard Practice in UAE Industrial Sections;
- Long-Term Human Resource Strategy;
- Development of the independent capability within the UAE to operate the reactors
- Established Early Relationship with Country of Origin National Regulator;
- Regulatory Framework Development Strategy;
- Extensive Use of IAEA Standards for Regulations;
- Extensive use of Existing Regulatory Guidance, e.g. USNRC.

Remaining Operational Challenges Going Forward:

- Finishing Operating License Review;
- Inspecting Readiness New Operating Company;
- FANR Processes for oversight of operations.

SESSION 3

Challenges in Regulating Small Modular Reactors (SMRs)

This session included seven presentations summarized below

N. Common Issues in Safety, Licensing and Regulatory Frameworks for SMR Deployment

Stewart Magruder, Senior Nuclear Safety Officer, IAEA

The IAEA SMR Regulators' Forum is comprised of the following member countries: Canada, China, Finland, France, Korea, Russia, Saudi Arabia, the United Kingdom, and the United States.

The objectives of the Forum are to:

- share regulatory experience among forum members preparing to license SMRs and stakeholders;
- identify and discuss common safety issues to recommend, if possible, common approaches for resolution;
- capture good practices and methods; and
- propose changes, if necessary, to national requirements and regulatory practices.

A pilot project with working groups was conducted from 2015 to 2017. The Project resulted in the following findings regarding the regulation of SMRs published in the January 2018 Pilot Project Report:

- Regarding a Graded Approach:
    - Graded approach can enhance regulatory efficiency without compromising safety;
    - Starting point for SMRs should be requirements for Nuclear Power Plants (NPPs);
    - Need to determine what is necessary to demonstrate "proven-ness"; and
    - IAEA should lead development of technical guidance on graded approach for NPPs.
- Regarding Defense in Depth:
    - Defense in depth (DiD) concept should be fundamental for design and safety demonstration of SMRs;
    - SMRs raise questions regarding application of DiD in several areas; and
    - Further guidance to help safety assessment of DiD applied to SMRs is needed.
- Regarding Emergency Planning Zone Size:
    - EPZ is required but may be scalable;
    - Novel features and technology;
    - IAEA safety requirements and methodology for EPZ size are applicable;
    - Same SMR design may result in different EPZ size in different countries:
    - Dose criteria;
    - Policy factors; and
    - Public acceptance.

The Forum will continue with new working groups addressing Licensing issues, Design and Safety Analysis, and Manufacturing, Commissioning and Operation.

O. Readiness for Regulating Small Modular Reactors

Hugh Robertson, Director General, Canadian Nuclear Safety Commission (CNSC)

There is significant interest in potential deployment of SMRs in Canada:

- 10 vendor design review (VDR) applications, and more to come
- Utility, federal and provincial government interest
- Canadian Nuclear Laboratories – Request for Expression of Interest for SMR demonstration project

Many reactor concepts claim to be advanced reactor designs.

NRCan led the development of a pan-Canadian SMR roadmap. A Roadmap is essential to identify potential benefits and to guide important decisions and reduce uncertainty.

Three main applications have been identified: on grid (150-300 MWe), heavy industry (10-50 MWe), and off-grid (< 2.5 MWe).

The Canadian National Laboratory stated long-term strategy is the siting of an SMR on an AECL site by 2026.

A number of CNSC vendor design reviews are currently in progress.

Challenges to regulators arise with SMRs using novel technologies:

- use of technologies common in other industries but novel to reactors;
- coolant (metal, sodium, molten fuel, gas);
- different approaches to defense in depth (passive features, containment provisions);

and novel approaches to deployment:

- operating model (reduced staffing / remote operation);
- transportable reactors;
- security by design;
- fleets of reactors (environmental assessment (EA), licensing, credit for prior reviews); and
- location (remote location, close to industrial application, or closer to population).

The CNSC Discussion Paper DIS-16-04, *Small Modular Reactors: Regulatory Strategy, Approaches and Challenges*, discusses next steps and follow up actions identified in the *What We Heard Report* (published in September 2017).

The CNSC is benchmarking, informing and exchanging with other countries facing similar challenges, in a number of forums:

- IAEA SMR Forum, Working Group on the Regulation of New Reactors (WGRNR), - Multinational Design Evaluation Program (MDEP), Group on the Safety of Advanced Reactors (GSAR), bilateral with USNRC and UKONR
- USDOE bilateral agreements led to molten salt reactor training and sharing of information on gas cooled reactors

P. Licensing the Argentine CAREM Prototype Reactor

Nestor Masriera, President, ARN, Argentina

ARN Regulatory Approach

- Goal setting approach (NON prescriptive)
- Adherence to international guidelines (IAEA Safety Standards)
- A clear view of the integration of the safety assessment, connecting:
    - The "safety demonstration" essentially by a deterministic-functional-analysis
    - A safety classification by an essentially deterministic method (SSG-30). Regulatory – safety – engineering requirements are defined for each Class
    - Requirements on systems coming from Safety Standards
    - Regulatory relevant requirements on components are focused on functional capability / reliability / robustness and are dealt by specific C&S
- C&S are essentially a qualification means, and the adequacy of their use has to be justified by the licensee
- Concept of Licensing Basis, to be kept during life cycle

Licensing The CAREM prototype reactor

- CAREM is a small, advanced, integrated reactor (SMR).
- Comisión Nacional de Energía Atómica (CNEA) is the licensee.
- Licensing of CAREM began as a non-routine practice licensing procedure, and a "Use of site and initiation of constructions authorization" was issued against a "Design Report" (2013).
- From now on, it is foreseen to catch up the "standard" NPP licensing procedure, and a PSAR is due by 2019. Its approval will lead to the Commissioning License.

Q. Licensing for System-Integrated Modular Advanced Reactor (SMART) in Korea

Seunghun Yoo, Senior Researcher, Dept. of Reactor Licensing Project Management, Korea Institute for Nuclear Safety (KINS)

The regulatory authority in Korea is the Nuclear Safety and Security Commission, with technical support organizations KINS and the Korea Institute of Nuclear Nonproliferation and Control (KINAC).

The licensing process includes an initial Standard Design Approval (SDA) step where the items approved in the standard design are exempted from the subsequent licensing review. The SDA provides an accredited reactor safety and environmental statement for construction and reduces uncertainty and risk before CP application.

The NSSC issued the SDA for the initial SMART design in 2012. The new SMART design is currently undergoing a second SDA review process.

In response to the NSSC review after the Fukushima Daiichi accident the following items were implemented in the standard design:

- Adding automatic seismic trip system @ earthquake > 0.18 g
- Strengthening a seismic design for MCR panel
- Providing watertight door & drain pump

- Securing mobile generator & battery
- Preparation of measure to cool-down spent fuel pool
- Providing external safety injection flow path
- Providing passive autocatalytic hydrogen recombiner

Major Design Changes in the new SMART design include:

- Core Power & SG's Heat Transfer Rate Increase (10%)
- Full Passive Safety Systems Residual Heat Removal System
- Safety Injection System
- Containment Pressure Depression System, etc.
- EDG Elimination due to Adaption of Full Passive Safety Systems

Anticipated licensing issues for the new SMART design:

- Conformance of Technical Standards for Passive Systems
- Use and Validation of Unauthorized Safety Analysis Codes
- Application of Single Failure Criteria for Passive Systems
- Uncertainty and Reliability of FOAK Design
- Application of Defense In Depth Concept

R. Licensing of Floating Power Unit "Academician Lomonosov"

Alexey Ferapontov, Deputy Chairman, Rostechnadzor, Russian Federation

Licensing process for the Floating Power Unit (FPU):

- Nuclear installation design (Central Design Bureau "Iceberg") (license issued)
- Design and manufacturing of equipment for nuclear installation. Activities and services in the field of atomic energy use (licenses issued)
- Construction of nuclear installation (Baltic Shipyard) (license issued)
- Operation of nuclear installation (operator – Concern Rosenergoatom) (license expected date: 2018 – early 2019)

Regulations and rules:

- General safety provisions for nuclear power installations of vessels
- Rules of safe operation of nuclear power installations of vessels
- Rules of design and safe operation of equipment and components of water-cooled reactors of floating nuclear plants
- Rules of classification and building of sea vessels
- Rules of classification and building of nuclear vessels and floating structures

S. Preparing for Regulating Advanced Nuclear Technologies (ANTs)

Elspeth McGregor, Associate in New Reactors Division, ONR, United Kingdom

Office for Nuclear Regulation work on Advanced Modular Reactors (AMR) includes:

- providing advice to the UK Department for Business Energy and Industrial Strategy (BEIS) on the conduct of their AMR competition,

- developing the regulatory capability and capacity needed to regulate AMRs, and
- identifying what is needed to ensure that regulators' processes and guidance are fit for the purpose of regulating AMRs.

The ONR is reviewing its assessment guidance and had determined that some areas may require additional guidance, e.g. judging the adequacy of the deployment model (multiple units). Also under consideration is the need to develop an additional Technical Assessment Guide (TAG) for ANTs.

The ONR is also looking at options to develop a more flexible design assessment process (and seeking to improve efficiency), which can accommodate ANT technology and requirements while remaining consistent with previous GDAs to achieves the same objectives.

For Phase I of the BEIS AMR Program involving feasibility studies of AMR designs, the ONR will assess regulatory confidence (safety, security and environment sections of the feasibility reports) and provide input to selections for Phase 2 in which, subject to phase 1 demonstrating clear value for money and government approval, funding will be available for selected projects to undertake development activities.

A key objective for ONR is to strengthen engagement with international regulators. ONR is currently undertaking the following:

- Participation in the SMR Regulators' Forum (under IAEA)
- Participation in the NEA's Working Group on the Safety of Advanced Reactors (WGSAR) – joined recently, and
- Multilateral / bilateral discussion with international regulators.

T. Design Certification of the NuScale Small Modular Reactor

Anna Bradford, Deputy Director, Division of New Reactor Licensing, USNRC

The following SMR applications are under review by the NRC:

- TVA Clinch River Early Site Permit
    - Application docketed in January 2017
- NuScale Design Certification
    - Application docketed in March 2017
    - Issued final DSRS for NuScale in August 2016

Currently the design certification rulemaking is scheduled to be completed by January 2021.

NuScale has requested exemption from fifteen NRC Part 50 regulations. The following significantly challenging technical issues for the NuScale design certification review have been identified by the NRC:

- Integrated Systems Validation testing,
- Control room staffing,
- No Class 1E electrical power,
- Seismic analysis of flange tool,
- Comprehensive vibration assessment program,
- Pipe break location,

- Integrated leak rate testing,
- GDC 27 exemption (aka return to power).

NuScale is working with NRC staff to resolve these issues.

SPEAKER BIOGRAPHIES

Haitham Saleh Abdulla ALSENAANI, Federal Authority for Nuclear Regulation

Haitham is a UAE national working as a Senior Specialist at the Federal Authority for Nuclear Regulation (FANR). He received a B.Sc. degree in Geological and Geophysical engineering from the University of Arizona, Tucson, United States, in 2004, and a M.Sc. Degree in Safety and Risk Management from the Liverpool John Moores University Liverpool, United Kingdom, in 2012.

In 2010, Haitham joined the Federal Authority for Nuclear Regulation (FANR) which was newly established around that time, where he began his career in site assessment in the nuclear safety department.

Once FANR received the Construction License Application (CLA) from ENEC, Haitham became heavily engaged with the review and assessment of the CLA for all four reactor units. He was responsible for the siting assessment of the second submitted construction license. After completing the evaluation of the construction licenses, Haitham achieved a technical specialist level where his attention moved towards reactor safety operations and organizational readiness. Currently, and as a subject matter expert, he is actively engaged in the evaluation of operation license application and operators training process as well as inspection.

Anna H. BRADFORD, US Nuclear Regulatory Commission

Anna H. Bradford is the Deputy Director, Division of New Reactor Licensing, Office of New Reactors at the US Nuclear Regulatory Commission (NRC). Ms. Bradford joined the US NRC in 2000 in the Office of Nuclear Material Safety and Safeguards. Since that time, she has held positions in multiple offices in the Agency, leading efforts in a wide range of areas such as low-level waste management and disposal, environmental reviews, fuel cycle facility licensing, small modular reactor licensing, and non-light water reactor policy issues. Prior to joining the NRC, Ms. Bradford worked at an engineering consulting firm supporting nuclear-related projects for the Department of Energy. Ms. Bradford has a Bachelor's degree in Mechanical Engineering from Virginia Tech, and a Master's degree in Environmental Engineering from Johns Hopkins University.

Alexey FERAPONTOV, Rostechnadzor

Alexey Ferapontov is a Deputy Chairman of Rostechnadzor (Russian regulatory body) in charge of all aspects of nuclear and radiation safety and security regulation in the peaceful use of atomic energy. He joined Rostechnadzor in 2003 as a Deputy Director of FSUE VO "Safety" - Rostechnadzor's TSO. In 2008, he was appointed Deputy Chairman and in 2010, State Secretary – Deputy Chairman of Rostechnadzor responsible for legislative issues related to safety regulation. In 2014 he became a Deputy Chairman of Rostechnadzor for nuclear and radiation safety and security regulation. Mr. Ferapontov graduated from the Moscow Institute of Electronic Machine Building and the Russian State Open Technical University of Railways with a PhD in Engineering.

Erastus GATEBE, Kenya Radiation Protection Board

Erastus Gatebe is an environmental chemist with over 15 years' extensive experience in research and teaching at the university and is a registered Lead Consultant with the national environmental management authority. He is currently the Chairman of the Kenya Radiation Protection Board, the state regulator of nuclear and radiation safety. He also chairs the multi-agency Nuclear Security Guidance Committee (NSGC) as well as the Strategic Trade Control (STC) Working Group drafting the STC Bill. Previously, Professor Gatebe chaired the ad hoc inter-ministerial committee on drafting the Nuclear and Radiation Regulatory Bill. Currently, he is Kenya's representative at IAEA NSGC and is on his second 3-year term. Professor Gatebe is also the Chief Research Scientist at the Kenya Industrial Research and Development Institute where he oversees industrial research and supervises scientists undertaking higher training in the universities. Prior to KIRDI, Prof. Gatebe was Professor of Chemistry at Jomo Kenyatta University of Science and Technology, where he continues to supervise postgraduate students, with responsibility for Masters and PhD programs. Professor Gatebe has also published extensively with over 50 publications in peer-reviewed journals and has supervised over 40 postgraduate students. Professor Gatebe completed his postgraduate studies at Eastern Illinois and Southern Illinois Universities in the United States and holds an undergraduate degree from Kenyatta University in Kenya.

Karine HERVIOU, Institute for Nuclear Safety and Radiological Protection

Karine Herviou has been the Director of systems, new reactors and safety approaches at the Institute for Nuclear Safety and Radiological Protection (IRSN) in France since 2017. After graduating in nuclear engineering in 1991, Karine Herviou joined the IRSN in 1991. After 5 years working on Emergency Operating Procedure safety analysis of pressurized water reactors (PWRs), she then accumulated15 years' experience in the field of emergency preparedness and response. In 2009, she became head of project of the French EPR project in Flamanville and, in 2012, head of the new reactors department in charge of the assessment of Generation III and Generation IV reactor safety. In parallel, in 2011, she coordinated the analysis of post-Fukushima Daiichi stress tests in French nuclear installations..

Donald R. HOFFMAN, Excel Services Corporation

Donald R. Hoffman holds a B.S. degree in Nuclear Engineering. He served in the US Nuclear Submarine Navy as a Senior Reactor Operator and Engineering Officer from 1970 to 1979. He was the Manager in the Nuclear Regulatory Commission's (NRCs) Licensing Branch, and was responsible for the licensing of 26 plants in the US Post Three Mile Island (TMI) from 1980-1985.

Donald founded Excel Services Corporation (EXCEL) in 1985 and in the more than 32 years since the formation of the company, EXCEL has become globally recognized as the premier supplier of licensing, regulatory, engineering, technical, operations and critical infrastructure services.

Selected Posts Include:

- Past President of the American Nuclear Society (ANS)
- Fellow American Nuclear Society (ANS)
- Member of the Secretary of Commerce's Civil Nuclear Trade Advisory Committee

- Vice Chair of the World Nuclear Association Cooperation in Reactor Design, Evaluation and Licensing (CORDEL) Group
- President/CEO of Sensible Energy Matters to America (SEMA)
- Chair, Next Generation Nuclear Plant (NGNP) Alliance

Hoffman is also deeply involved in a number of charitable activities.

Youngdoo KANG, KINS

Youngdoo Kang is the Project Manager of Shin-Hanul 1&2, Division of Reactor Licensing, KINS since December 2016. He has worked for KINS for 18 years where he has been mainly involved in areas of regulation for Digital Instrumentation & Control Systems of NPPs in Korea. He was the member of Multinational Design Evaluation Programme (MDEP) Digital I&C Working Group, and he contributed to several of IAEA task groups such as developing the Agency's Safety Guides.

Diego LISBONA, UK Office for Nuclear Regulation

Dr Diego Lisbona is a Nuclear Safety Inspector at the United Kingdom's Office for Nuclear Regulation. Diego holds a BEng and MEng in Chemical Engineering by the University of Oviedo (Spain) and a PhD, also in Chemical Engineering, from the University of Nottingham (U K). Prior to joining the ONR and for over 10 years, Diego conducted research both in academia and in UK government research laboratories on major hazards risk assessment and process safety. Following roles as Hazard and Operability Analysis (HAZOP) facilitator and safety case author in the UK consultancy sector, Diego joined the ONR in 2016 as Internal Hazards assessor for the Generic Design Assessment of the UK advanced boiling water reactor (ABWR). Diego currently acts as Deputy Delivery Lead for the Advanced Modular Reactor project and as Internal Hazards specialist in the ONR New Reactors Division.

Stewart MAGRUDER, International Atomic Energy Agency (IAEA)

Mr Magruder is a Senior Nuclear Safety Officer with the IAEA. His responsibilities include serving as Scientific Secretary for the Small Modular Reactor Regulators' Forum and assisting countries embarking on nuclear power programs. He joined the IAEA on 1 March 2015 after more than 25 years with the US Nuclear Regulatory Commission in Washington, DC.

Mr Magruder holds a Master of Business Administration degree from Johns Hopkins University and a Bachelor of Science in Mechanical Engineering degree from Cornell University.

Nestor MASRIERA, Nuclear Regulatory Authority

Engineer Nestor Masriera was appointed as President of the Board of Directors of the Nuclear Regulatory Authority – Autoridad Regulatoria Nuclear (ARN) by the President of Argentina on January 5, 2016. In this capacity, he is the Second Alternate Governor for Argentina to the Board of Governors of the International Atomic Energy Agency (IAEA) and a member of the Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials (ABACC).

Mr Masriera has extensive experience in the nuclear sector and specializes in reactors. He worked at INVAP for 22 years and, prior to that, he served in ENACE (Empresa Nuclear Argentina de Centrales Eléctricas - Argentina Nuclear Power Plant Company), currently NA-SA (Nucleoeléctrica Argentina S.A. – Argentine Nucleoelectric Inc.) and CNEA (Comisión Nacional de Energía Atómica - National Atomic Energy Commission). He has also participated as an appointed expert by the IAEA in various international meetings and expert missions.

His last post at INVAP was as Head of the Regulatory Technical Assistance Division of the Nuclear Projects Department. Previously, he participated in various projects of the company, which include the development, testing and commissioning of the source of cold neutrons of the OPAL reactor for the Australian National Science and Technology Organization (ANSTO) and the qualification of innovative features of the CAREM 25 reactor for CNEA. He was also a board member of INVAP between 2007 and 2010.

Between 1997 and 2007, he was a member representing Argentina in the International Nuclear Desalination Advisory Group" (INDAG), which reports to the Director General of IAEA.

Nestor Masriera holds a Nuclear Engineering degree from the Balseiro Institute where he also taught. Between 1996 and 1998, he was assistant professor of Fluid Mechanics at the School of Nuclear Engineering and between 2010 and 2011 he was a professor of the Thermal Fluid course in an introductory course for Masters in Nuclear Engineering from Saudi Arabia.

Elspeth MCGREGOR, UK Office for Nuclear Regulation

Elspeth McGregor is an Associate in the Office for Nuclear Regulation's New Reactors Division, and is part of a team of specialists working on the Advanced Nuclear Technologies project.

Elspeth has a background in chemistry, holding an MSc in chemistry from the University of Birmingham, UK. She began her career in the nuclear industry in the Office for Nuclear Regulation's graduate development scheme and then completed several industry secondments, gaining experience in the areas of reactor chemistry and radioactive waste management.

Elspeth currently works within the Office for Nuclear Regulation's Chemistry and Nuclear Liabilities specialisms, providing specialist support to several regulatory Divisions. She is part of a team working on the New Reactors Division's Advanced Nuclear Technologies project, specifically focussing on preparations for the regulation of Advanced Modular Reactors.

Ho NIEH, Nuclear Energy Agency

Mr Ho Nieh was appointed as the NEA Head of the Division of Nuclear Safety Regulation and Technology in August 2015. Mr Nieh has 24 years of experience in nuclear power plant safety regulation and policy. He began his career in operation, maintenance and training at a United States Navy nuclear power plant. Mr Nieh joined the United States Nuclear Regulatory Commission (NRC) in 1997 as a resident inspector and conducted safety inspections at pressurized water and boiling water reactors. His extensive management experience has included responsibilities for emergency response; licensing and rulemaking; research and test reactor oversight; safety/security interface; operating experience; financial qualification and decommissioning funding; control room operator licensing; and the NRC's Reactor Oversight Process. Mr Nieh also served as the Chief of Staff for an NRC Commissioner. Prior to joining the NEA, Mr Nieh was the Director of the

Division of Reactor Projects in the NRC Region 1 office where he was responsible for the resident inspectors assigned to nuclear power plants in the north-eastern United States. Mr Nieh, a United States national, holds a Bachelor's degree in Marine Engineering from the New York Maritime College. Mr Nieh is a graduate of the United States Naval Nuclear Power School and attended Rensselaer Polytechnic Institute for graduate studies in nuclear engineering. Mr Nieh also holds a Masters of Business Administration from the Johns Hopkins University.

Hugh ROBERTSON, Canadian Safety Nuclear Commission

Mr. Robertson is the Director General of the Directorate of Regulatory Improvement and Major Projects Management. In this position, he leads a dynamic team that supports the Canadian Safety Nuclear Commission's (CNSC) mission and mandate by managing the licensing of new nuclear reactors, implementing and maintaining the CNSC Management System, managing the operations planning and performance process, as well as coordinating cross cutting corporate improvement initiatives under the Harmonized Plan.

Prior to joining the Canadian Nuclear Safety Commission in 2005, Mr. Robertson worked at the Department of National Defence in various Information Technology management positions.

In 2014-2015 Mr. Robertson accepted an assignment with the Chief Information Officer for the Government of New Zealand, as Manager of Information and Communication Technology (ICT) Operations Assurance. In this role he was responsible for implementing and monitoring a standard ICT assurance program across all major government departments.

Denis ROGATOV, Rostechnadzor

Mr. Denis Rogatov graduated from the Bauman Moscow State Technical University as a Mechanical engineer. He then worked as an Engineer at JSC "Atomenergoproekt" (Moscow). In 2014, he joined the Scientific and Engineering Centre for Nuclear and Radiation Safety (Technical support organization of the Russian Regulatory body Rostechnadzor). There he works as Lead engineer in the NPP Safety Division. One of his professional responsibilities is the safety review of VVER-type NPPs.

Shi WEI, Shanghai Nuclear Research and Design Institute Co. Ltd

Shi Wei, Assistant Chief Engineer of Shanghai Nuclear Research and Design Institute Co. Ltd, has 20 years' experience in nuclear power design. He is responsible for the process system design of nuclear power plants, and has participated in several nuclear power plants' design. In the past 10 years, Mr. Shi acted as process system supervisor of design sub-contractor of Sanmen & Haiyang AP1000 design. In 2013 and 2014, Mr. Shi was the site manager of SNERDI in the Sanmen NPP site. He was the director of the process system in CAP1400 design.

Tianmin XIN, Hualong Pressurized Water Reactor Technology Corporation. Ltd.

Tianmin XIN is the Vice President of Hualong Pressurized Water Reactor Technology Corporation. Ltd.

Tianmin XIN graduated from Zhejiang University of east China. He has more than 30 years' experience on design and engineering work in nuclear field. As the leader of the team, he was in charge of the process and safety design for the first China two loop reactors Qinshan Phase two power plant in the 1990s. In the 2000s, he participated in different domestic nuclear power plant projects of three loop reactors, and was responsible for the design, engineering and technical management of nuclear inland. In the meantime, leading a technical support organization of the China nuclear safety administration, Mr Xin is overseeing the technical safety assessments of China CANDU reactors and China Experimental Fast Reactor.

In the year 2007, as the design chief engineer of CNNC Hualong One project, Mr Xin focused on the research and development of Hualong One. Hualong One is a generation three plus nuclear power plant developed by China National Nuclear Corporation (CNNC) and China General Nuclear Power Group (CGN). New safety philosophy and safety measures were implemented in the reactor including the combinations of active safety systems plus passive safety systems, etc. These combinations of different safety systems could efficiently prevent or mitigate beyond design base accidents or severe accidents.

Based on his research and engineering work, more than 30 reports or articles were published. Mr Xin received prizes awarded by the Chinese Technical Society as well as the title of Design Master awarded by the China Nuclear Industry Investigation & Design Association in 2015.

Seung Hun YOO, Korea Institute of Nuclear Safety

Seung Hun Yoo is the senior regulator at the Department of Reactor Licensing Project Management of the Korea Institute of Nuclear Safety (KINS) since February 2018. He has worked for KINS since 2010 and has been mainly involved in the area of regulation for accident analysis, especially loss of coolant accidents. He is involved in the Design and Safety Analysis Working Group of the Small Modular Reactor (SMR) Regulator's Forum at the IAEA.

www.ifnec.org

Printed by the OECD Nuclear Energy Agency for the International Framework for Nuclear Energy Cooperation