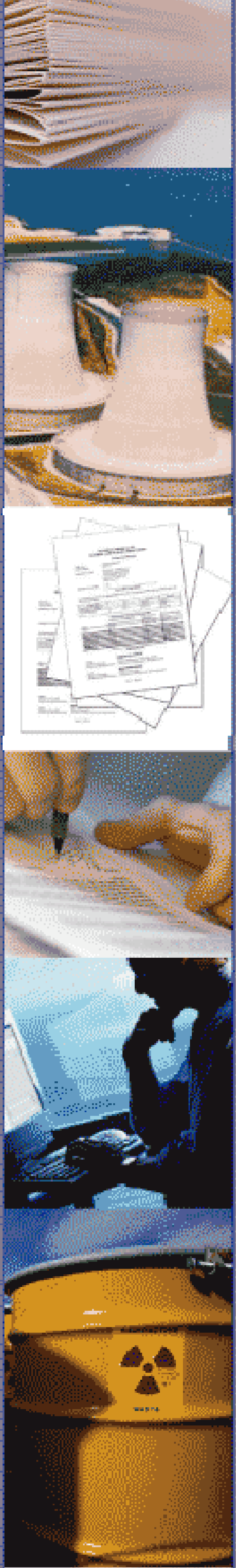


International Meeting of Nuclear Regulatory Advisory Committees - March 2023

Contributing Advisory Committees, Regulator (Country):

Advisory Committee on Nuclear Safety, Radiation and Nuclear Safety Authority (Finland)
Groupe Permanent d'Experts, Autorité de sûreté nucléaire (France)
Nuclear Fuel Safety Examination Committee and Reactor Safety Examination Committee, Nuclear Regulation Authority (Japan)
Chief Nuclear Inspector's Independent Advisory Panel, Expert Panel on Natural Hazards, and Advisory Groups on Graphite Office of Nuclear Regulation (U.K.)
Advisory Committee on Reactor Safeguards, U.S. Nuclear Regulatory Commission (U.S.)

June 2023

International Meeting of Nuclear Regulatory Advisory Committees - March 2023

Contributor Organizations, Regulator:

- **Advisory Committee on Nuclear Safety to the Radiation and Nuclear Safety Authority (Finland)**
- **Groupe Permanent d'Experts, Autorité de sûreté nucléaire (France)**
- **Nuclear Fuel Safety Examination Committee and Reactor Safety Examination Committee, Nuclear Regulation Authority (Japan)**
- **Chief Nuclear Inspector's Independent Advisory Panel, Expert Panel on Natural Hazards, and Advisory Groups on Graphite Office of Nuclear Regulation (U.K.)**
- **Advisory Committee on Reactor Safeguards, U.S. Nuclear Regulatory Commission (U.S.)**

June 2023

ABSTRACT

In March 2023, representatives from advisory committees to nuclear reactor regulators completed an international interaction to gain a working understanding of advisory committee roles and organizations as well as to discuss common technical safety issues of interest and effective solutions to address these challenges. Representatives from advisory committees providing support to regulators in Finland, France, Japan, the United Kingdom, and the United States participated in meetings supporting associated with this interaction. This document summarizes the objectives and approach for, as well as the findings and insights gained from, this international interaction. Presentations from these meetings are also included.

ACKNOWLEDGEMENTS

Successful conduct of this international interaction and preparation of this report required contributions from several individuals and organizations. The effort to resume this international collaboration of nuclear regulatory advisory committees would not have been possible without the active contributions of the following individuals: Lasse Reiman and Juhani Hyvärinen (ACNS); Karin Rantamäki (STUK); Thierry Charles, Bertrand de L'Epinois, and Hervé Mbonjo (GPR); Naoto Sekimura (RSEC); Akio Yamamoto (NFSEC); Shinji Kinjo and Tomoya Ichimura (NRA); Paul Garesse, Aidan Parkes, and Tim Parkes (ONR); Ron Ballinger, Vicki Bier, Dave Petti, Joy Rempe (ACRS); and Alesha Bellinger, Thomas Daschiell, Kent Howard, Scott Moore, Hossein Nourbakhsh, Quynh Nguyen, Tammy Skov, Andrea Torres, and Sandra Walker (NRC). Their efforts are greatly appreciated.

CONTENTS

FIGURES

TABLES

ACRONYMS

ACRS	Advisory Committee on Reactor Safeguards (U.S.)[a]
ACNS	Advisory Committee on Nuclear Safety (Finland)
AEA	Atomic Energy Act (U.S.)
AESJ	Atomic Energy Society of Japan (Japan)
AMP	Accident Management Program
AMTE	Aging Management Technical Evaluation
ASN	Autorité de Sûreté Nucléaire (France)
BWR	Boiling Water Reactor
CCF	Common Cause Failure
CNI	Chief Nuclear Inspector (U.K.)
CNI's IAP	CNI's Independent Advisory Panel (U.K.)
COI	Conflict-of-Interest
EPR	European Pressurized Reactor
EPZ	Emergency Planning Zone
EU	European Union
FACA	Federal Advisory Committee Act (U.S.)
FFRD	Fuel Fragmentation, Relocation and Dispersion
FOAK	First-of-a-Kind
GD	Government Decree (Finland)
GOJ	Government of Japan

[a] In cases where an acronym is country-specific, the country is identified in parentheses.

GPD	Groupe permanent d’experts pour les déchets (France)
GPDEM	Groupe permanent d’experts pour le démantèlement (France)
GPE	Groupes permanents d’experts (France)
GPESPN	Groupe permanent d'experts pour les équipements sous pression Nucléaires (France)
GPR	Groupe permanent d’experts pour les réacteurs (France)
GPRP	Groupe permanent d’experts en Radioprotection (France)
GPT	Groupe permanent d’experts pour les transports (France)
GPU	Groupe permanent d'experts pour les laboratoires et usines (France)
GX	Green Transformation (Japan)
HEAF	High Energy Arcing Fault
IAEA	International Atomic Energy Agency
IAP	Independent Advisory Panel (U.K.)
I&C	Instrumentation and Control
INES	International Nuclear Event Scale
INRA	International Nuclear Regulators Association
IRRS	Integrated Regulatory Review Service (by IAEA)
IRSN	Institut de radioprotection et de sûreté nucléaire
LOCA	Loss of Coolant Accidents
LWR	Light Water Reactor
MEAE	Ministry of Economic Affairs and Employment
METI	Ministry of Economy, Trade and Industry (Japan)
NFSEC	Nuclear Fuel Safety Examination Committee (Japan)
NPP	Nuclear Power Plant

NPS	Nuclear Power Station
NRA	Nuclear Regulation Authority (Japan)
NRC	Nuclear Regulatory Commission (U.S.)
NSC	Nuclear Safety Commission (Japan)
OECD	Organization of Economic Cooperation and Development
OECD/NEA	OECD Nuclear Energy Agency
OL	Operating License
ONR	Office for Nuclear Regulation (U.K.)
PRA	Probabilistic Risk Assessment
PSA	Probabilistic Safety Assessment
PSACI	Periodic Safety Assessment of Continuous Improvement
PSR	Periodic Safety Review (Finland)
PWR	Pressurized Water Reactor
ROP	Reactor Oversight Process
RSEC	Reactor Safety Examination Committee (Japan)
RPV	Reactor Pressure Vessel
SLR	Subsequent License Renewal (U.S.)
SMR	Small Modular Reactor
SFP	Spent Fuel Pool
SSC	Structures, Systems, and Component
STUK	Radiation and Nuclear Safety Authority (Finland)
TSO	Technical Support Organization
U.K. or UK	United Kingdom
U.S. or US	United States

VD	Vvisite Décennale (Ten Year Outage, France)
WENRA	Western European Nuclear Regulators Association
YVL	Regulatory Guides on Nuclear Safety (Finland)

International Meeting of Nuclear Regulatory Advisory Committees - March 2023

1. INTRODUCTION

Recently, there has been significant international interest in nuclear power as a carbon-free source of electricity. However, there are challenges associated with proposed new designs and with continued operation of the current fleet. New reactor designs are being proposed for which there is little, if any, operating experience to support their safety case. In addition, aging issues are emerging with the operating fleet of reactors. Furthermore, new technologies and fuel types, with little nuclear operational experience, are proposed that may benefit current and new reactor operation. Regulation of the current fleet and licensing of new fuels, technologies, and designs are required to ensure the safety of the current operating fleet and the safety benefits of these advanced options.

Although nuclear reactor regulation is a national responsibility, several opportunities for international collaboration exist to facilitate communication between regulatory agencies, such as the International Nuclear Regulators Association (INRA), Western European Nuclear Regulators Association (WENRA), and other activities sponsored by the Organization of Economic Cooperation and Development (OECD) and the International Atomic Energy Agency (IAEA).[1, 2, 3, 4] No such opportunity exists, however, for advisory committees for nuclear safety to regulatory agencies. Nevertheless, the importance of having independent technical advice, by a standing panel of experts, is internationally recognized as a key component of a strong nuclear regulatory subsubsystem (see Figure 1).[5] Representatives of advisory committees to regulatory agencies in several countries [e.g., Finland, France, Japan, the United Kingdom (U.K.) and the United States (U.S.)] agreed that an international interaction by regulatory advisory committees would be beneficial and held a meeting in March 2023.

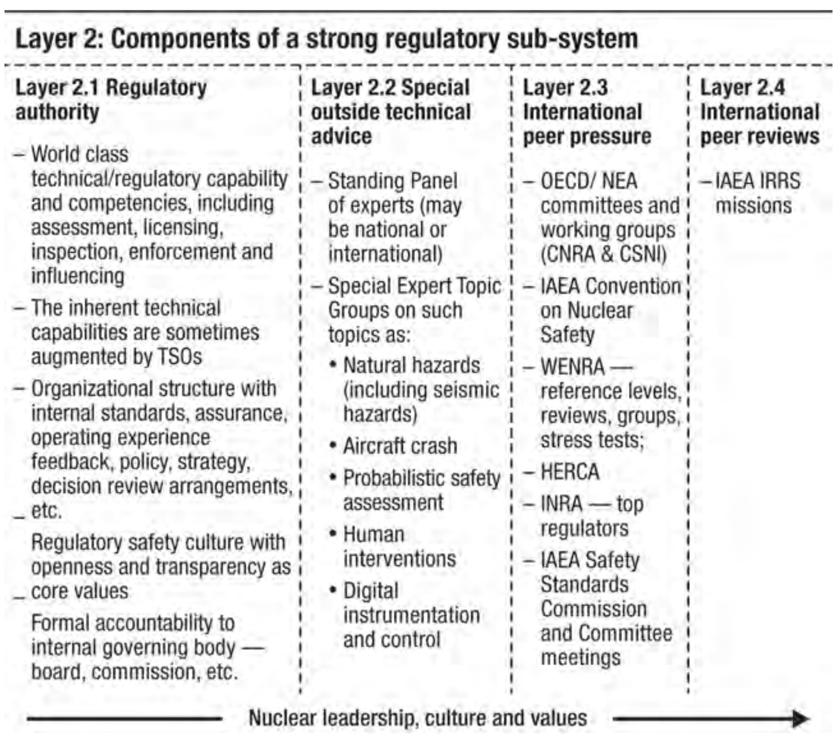


Figure 1. Components of a strong regulatory sub-system (Image courtesy of IAEA [5])

1.1 Objectives

Advisory committee representatives collectively agreed this interaction should focus on the following objectives:

- Gain a working understanding of differences in advisory committee roles and organizations
- Share experience on common issues of interest and discuss effective advisory committee solutions to address these issues (recognizing nuclear reactor regulation is a national responsibility)
- Increase advisory committee effectiveness by:
  - Gaining knowledge about emerging issues and new technologies of interest
  - Identifying, contributing to, and gaining from international regulatory advisory group 'best practices' and 'safety perspectives'
  - Sharing knowledge about activities to strengthen advisory committee roles

With respect to the first objective, there are significant differences in the roles and structures of advisory committees. Participants recognized that understanding these differences is important. The second objective pertains to gaining insights from each other's experience and solutions. Although nuclear reactor regulation is a national responsibility, regulatory advisory committees are facing similar challenges. With respect to the third item, representatives agreed it was important to increase committee effectiveness. Shared knowledge about "best practices", "safety perspectives", and activities to strengthen advisory committee roles were identified as mechanisms to increase advisory committee effectiveness.

1.2 Approach

In this interaction, representatives from the five regulatory advisory committees listed in Table 1 participated. To better accomplish the objectives for this interaction, participants held a December 5, 2022, planning meeting to become acquainted with organizational differences and select the topics for discussion at the main hybrid meeting (March 14 and 15, 2023). Agendas and a list of participants for each of these meetings are found in Appendix A.

Table 1. Organizations represented in international meeting of regulatory advisory committees

Country	Regulatory Agency	Participating Advisory Committee
Finland	Radiation and Nuclear Safety Authority (STUK)	Advisory Committee on Nuclear Safety (ACNS)
France	Autorité de Sûreté Nucléaire (ASN)	Groupes permanents d'experts (GPE) • **Groupe permanent d'experts pour les réacteurs (GPR)**[b] • Groupe permanent d'experts pour les laboratoires et usines (GPU) • Groupe permanent d'experts pour les déchets (GPD) • Groupe permanent d'experts pour le démantèlement (GPDEM) • **Groupe permanent d'experts pour les équipements sous pression Nucléaires (GPESPN)**[b] • Groupe permanent d'experts pour les transports (GPT) • Groupe permanent d'experts en Radioprotection (GPRP)

[b] GPE committees participating in this international reactor safety interaction.

Country	Regulatory Agency	Participating Advisory Committee
Japan	Nuclear Regulation Authority (NRA)	• Nuclear Fuel Safety Examination Committee (NFSEC) • Reactor Safety Examination Committee (RSEC)
United Kingdom	Office for Nuclear Regulation (ONR)	• Chief Nuclear Inspector's (CNI) Independent Advisory Panel (IAP) • Expert Panel on Natural Hazards • Advisory Groups on Graphite
United States	Nuclear Regulatory Commission (NRC)	Advisory Committee on Reactor Safeguards (ACRS)

1.3 Report Organization

This report summarizes outcomes from this international interaction. The balance of this report is organized as follows. Section 2 summarizes preliminary introductory meeting discussion topics. Sections 3 and 4 summarize insights from the two selected discussion topics. Section 5 of this report summarizes insights and recommendations from this effort. References are listed in Section 6. Appendices to this document provide more detailed information. Specifically, Appendix A provides lists of attendees and agendas from the planning and main meeting. Appendices B through D contain meeting presentations.

2. PLANNING MEETING

In preparatory interactions, participants concluded it would be beneficial to hold a December 2022 planning meeting prior to the March 2023 meeting. This planning meeting allowed paricipants to become aware of differences among advisory committee structures, authority, membership, and organizations. In addition, this real-time virtual interaction allowed participants to better understand the objectives for this international activity and facilitated selection of topics for the March 2023 meeting. Appendix A includes an agenda for and a list of participants in this planning meeting. Appendix B includes slides presented during this planning meeting.

2.1 Advisory Committee Overviews

In the December 2022 planning meeting, representatives from each advisory committee provided presentations describing their committee structure, authority, and organization. In these presentations, many participants also proposed topics for the March 2023 meeting.

2.1.1 Finland

Dr. Lasse Reiman, ACSN Chairman, provided an overview of their committee structure, organization, and on-going activities. The ACSN is an independent body nominated by the Government of Finland. It was established in connection with the renewal of the Nuclear Energy Act in 1987.[6] ACSN tasks, composition,and meeting practices are defined by the Government Decree (GD) 1015/2016, 24 November 2016.[7] ACSN has seven members and a part-time secretary from STUK. According to GD 1015/2016, the Director General of STUK is a permanent expert on ACSN. Other permanent experts can be nominated for a specific term of the Committee. ACSN activities are supported by two international subcommittees (reactor safety, nuclear waste safety), with five foreign members on each subcommittee. International participation provides a means to gather information from regulatory approachs on selected safety issues in other countries. The chair of a subcommittee must be a member of ACSN. The subcommittees discuss and give recommendations to STUK concerning important topical safety issues, and the main committee reviews (and typically confirms) their recommendations.

Per GD 1015/2016,[7] ACSN main tasks are:

- To give statements on license applications concerning construction and operation of a nuclear facility and on other important applications concerning the use of nuclear power,
- To give statements on regulations and guides concerning safe use of nuclear power,
- To give statements on important issues related to regulatory oversight of the safe use of nuclear power,
- To follow development of nuclear safety and related research,
- To promote national co-operation and follow international co-operation concerning safe use of nuclear power, and
- To make initiatives to competent authorities for necessary actions concerning the safe use of nuclear power.

In reviewing license applications, ACSN follows their rules and procedures [8] to assess the application and the scope and depth of STUK's review. ACSN reviews include applicant/licensee and STUK presentations and related facility visits. Meeting memorandum issued by ACSN are public. For each ACSN term, an Action Plan is developed based on tasks defined in GD 1015/2016.[7] In addition to review of license applications and review of regulations and regulatory guides, Action Plan activities include, for example, the following:

- Important operating experiences and events at Finnish nuclear facilities,
- Implementation of STUK's strategy,
- Development of on-site emergency preparedness arrangements, and
- Experiences from safeguards oversight.

Currently, ACSN is reviewing two license applications:

- Renewal of the Operating License (OL) of the Loviisa Nuclear Power Plant (NPP) until 2050. The existing operating licenses expire in 2027 (Loviisa 1) and 2030 (Loviisa 2). At these times, the units will have operated for 50 years.
- Operating License of the final disposal facility and encapsulation plant for spent fuel (ONKALO facility).

In recent years, other topics reviewed by ACSN include: Olkiluoto 3 OL application; periodic safety review (PSR), including the plan for final disposal of low and medium level waste, for the Loviisa nuclear power plant (NPP); revisions to STUK regulations and regulatory guides; approval of standard equipment for safety related applications (KELPO project); modernization of Instrumentation and Control (I&C) systems at operating NPPs; and major events at operating NPPs. In addition, ACSN made an initiative related to identifying preparations needed by the government and STUK for the possible use of small modular reactors (SMRs). This effort led to several statements regarding possible licensing process revisions and needed research resources.

In his presentation, Dr. Reiman also discussed ACSN challenges, such as the amount of required work, cognizance of recent nuclear safety developments, and maintaining independence.

For the March 2023 meeting topics, ACSN members suggested the following three topics:

- Approval practices and processes (for example plant and systems design maturity in the construction license phase, qualification practices for equipment approvals including approval of standard 'commercial grade' products)
- Near-future nuclear technologies and their regulatory challenges
- Regulatory oversight of organizational issues

During the discussion after this presentation, participants inquired about the contents of, and the actions being taken to address, the statements given by ACSN during 2021. In his response, Dr. Reiman indicated that most statements pertain to changes concerning Finnish regulatory guides (YVL Guides) and legislation related to nuclear safety, related to emergency planning, and security-related licensing requirements. He observed that there is concern that there may be several applications for new reactors (including SMRs) to review simultaneously, which would be a challenge to Committee resources.

2.1.2 France

Dr. Thierry Charles, GPR Chairman, provided an overview of the technical expertise provided to ASN, which includes input from the Institut de radioprotection et de sûreté nucléaire (IRSN), the French technical support organization, and input from several expert advisory committees (Groupes permanents d'experts or GPE). Upon ASN request (and prior to ASN decisions),[9] IRSN and GPE advisory committees issue opinions on important safety or radioprotection issues (e.g., new regulations; plant development, commissioning, and decommissioning; and incidents). The seven ASN advisory committees are identified in Table 2 with their main review topic and typical areas of member expertise. Consistent with their procedures and bylaws [9], each advisory committee has a chair and vice-chair with approximately 30 to 35 members. GPE opinions are formulated by the committee members after plenary and information meetings. As appropriate, several advisory groups work together on a specific issue. For example, the GPR and GPESPN jointly address common reactor issues, such as the current stress corrosion cracking issue affecting several French reactors. By developing informed and independent opinions, GPEs contribute to the development of and act as guarantors of the nuclear safety and radiation protection doctrine.

Table 2. GPE advisory committees and areas of expertise

<table>
<tr><th>Committee</th><th>Topic</th><th>Member Areas of Expertise</th></tr>
<tr><td>Groupe permanent d'experts pour les réacteurs (GPR)</td><td>Nuclear Reactors</td><td rowspan="4">• Design and operation of plants (e.g., PWR for GPR)
• Technical fields (e.g, neutronics, thermohydraulic)
• General risks (e.g., fire, high energy arcing fault or HEAF)</td></tr>
<tr><td>Groupe permanent d'experts pour les laboratoires et usines (GPU)</td><td>Laboratories and Plants</td></tr>
<tr><td>Groupe permanent d’experts pour les déchets (GPD)</td><td>Waste</td></tr>
<tr><td>Groupe permanent d’experts pour le démantèlement (GPDEM)</td><td>Decommissioning</td></tr>
<tr><td>Groupe permanent d'experts pour les équipements sous pression Nucléaires (GPESPN)</td><td>Nuclear Pressure Equipment</td><td>Nuclear pressure equipment (e.g., materials, mechanics, corrosion, welding, non-destructive control)</td></tr>
<tr><td>Groupe permanent d’experts pour les transports (GPT)</td><td>Transport</td><td>Radioactive transport and associated risks, in particular representatives from the French committee for certification of companies in training and monitoring of personnel working with ionizing radiations.</td></tr>
<tr><td>Groupe permanent d’experts en Radioprotection (GPRP)</td><td>Radiation Protection</td><td>Radiation protection of workers, the public and patients and for medical, industrial and research applications of ionizing radiations, including natural ionizing radiations</td></tr>
</table>

With respect to the operating fleet, GPE is reviewing the following topics:

- Long term operation and periodic safety reviews
  - Aging management
  - Safety reassessment: accident analyses, internal and external hazards, severe accidents, probabilistic safety assessment, modifications to improve safety
- Lessons learnt from operation
- Lessons learnt from Fukushima Daiichi

Dr. Charles highlighted several challenges associated with the operating fleet, such as continued plant conformance with safety requirements, human and organizational factors, aging management (including the reactor pressure vessel), safety improvements associated with lifetime extension, severe accident mitigation, and the impact of climate change (e.g., changes in flooding risk).

With respect to new reactors, GPE is reviewing the following topics:

- European Pressurized Reactor (EPR) Flamanville 3: including more than 20 meetings of GPR and GPESPN about the safety case and deviations
- EPR2: general safety options, design, and safety case

Dr. Charles highlighted several challenges associated with licensing of new reactors, such as control of quality and reliability of industrial equipment, project management and safety requirement integration, implementation of the break preclusion (i.e., ‘break exclusion’) approach, consideration of defense in depth, consideration of passive systems, and definition of SMR general safety objectives. For the March 2023 meeting topics, GPE members suggested the following topics:

- Operating fleet: Lessons learnt from NPP operation and long-term NPP operation
- New challenges: General safety objectives for new reactors

The GPE presentation also included two slides regarding the format of the March 2023 meeting; these slides were discussed by Dr. Charles during the closing meeting discussion (see Section 2.2).

During the discussion after this presentation, participants inquired about the process used to obtain the GPE advisory committee members and the ability to arrive at consensus opinions with the many (30-35) members in each advisory committee. In his response, Dr. Charles indicated that many members stay on their advisory committee for multiple terms, which helps reduce the number of new members from public calls (ASN has procedures in place for reviewing applications and selecting new members). Although the final committee opinion may note differences in member views on some topics, Dr. Charles observed there are consensus views on most topics discussed in advisory committee opinions.

2.1.3 Japan

Dr. Naoto Sekimura, Chairman of RSEC and Dr. Akio Yamamoto, Chairman of NFSEC, provided an overview of the two advisory committees that provide technical advice to NRA for regulatory decision-making. These two advisory committees, RSEC and NFSEC, were established in NRA, the regulatory body established by the Government of Japan after TEPCO's Fukushima Daiichi NPS accident, in the 2012 Act for Establishment of Nuclear Regulation Authority.[10] Advisory committees with the same names, i.e. RSEC and NFSEC, existed in the previous regulatory systems in Japan, which were established in 1961 and 1976, respectively, under the Nuclear Safety Commission (NSC). The NSC was responsible for double-checking of applications examined by the regulatory authority; and RSEC and NFSEC in NSC carried out the responsibility. The Japanese Diet required RSEC and NFSEC in NRA to play a different role from the committees in NSC.[11] The roles of the RSEC and NFSEC in NRA are to provide objective advice on the decisions of NRA (without substituting NRA's own decision-making) and to investigate and deliberate on matters requested by NRA. RSEC and NFSEC meetings and meeting materials are available to the public, consistent with published guidance. [12,13]

RSEC, which may have up to 30 members, reviews topics associated with reactor safety, and NFSEC, which may have up to 20 members, reviews topics related to nuclear fuel safety. Both RSEC and NFSEC review hazards associated with volcanoes, earthquakes, and tsunami. Several members serve on both RSEC and NFSEC. For some topics, joint reviews are conducted.

Currently, NRA has requested RSEC and NFSEC provide input on the following:

- To conduct investigations and deliberations on the necessity of responses based on the collection and analysis of information on accidents and troubles that have occurred in Japan and overseas (as well as on trends in regulations overseas) and to provide advice;
- To evaluate and advise on the status of NRA responses to conclusions (including conclusions related to transportation) of the Integrated Regulatory Review Service (IRRS) of the IAEA follow-up mission conducted in January 2020 [14];
- To conduct investigations and deliberations on the implementation status of the new nuclear regulatory inspection system [i.e., a Reactor Oversight Process (ROP)-type inspection] enforced in April 2020 by regulatory bodies and operators and to provide advice;
- With regard to the evaluation for improving the safety of reactor facilities for power generation conducted by the establishers of reactors for power generation under Article 43-3-29 of the Reactor Regulation Act [15], to advise how the system should be organized and how its operation should be improved, at first, to report on the improvement of the operation of the system based on the framework of the current system;

- To conduct investigations and deliberations on the NRA's evaluation of the volcano monitoring results of nuclear power generation operators and provide advice [only RSEC subcommittees on volcanic hazards and earthquake hazards];
- To conduct investigations and deliberations on the NRA's evaluation of the volcano monitoring results of nuclear fuel facility operators and provide advice [only NFSEC subcommittees on volcanic hazards and earthquake hazards];
- To conduct investigations and deliberations on the necessity of regulatory responses and provide advice, based on the results of collection and analysis of information related to earthquakes, tsunamis, and other events, such as disasters that have occurred in Japan and overseas, and knowledge announced by administrative agencies, etc. [both RSEC and NFSEC subcommittees on volcanic hazards and earthquake hazards]; and
- To conduct investigations and deliberations on the necessity of regulatory responses and provide advice, based on the results of collection and analysis of information related to volcanic events, such as disasters that have occurred in Japan and overseas, and findings announced by administrative agencies, etc. [both RSEC and NFSEC subcommittees on volcanic hazards and earthquake hazards].

In recent years, RSEC and NFSEC have reported to NRA on significant topics, such as the following:

- Collection and analysis of international nuclear reactor accidents, issues, and regulatory changes;
- Implementation status of the new nuclear regulatory inspection system established in April 2020;
- Progress in collecting information from operators about safety improvements in Japanese power reactor installations; and
- Comparative evaluation between the new NRA safety goal and safety achieved by compliance with new Japanese regulatory standards.

With respect to the latter topic, the RSEC report provided several recommendations, such as the importance of continuous safety improvements in the new NRA safety goal (in order to preclude future severe accidents), the need for NRA to refer to the safety goals when formulating regulatory standards, to note that safety goals and safety levels cannot and should not be directly compared using probabilistic assessments, and to explain these points to the public. Because NRA had not authorized RSEC and NFSEC participation in the March 2023 meeting at the time that the December 5, 2022, meeting was held, no discussion topic suggestions were offered.

During the discussion after this presentation, participants expressed interest in NRA's new safety goal and the use of the response from RSEC and NFSEC in the regulation. In his response, Dr. Sekimura indicated that the process of NRA's consideration was on-going. Although the report is in Japanese, he agreed to provide a copy to meeting participants.

2.1.4 United Kingdom

Mr. Paul Garesse, ONR Principal Inspector, ONR, Dr. Lee Easterbrook, ONR Principal Inspector, and Dr. Aidan Parkes, ONR Inspector, provided an overview of several expert panels that provide input to the ONR.[16] They described three ONR expert panels: the Expert Panel on Natural Hazards (established in 2010), which addresses seimic, meteorologic, coastal flooding (including tsunami), aircraft crash hazards and climate change impacts; the ONR Advisory Groups on Graphite, which address graphite topics associated with Magnox and AGR graphite topics such as aging; and the Chief Nuclear Inspector's (CNI's) Independent Advisory Panel (IAP), which provides advice on nuclear related matters including regulator strategy, policy, and new technology developments. Chaired by the ONR CNI, the panel membership is comprised of experts from industry, academia, non-government organizations, and other government departments. Thus, the IAP is designed to provide the ONR access to independent external advice on a diverse range of nuclear matters.

Currently, the IAP provides advice and perspectives on the following topics:

- Development of regulatory priorities and strategies (consideration of ethics in regulatory decision-making)
- Developments in nuclear technologies and their potential implications for nuclear regulation (e.g., regulating innovation, improved regulatory efficiency
- Research needs (e.g., impact of climate change, cyber security, regulatory strategy)
- Engagement with external centers

It was emphasized that expert panel contributions are their advice and not considered ONR views.

During the discussion after this presentation, participants inquired about the timing when the expert panel on external hazards was formed (noting it was prior to the March 2011 Fukushima events). ONR representatives indicated this panel was formed after a PSR of reactors at the Hinkley site. However, it was acknowledged that the significance and scope of this panel increased considerably after the 2011 Fukusima events.

2.1.5 United States

Dr. Joy Rempe, ACRS Chairman, provided an overview of the ACRS structure, organization, and on-going activities. The ACRS is the NRC's only statutory committee established by the 1957 amendment to the Atomic Energy Act (AEA) of 1954.[17] The AEA authorizes up to 15 ACRS members, which are appointed by the NRC Commissioners for a term of 4 years and may be reappointed to additional terms. ACRS members come from industry, academia, and national laboratories with diverse backgrounds in various disciplines (e.g., risk assessment, reactor safety, thermal hydraulics, fuels, materials, plant operations, and digital I&C).

The ACRS is independent of the NRC staff. ACRS issues publicly available letter reports[18] that provide the Commission with its independent technical reviews of, and advice on the NRC safety research program and NRC staff evaluations of the safety of proposed or existing reactor facilities and assessments of proposed safety standards. ACRS also provides briefings to the NRC Commissioners on topics of interest. It is required (by the AEA or Commission direction) that ACRS participate in the reviews of several topics, such as submittals for new reactor licenses, subsequent license renewals, and the NRC's research program. In addition, ACRS may initiate reviews on safety topics of interest. ACRS conducts monthly full committee and subcommittee meetings according to requirements of the Federal Advisory Committee Act (FACA) and processes outlined in ACRS Bylaws.[19,20] In addition, ACRS periodically visits NRC regional offices and licensee facilities of interest (operating plant sites, construction sites, and fuel fabrication facilities).

With respect to the operating fleet, ACRS is reviewing staff reviews or guidance on the following topics:

- Subsequent License Renewal (SLR) applications (that allow plant operation up to 80 years)
- New analytical methods to simulate accident progression and phenomena
- Fuel performance topics
- Digital I&C implementation (common-cause failure, software, etc.),
- Emerging technologies, such as digital twins, and artificial intelligence) and issues, such as HEAFs, vessel embrittlement under high fluence conditions, and cyber security

With respect to licensing and operation of new reactors, ACRS is reviewing the following topics:

- Alignment and lessons learned for NRC's current licensing pathways (10 CFR Part 50 for applicants pursuing separate Construction Permits and Operating Licenses and 10 CFR Part 52 for applicants pursuing Certified Designs)
- 10 CFR Part 53 development (optional new technology-inclusive licensing framework), and

- Related licensing guidance on topics such as emergency planning, operator licensing, licensing basis event selection, etc.
- Staff reviews of licensing documents (along with applications) provided by several design centers (This includes KAIROS, NuScale, X-Energy, Terrapower, Westinghouse, and about a dozen anticipated additional organizations during the next three to five years).

In her presentation, Dr. Rempe elaborated on several ACRS challenges:

- Numerous (potential) applications from design developers
- Industry concerns about cost/schedule for licensing reviews
- Appropriate membership succession

The first item pertains to the number of licensing documents for new reactor designs that differ substantially from the operating fleet. ACRS is focusing on how licensing basis events should be identified for designs with little (or no) operating experience, and the lack of sufficient data to validate fuel, reactor system performance, and methods to evaluate event progression in these designs. The second item relates to industry concerns about the cost and time required for regulatory reviews. ACRS is implementing new approaches to increase review effectiveness without adversely impacting safety. The third item pertains to ACRS membership succession. As noted above, ACRS may have up to 15 members, but there are no term limits. Although ACRS benefits from new member perspectives, there is a need for knowledge transfer to these new members and the process to obtain and transfer knowledge to new members requires time.

For the March 2023 meeting topics, ACRS members suggested the following three topics:

- Operating Fleet (including aging-related issues and the use of high burnup fuels)
- Licensing and operation of First-of-a-Kind (FOAK) reactors, including areas such as:
  - Achievement of safety with little or no operating experience
  - The suitability of current licensing frameworks
  - Treatment of uncertainties
  - Application of defense in depth
- Risk surrogates (Safety Goals) for small modular Light Water Reactors (LWRs) and non-LWRs

Finally, Dr. Rempe closed by emphasizing two desired ACRS outcomes from this international activity: (a) identifying emerging issues related to the operating fleet, and (b) advice being given to address issues associated with new FOAK reactors. In the discussion following this presentation, participants inquired about time constraints on ACRS members (considering the broad spectrum of activities members address) and how conflict-of-interest issues (COI) are avoided by ACRS members. Dr. Rempe responded that ACRS positions are considered "part-time", and financially compensated accordingly. When COI issues arise, she noted that members recuse themselves from deliberations on the topic of concern.

2.2 Summary and March 2023 Planning

As indicated in the agenda for this meeting, the final session was a joint discussion to summarize insights from the December 5 planning meeting and prepare for the March 2023 meeting. During this discussion, participants agreed upon topics, such as the meeting objective, the topics for discussion, the meeting date, and the documentation of meeting accomplishments. Appendix B.6 contains slides, which were jointly developed by meeting participants, to document results from this December 2022 discussion.

2.2.1.1 Summary

Significant differences were identified in advisory committee organizations and roles:

- Committee membership number

- Committee member composition-nationality (several advisory committees include international members), areas of expertise (safety, reactor design, radiation safety, external events, waste management, etc.) and employment history (industry, university, national laboratory, regulator, etc.)
- Role (proactive versus reactive activities)
- Topics addressed and process for selection of topics
- Methods for providing input to the regulator
- Methods for including public stakeholder participation and public education

Despite these differences, participants agreed that advisory committees have similar objectives and are reviewing many similar topics. Participants observed, however, that implementation of 'best practices' and 'insights' identified in subsequent interactions may be limited due to 'national' differences in the following:

- Committee charter, regulation, or public law and the manner in which advisory committee discussions and contributions are made available to stakeholders; and
- External factors (e.g., reliance on nuclear, political, public acceptance and communication, prior events in a country, emphasis on cost/benefit criterion versus continuous improvement, standardization of existing fleet, interest in new builds and advanced reactors, long-term solution for waste, work force availability).

Nevertheless, it was agreed that the interaction should be pursued because of the importance of identifying these "best practices" and "insights".

2.2.1.2 March 2023 Planning

This planning discussion emphasized selection of meeting objectives, format and discussion topics for the March 2023 meeting and documentation of this interaction.

During the discussion on the March 2023 meeting objectives, Dr. Naoto Sekimura shared slides (see Appendix B.3.2) regarding the importance of having an expert panel to provide independent advice to a regulator. This point was added to the discussion about meeting objectives (see Section 1.1).

Dr. Charles led the discussion of the meeting format and discussion topic selection. It was agreed that a two-day meeting, consisting of two half-day thematic sessions) would be the best format. The first session (on Day 1) should focus on issues pertaining to the operating fleet, including topics such as operating experience feedback, long-term operating issues (including aging of non-replaceable equipment), and modernization of regulatory activities (including risk-informed applications). The second session (on Day 2) should focus on new challenges, including topics such as safety objectives for new LWR and FOAK reactors, international perspectives pertaining to emerging technical issues, and efforts to strengthen the role of advisory committee experts (including methods to address diverse opinions). Meeting participants agreed that the March 2023 sessions would occur on the afternoon of Tuesday March 14, 2023, and on the morning of Wednesday, March 15, 2023.

Finally, with respect to documentation of this international meeting activity, members of the ACRS, the hosts for the March 2023 meeting, agreed to develop a draft report template for interaction meeting with populated draft sections for the planning meeting. This draft document was circulated to participants for comment (and revised accordingly).

3. SESSION 1 – OPERATING FLEET

Participants in Session 1 represented four countries: Finland, France, Japan, and the U.S. This section summarizes input from each presentation (Section 3.1) and subsequent discussion (Section 3.2). . Appendix A includes an agenda and a list of participants for Session 1. Appendix C includes slides presented during this session.

3.1 Presentations and Discussions

3.1.1 Finland

In this presentation, which was authored by Dr. Karin Rantamäki, ACSN Secretary, Dr. Petri Kinnunen, Member ACSN, and Dr. Heli Talja, Member ACSN, Dr. Rantamäki focused on aging management and described Finland's approach, which can be summarized with the statement, "We know our plants". Their comprehensive aging management program (AMP) requires understanding functioning of the whole plant as well as relevant components, consideration of risk assessment, understanding aging mechanisms (embrittlement, fatigue, thermal fatigue, stress corrosion cracking, corrosion, etc.), and cooperation between the plant owner, the regulator, and research institutes. Appropriate actions are taken to prevent, detect, monitor, and mitigate aging so that components are maintained with defined acceptance criteria. The most important aging issue, embrittlement of the reactor pressure vessels (RPVs) of the Loviisa plant units was discussed in depth in the Finnish presentation. In addition, subsequent discussion raised three additional topics, namely aging of concrete, aging of cabling and obsolescence of I&C technology. The principle of continuous improvement, which is related to their PSR reviews, was also discussed.

3.1.2 France

For Session 1, Dr. Bertrand de L'Epinois, Member GPR, provided GPE presentations on two topics: implementing lessons learned from operating plant events; and periodic safety review (PSR) and long-term operation (LTO).

3.1.2.1 Operating Plant Feedback

On top of the utility's responsibility to process the operational feedback and the day-to-day regulator interaction to check that lessons learnt are properly implemented, the presentation emphasized that the GPR holds regular meetings (now every year) dedicated to operational feedback. Based on a comprehensive report by IRSN, the GPE discusses the main events, families of events, and trends (as the weight of human and organizational factors in a majority of events). The main events addressed in recent years include topics, such as an International Nuclear Event Scale (INES) level 2 operating incident review of lessons learnt (e.g., primary circuit drainage under void conditions), the stainless-steel stress corrosion cracking (SCC) in 2022, and the Fukushima Daiichi accident (the GPE being instrumental in setting the safety philosophy and strategy following this accident). Some themes are also discussed; for example, last year, discussions focused on heat sink issues (marine ingress, risks of clogging, corrosion); maintenance operational feedback; and an attempt to *a posteriori* detect declining trends at one site using indicators (the thorough analysis gave no clear result, showing that qualitative information and 'in-field' interaction are essential to appreciate "how the work is done" and foresee a potential decline of a plant).

3.1.2.2 Periodic Safety Review (PSR) and Long-Term Operation (LTO)

In France, the license for an operating plant has no fixed term, but a periodic safety reassessment must be performed every ten years, after which the regulator approves continued operation. The GPR presentation emphasized these ten-year exercises are organized into two parts: a compliance review, including extended inspection during the ten-year outage or 'visite décennale' (VD) and a PSR. To determine which safety improvements make sense (or appear necessary) for a plant, the PSR considers operational feedback (at fleet and international levels), the progress of knowledge, and the development of technologies and standards for new reactors. The PSR includes a generic phase (considering the whole series of reactors) and a specific phase (dedicated to a given reactor). The licensee proposes a PSR orientation (i.e., a draft proposal for the PSR evaluation), which is reviewed and amended by the regulator (which includes a review by the GPE); the licensee then performs the PSR studies, which are reviewed by IRSN followed by the GPE before the ASN takes a position and before changes are implemented by the licensee.

Significant upgrades are performed during VDs, especially the fourth VD (VD4) after forty years of operation. The compliance checks were augmented (including extra inspections of components such as anchoring, a thorough aging assessment, equipment qualification beyond 40 years, etc.) In terms of an upgrade, a specific objective is, along with completing the post Fukushima backfitting, to approach the new reactor safety objectives, in particular: avoid protection measures for the population in case of a design basis accident; increase the prevention and mitigation of severe accidents (including a new injection and cooling injection path - to prevent core melt and, in case of core melt, to extract residual heat from the containment without venting – and measures to prevent basemat ablation in case of core melt); and reduce the residual risk of fuel damage in the spent fuel pool. Many GPE meetings occurred, providing opinions on the VD4 objectives, accident studies, hazards, RPV and primary circuit integrity, severe accidents, the probabilistic safety assessment (PSA), and the overall conclusions.

3.1.3 Japan

For Session 1, Dr. Tomoya Ichimura, Deputy Secretary-General for Technoical Affairs, NRA, presented an overview of recent changes in nuclear power station (NPS) regulation in Japan; this was followed by a presentation by Dr. Naoto Sekimura, Chair NRA RSEC, on the status of regulation, aging, management, and safe LTO of nuclear power plants in Japan.

3.1.3.1 Operating Fleet Regulation

After the March 2011 accident at TEPCO’S Fukushima Daiichi NPS, safety regulations for nuclear reactors in Japan totally changed. Changes included establishing new sets of regulatory requirements, which became effective on July 8, 2013, based on the lessons learned from the Fukushima Daiichi accident. At present, plant operators have applied for the conformity review for 27 reactors (of which 17 have been permitted through NRA review processes), while 24 are being decommissioned. Continuous improvement of safety is one of the most important lessons learned from the Fukushima Daiichi accident. Through a “back-fitting” system, the latest knowledge is incorporated into requirements and applied to the operating fleet. The NRA has been constantly collecting and reviewing new findings / knowledge and incorporating them into regulatory requirements and require back-fitting with specific time limits. In this process, the NRA seeks advice from the Reactor Safety Examination Committee (RSEC) and the Nuclear Fuel Safety Examination Committee (NFSEC), both established in May 2014.

Introduction of Periodic Safety Assessment of Continuous Improvement (PSACI) is also a part of continuous improvement. The NRA requires operators to conduct PSACI including PSRs, stress tests, and probabilistic risk assessment (PRA) on their operating reactors and submit the results to the NRA. Also, the NRA introduced a new inspection framework in 2020, which made the role of operators and regulator clearer and introduced the risk-informed, performance-based regulation similar to the Reactor Oversight Proces (ROP) in the US. The NRA has asked the RSEC and the NFSEC to deliberate on the improvements to the PSACI system as well as advise on this regulatory inspection system.

In the amended Reactor Regulation Act after the Fukushima Accident,[15] the operating period of NPP is set to 40 years with a maximum extension of 20 years only once. In the green transformation (GX) strategy announced by the Government of Japan (GOJ) in December 2022,[21] however, a modification of the operational period of NPP was suggested, which maintains the general framework of 40 years plus

20 years while considering a mechanism that would allow the period during which operation is suspended after the Accident to be added to the operating period subject to approval by Japan's Ministry of Economy, Trade and Industry (METI). Resonding to this movement, the NRA has started considering a regulatory proposal to revise the Reactor Regulation Act, so that appropriate safety regulations can be applied to reactors regardless of the operating period. The proposal will be discussed in the current Diet session.

3.1.3.2 Current Status of Regulation, Aging Management, and Safe LTO

The NRA requires that NPP operators conduct an Aging Management Technical Evaluation (AMTE) prior to 30 years of operation and every 10 years thereafter in each plant. In the evaluation, all safety-related components, systems, and structures (etc.) are assessed assuming 60 years of operation. Licensees can apply a Standard,[22] complied and updated by the Atomic Energy Society of Japan, which lists possible aging degradation mechanisms and references the latest findings and existing knowledge base. The AMTE also requires evaluation of the simultaneous superposition of aging degradation and possible effects of earthquakes and tsunamis. In addition, the AMTE requires the effectiveness of the current maintenance program be evaluated, and if necessary, a long-term maintenance plan for the next 10 years be developed and implemented.

The NRA requires operators conduct special inspections of RPVs, containment vessels, concrete structures, etc., if they are to operate for more than 40 years. In addition to these data collection requirements, the expansion of knowledge on degradation using harvested materials from decommissioning reactors is underway by several projects, which are led by METI, operators, and the NRA.

3.1.4 United States

In his presentation, Dr. Ron Ballinger, ACRS member, focused on a selection of current issues related to LWR structural materials and nuclear fuel that will impact extended operation. The presentation emphasized issues addressed in the ACRS letter reports.[23,24,25] These issues included:

- RPV embrittlement
- Environmentally assisted structural materials degradation
- Fuel cladding embrittlement
- Fuel fragmentation and relocation

Dr. Ballinger provided a brief overview of materials and fuel degradation issues related to extended operation. His presentation included a list of structures and components for which degradation must be evaluated. Due to timely replacement of most major components (e.g., steam generators, turbines, pressurizers, condensers, steam dryers) and "dispositioning" of all dissimilar welds (e.g., replaced or mitigated), he observed that 'elapsed operating time' was an inappropriate measure for the age of a plant. As a practicable matter, the only major components that are not replaceable are the RPV, vessel support structures, and major concrete components (e.g., basemat, pedestal, reactor cavity). Because fuel is a consumable item, aging issues concern reliability when burnup and exposure time are extended.

He observed that the expected neutron fluence at extended operation may likely exceed the bounds of the empirical data base for evaluating the effect of exposure on RPV embrittlement criteria using the current model found in Regulatory Guide 1.99. An updated model that includes a much-enhanced database was discussed which addresses this shortcoming.

Environmentally assisted structural materials degradation, primarily due to stress corrosion cracking of stainless steel, including welds and heat-effected zones, is one of the most significant degradation mechanisms for LWR structural materials. This issue has been an ongoing problem since the early days of the LWR industry. Extensive research has been conducted to develop mitigation strategies. However, the issue persists, as suggested by recent incidents of cracking in Type 316 stainless steel weld heat affected zones in nominally reducing (thought to be benign) environments.

Fuel issues, including cladding embrittlement and pellet fragmentation and relocation are becoming more important for some LWR accident scenarios. First-generation fuel cladding (containing Zircaloy-2,4) corrosion results in the absorption of corrosion-generated hydrogen. This reduces cladding ductility, with the reduction increasing with burnup (exposure time). Second (and higher) generation fuel cladding (M5, ZIRLO[c], etc.) are much more corrosion resistant, producing much less hydrogen that can be absorbed by the cladding. Hence, the effect on ductility is greatly reduced, allowing for better performance at higher burnup (exposure time).

Although cladding performance has been greatly improved, the effect of increased burnup on fuel pellet performance has been identified as a potential issue. At high burnup (> ~50 GWd/MTU) and cladding strains exceeding 3% (where the cladding is actually breached), there are concerns about the possibility of fuel fragmentation, relocation, and dispersion (FFRD) of fuel "fines" into the coolant. Potential limitations on fuel duty are being discussed. However, FFRD phenomena are complex; and little representative data exist for LOCA or other severe transients that could lead to such conditions. In an ACRS letter report on this topic,[24] the committee suggested a more risk-informed approach be taken to estimate the occurrence frequencies, as well as the consequences, of events that could lead to FFRD conditions.

3.2 Summary

Session 1 presentations considered several topics, including aging management "best practices" lessons learned from operating experience and PSR or license renewal application reviews. Presentations indicated similar aging mechanisms have been identified and are monitored, especially in evaluations of PSRs and/or license renewal applications. Discussions emphasize advisory committee contributions in developing approaches to address topics, such as RPV embrittlement, concrete aging, cable aging, and I&C technology obsolescence. With respect to the latter, discussions emphasized that similar principles (redundancy, redundant division independence, defense-in-depth and diversity, control of physical and external source electronic access) were emphasized before allowing the introduction of digital I&C into the operating fleet.

Advisory committee contributions differed in PSR/license renewal reviews and on ensuring implementation of lessons learned from operating experience. For example, the GPE holds an annual meeting with an in-depth focus on recent operating experience identification and implementation. The RSEC and the NFSEC PSACI deliberations on improvements appear similar to ACRS involvement in reviewing guidance developed for evaluating life extension and SLR. However, contributions differ because of country-specific differences: U.S. regulatory processes emphasize risk insights (using risk information to detect and prioritize plant vulnerabilities) and cost/benefit limitations; whereas Finland, France, and Japan regulatory processes emphasize the "continuous improvement" approach associated with PSR evaluations.

---

[c] ZIRLO is a trademark of Westinghouse Electric Company LLC.

4. SESSION 2 – NEW CHALLENGES

Participants in Session 2 represented five countries: Finland, France, Japan, the U.K., and the U.S. This section summarizes input from each presentation (Section 4.1) and subsequent discussion (Section 4.2). Appendix A includes an agenda for and a list of participants in Session 1. Appendix D includes slides presented during this session.

4.1 Presentations and Discussions

4.1.1 Finland

In their Session 2 presentation, Professor Juhani Hyvärinen, ACNS Member, provided an overview of recent new build experience in Finland, the outlook on SMRs in Finland, and the impact of ACNS contributions on these activities. The presentation emphasized not only the issues in deploying new builds (large PWRs and SMRs), but also the benefits associated with deploying new reactors in Finland, such as public acceptance, a path forward for waste management, and a skilled nuclear workforce.

In reviewing the recent new build experience, Professor Hyvärinen emphasized difficulties associated with design modifications after approval of the construction license, suggesting design incompleteness, along with cultural differences, led to licensing delays (in the case of Olkiluoto 3 EPR) and plant cancellation (in the case of the Hanhikivi 1 VVER). In both the Olkiluoto 3 and Hanikivi 1 cases, attempts to create safety through compliance with the letter of the requirements were not very successful. In addition, he cited difficulties associated with equipment quality, supply chain difficulties, and failures to respond to the supplier, owner, and regulator expectations.

There is considerable interest by large companies in Finland to deploy SMRs and by one university to deploy a microreactor. The ACNS October 2019 initiative[26] was presented as an example of a proactive approach motivated by the potential for smaller reactor projects to overcome difficulties associated with larger reactors. The ACNS paper from this initiative emphasized SMR differences, such as design features, manufacturing methods, serial production, siting near population centers, and other potential SMR impacts (e.g., district heating, co-generation). Because of these differences, the ACNS paper emphasized the need for new regulatory processes, such as separate site and licensing reviews. To further assist their data collection on this topic, ACNS also held a seminar devoted to SMRs.

The ACNS paper contributed to a decision by the Finland Ministry of Economy and the Employment to include considerations on SMRs in the Nuclear Energy Act.[27] Revisions are considering differences in siting, land use, environmental impact, nuclear fuel and nuclear waste management, nuclear safeguards, and other SMR technology effects, such as modular construction, high-quality less-expensive (non-nuclear grade) equipment, passive safety systems, and smaller unit size. Revisions should allow a graded-approach for several aspects associated with SMR licensing reviews, such as: separate approvals for the SMR technology and plant site (to better enable serial production); better definition of the intent and purpose of Finland's Decision-in-Principle (which occurs prior to a construction license), performance-based safety assessments, and appropriate emergency protection zone sizing; and allow the use of high quality 'conventional' equipment. It was observed that this SMR 'rethinking' could also be beneficial for large reactors.

4.1.2 France

For Session 2, the presentation by Dr. Bertrand de L'Epinois, Member GPR, focused on Guide 22,[28] which addresses safety standards for new reactors. ASN Guides provide guidance on recognized ways to implement regulation. Guide 22 targets large PWRs, although its directions can be used for other types of reactors (e.g., light water SMRs). In addition to reviewing some basic principles, such as defense in depth, barriers, redundancy, single failure criterion, and equipment qualification, Guide 22 covers some features more specific to Generation 3 reactors, such as design extension conditions, severe accident mitigation, post-Fukushima considerations (e.g., design extension hazards), and modern technology implementation (e.g., digital I&C). Guide 22 primarily originated from EPR technical guidelines issued in 2000. The aim of this guide was to make the EPR guidelines less design-dependent and to provide an update on post-Fukushima considerations.

The GPE had a key role in setting EPR safety objectives and in writing EPR technical guidelines (holding tens of meetings over a decade with its German counterpart). In addition, the GPE met twice on draft Guide 22, providing 400 comments.

During this discussion, Dr. de L'Epinois also mentioned the philosophy being used in Europe which emphasizes practically eliminating core-melt accidents that could lead to large early releases and avoiding long-lasting effects in the environment.[29]

4.1.3 Japan

For Session 2, a joint presentation by Dr. Tomoya Ichimura, Deputy Secretary-General for Technoical Affairs, NRA, and Dr. Naoto Sekimura, Chair, NRA RSEC, focused on three challenges: next generation advanced reactors, advisory committee structure and discussion topics, and the nuclear regulatory human resource development project.

4.1.3.1 Next Generation Advanced Reactors

The Government of Japan (GOJ) announced its Green Transformation (GX) Strategy in December 2022.[21] The GX includes efforts to develop and construct innovative reactors that will replace current reactors. The government has suggested that the term, 'innovative reactors', include innovative LWRs, SMRs, fast reactors, gas-cooled reactors, and nuclear fusion reactors. The current regulatory requirements, however, are for existing Japanese LWRs (i.e., PWRs and BWRs). Hence, the NRA intends to develop a new set of requirements applicable to innovative reactors, according to the design maturity of discussions and interest expressed by plant operators. To date, however, no operators have expressed concrete intentions to construct new reactors.

4.1.3.2 Advisory Committee Structure and Activities

The RSEC and the NFSEC are advisory committees that investigate and deliberate on reactor safety and other issues requested by NRA. However, RSEC and NFSEC advice does not replace the NRA decision-making process. Regular RSEC and NFSEC meetings are open to the public, and results are reported to the NRA. Most RSEC and the NFSEC members are active university faculty members or senior-level researchers from research institutions.

Currently, the NRA has requested the RSEC and the NFSEC investigate and deliberate on the following issues: NRA response to information acquisition and analysis of accidents and emerging issues in domestic and international nuclear facilities; response of NRA to the recommendations and suggestions by the IRRS mission by IAEA; the implementation status of the new inspection system (Section 3.1.3.1), improvement of PSACI (Section 3.1.3.1), and response of NRA to the knowledge of natural hazards such as volcanoes and earthquakes. Previously, the RSEC and the NFSEC have worked on issues, such as the relationship between safety goals and the safety level of reactors that met the new regulatory requirements. While pointing out the importance of safety goals, it was noted that safety goals and safety levels cannot and should not be directly compared using probabilistic assessments. Discussions by the RSEC and the NFSEC also emphasized the peculiarities of risk profiles of nuclear power plants in Japan, in which contributions from large scale natural hazards, such as earthquakes, could overwhelm other challenges.

4.1.3.3 Nuclear Regulatory Human Resource Development Project

The NRA provides financial support for programs conducted at universities and other institutions in Japan to develop human resources effectively, efficiently, and strategically with the scientific and technical knowledge and management capabilities necessary for future nuclear regulation. The members of the universities and other organizations participating in the program include members of the RSEC and the NFSEC. For example, the University of Tokyo has been continuously promoting human resources with background knowledge and experience in processes that will facilitate introduction of international guidance and standards into domestic nuclear regulations. Activities include utilizing internships at international organizations such as IAEA and OECD/NEA and releasing reports documenting deliberations by RSEC and the NFSEC.

4.1.4 United Kingdom

For Session 2, the ONR presentation by Mr. Tim Parkes, Superintending Inspector, Head of Safety Regulation - Sizewell C, Advanced Nuclear Technologies and Innovation, focused on three points: approach to developing acceptance criteria for novel reactors, international collaboration on vendor inspections and commissioning test results, and practical elimination of emergency preparedness. The UK regulatory framework and supporting guidance is well-established, generally robust, and technology neutral. However, challenges arise from the ONR goal setting approach due to the lack of established relevant good practices and operational experience for advanced technologies. Mr. Parkes noted that ONR is open to collaborating with other regulators, considering criteria developed in other countries and working collectively to assess reactor designs and safety cases.

To ensure the success of SMRs, many multiples of reactor units need to be deployed. It is unlikely that they will all be delivered through home-grown supply chains and manufacturing capabilities. Therefore, vendor inspections and commissioning test results are necessary. Mr. Parkes noted that, in the past, advisory committees might have taken a key role in deciding what must be demonstrated. However, it is unclear how these requirements will be derived, shared, and demonstrated in the context of a goal of common designs across countries; and Mr. Parkes noted ONR welcomed further discussion on this topic.

SMR vendors entering the UK market have continually queried emergency preparedness and offsite planning requirements. There are two main drivers for this: deploying SMRs in new areas closer to populations and awareness of the U.S. NRC effort to develop a risk-informed technology-inclusive regulatory framework for advanced reactors.[30] The challenge in the UK is that it is the duty of the local government authority to determine the appropriate emergency planning zone (EPZ), with many considerations, including technical information provided by the operator. To support this, when a design undergoes assessment, the ONR focusses on the requirement that large or early releases are practically eliminated by design. During their presentation, the ONR participants also noted that they welcomed further discussion on this topic and on the topic of international collaboration to demonstrate the concept of practical elimination.

4.1.5 United States

For Session 2, the ACRS provided presentations on two topics: licensing FOAK reactors for which there is little or no operating experience and implementing safety goals for small modular reactors and micro-reactors.

4.1.5.1 Licensing FOAK Reactors

The presentation by Dr. David Petti, ACRS member-at-large, focused on licensing considerations for FOAK reactors when there is little or no operating experience. The presentation discussed the need for identification of safety functions in the design and how to confirm the integrated performance of systems that implement those functions. Safety margin, defense-in-depth, and relevant operating experience were identified as playing important roles in reducing uncertainties in the design. In addition, the importance of a robust process to identify all postulated accidents was emphasized as important for producing a credible safety analysis. Dr. Petti observed that the inherent safety characteristics and smaller thermal power of many of the advanced non-LWR systems should result in reduced source terms and smaller off-site consequences compared to existing large LWRs. In summary, advanced reactors' inherent safety characteristics should lead to a greater emphasis on accident prevention than accident mitigation. His presentation also emphasized that the lack of operating experience could be compensated with by greater reliance on inherent and passive safety features, large safety margins, and defense in depth in the design, supported by scaled testing and integral safety demonstration.

4.1.5.2 Safety Goals

Dr. Vicki Bier, ACRS member, presented a discussion of safety goals for nuclear-power plants in the United States, motivated by the ACRS review of draft language for a risk informed, technology-inclusive regulatory framework for advanced reactors.[30] The presentation began with a brief history of the development and implementation of safety goals in the U.S., including both quantitative and qualitative goals. The presentation then outlined several challenges that may be involved in applying the existing safety goals to new reactor designs. Examples include: smaller reactor sizes and source terms; the fact that core-damage frequency may not be well defined for some reactor designs; questions about how to apply quantitative safety goals to reactors that may have bounding analyses instead of probabilistic risk analyses; and changes to the nature of competing technologies for generating electricity (e.g., greater reliance on natural gas instead of coal). Further planned ACRS activities include collecting additional historical information, reviewing related international efforts, and preparation of a white paper discussing the issues outlined above.

The U.S. approach differs from other approaches, such as the European Union (EU) approach outlined in Council Directive 2014/87/EURATOM[29]:

> Member States shall ensure that the national nuclear safety framework requires that nuclear installations are designed, sited, constructed, commissioned, operated and decommissioned with the objective of preventing accidents and, should an accident occur, mitigating its consequences and avoiding:
> (a) early radioactive releases that would require off-site emergency measures but with insufficient time to implement them;
> (b) large radioactive releases that would require protective measures that could not be limited in area or time.

Criterion (b), imposing the condition that protective measures should be "limited in area or time," differs from the criteria in the current U.S. safety goals, which are based more directly on health effects. In other words, a large radioactive release that causes limited health effects, because of extensive protective measures, would satisfy the U.S. safety goals, but not the above obligation from the EU.

4.2 Summary

Session 2 presentations described several new challenges. In the area of new builds, presentations highlighted topics such as:

- Required information for construction permits/licenses versus operating licenses
- Appropriate Structures, Systems, and Component (SSC) quality and supply chain limitations
- Consideration of cultural differences in non-domestic designs
- Use of PRA in regulatory decision-making

Several presentations highlighted potential opportunities and challenges with FOAK SMRs and microreactors, such as:

- Appropriate EPZ sizing that considers new missions and enhanced safety (and application of concepts such as “practical elimination” and “safety goals” to characterize SMR safety)
- Key considerations: critical safety functions identification, initiating event and licensing basis event section, confirmatory analysis and testing of novel system performance, increased safety margin to compensate for uncertainties associated with lack of operating experience
- New guidance and a regulatory framework for advanced non-LWRs
- International collaboration/multi-national design evaluation

Presentations also highlighted other challenges, such as:

- Consideration of external events
- Digital I&C implementation
- Human resource development
- Public /stakeholder communication and engagement

In Session 2 discussions, several participants highlighted prior and recent advisory committee contributions to address the above challenges, such as input to regulatory guidance, white papers/reports to instigate regulatory actions (such as revising regulations to accommodate new reactors) and reviewing draft regulations and guidance. Discussions also emphasized the importance of country-specific external factors discussed in Section 2.2 (e.g., advisory committee organization and authorization, reliance on nuclear, public acceptance, regulation, status of long-term solution for waste, and current interest in deploying new builds). Several participants expressed interest in future interactions to probe more-deeply on several topics, in particular potential opportunities to advisory committees to collaborate on addressing challenges associated with FOAK SMRs and microreactors.

5. INSIGHTS GAINED AND FUTURE INTERACTIONS

As outlined in Section 1.1, this international effort was conducted with the following objectives:

- Gain a working understanding of differences in advisory committee roles and organizations
- Share experience on common issues of interest and discuss effective advisory committee solutions to address these issues (recognizing nuclear reactor regulation is a national responsibility)
- Increase advisory committee effectiveness by:
  - Gaining knowledge about emerging issues and new technologies of interest
  - Identifying, contributing to, and gaining from international regulatory advisory group "best practices" and "safety perspectives"
  - Sharing knowledge about activities to strengthen advisory committee roles

As summarized in this section, several insights were gained in the areas of advisory committee organization and role, operating fleet, and new challenges. These insights provided a basis for recommendations related to future interactions.

5.1 Insights Gained

Advisory Committee Organization and Role

As discussed in Section 2.2, significant differences were identified in advisory committee organization and roles. Selected 'best practices' of interest for future consideration include:

- Inclusion of international perspective (through international members, consideration of IAEA guidance and standards, or international advisory committee interactions)
- Inclusion of retired members from industry
- Publication of results from advisory committee meeting deliberations and recommendations
- Potential for self-initiated actions (areas where self-initiated actions led to significant changes being implemented in the regulatory framework or policies).

However, it was acknowledged that implementation of "best practices" and "insights" may be limited due to 'national' external factors. Because of potential benefits from process improvements, participants suggested this topic should continue to be explored in future interactions.

Operating Fleet

As discussed in Section 3.2, Session 1 discussions indicate similar aging mechanisms have been identified and are monitored in evaluations of PSRs and/or license renewal applications. Discussions emphasized that advisory committees provide input on methods used to address topics, such as RPV embrittlement, concrete aging, cable aging, and I&C technology obsolescence. However, the level of advisory committee contributions differed in PSR/license renewal reviews and on ensuring implementation of lessons learned from operating experience. In addition, discussions identified several country-specific differences: U.S. regulatory processes consider risk insights (as a tool for identifying and prioritizing plant vulnerabilities) and cost/benefit limitations; whereas Finland, France, and Japan processes emphasize a "continuous improvement" approach associated with PSR evaluations. Selected "best practices" of interest for future consideration include:

- Focused reviews of domestic (as well as international) operating experience lessons-learned identification and implementation.
- Methods to monitor SSC aging (in particular, RPV embrittlement)

New Challenges

As discussed in Section 4.2, Session 2 presentations described a wide range of new challenges associated with new builds, FOAK SMRs, and microreactors as well as new challenges affecting operating reactors. Session 2 presentations highlighted advisory committee contributions to address these challenges, such as developing white papers/reports to influence regulatory actions and reviewing new guidance and regulation. Discussions also emphasized the importance of country-specific external factors discussed in Section 2.2 (e.g., advisory committee organization and authorization, reliance on nuclear, public acceptance, regulation, status of long-term solution for waste, and current interest in deploying new builds).

Selected 'best practices' of interest for future consideration include:

- Methods for engaging stakeholders
- Development of "white papers" or reports with significant impact on regulatory processes

Several participants expressed interest in future international regulatory advisory committee interactions to further probe several topics. Although it is recognized that country-specific factors remain, several participants expressed interest in evaluating whether this international collaboration of advisory committees could provide useful contributions on the following topics:

- Appropriate EPZ sizing that considers new missions and enhanced safety (and application of concepts such as 'practical elimination' and 'safety goals')
- Development of common acceptance criteria (risk metrics) for FOAK reactors with little operating experience

During the discussions, several participants expressed optimism about the potential to propose globally acceptable limits if organizations focused on the primary safety function of control radiation release (see Section 4.1.5.1). Although differences may remain due to differences in the methods used to estimate doses (e.g., activity inventory, release mechanisms, radionuclide transport, intake paths), dose estimates should remain within reasonable safety margins for any given accident in different countries.

5.2 Future Interactions

Participants agreed to several 'follow-on' actions. This section summarizes these actions and suggestions for future interactions.

Report

Participants agreed to contribute to a publicly available document, which included all of the presentations and summarized the discussion topics and key findings, and insights. Publication of this document completes this action item.

Future Meeting Frequency, Location, and Participation

Participants agreed follow-on interactions would be beneficial. It was agreed that future hybrid meetings (with some in-person attendance) should occur in approximately 3 years. The location will be finalized at a later date.

Because of advisory committee membership changes, participants agreed that at least one-interim or more virtual interaction(s) should occur between each hybrid meeting. Participants from one organization suggested that specific networks between advisory committees be formed to exchange ideas on specific topics (such as collaboration to provide ideas/suggestions regarding guidance for SMR or microreactor deployment).

Many participants indicated the number of participating countries was appropriate. If additional advisory committees from other countries are included in future interactions, participants observed that the discussion time should also be included (because of the importance of active discussions in this interaction). It was suggested that future interactions should try to include members of advisory committees that support the Canadian Nuclear Safety Commission.

Future Meeting Structure and Candidate Topics

In general, the interaction structure (a 'pre-meeting' virtual meeting to finalize technical topic selection followed by a hybrid meeting with two sessions focused on the two technical topics) was deemed appropriate. However, it was suggested the hybrid interaction be expanded to include a visit to a nuclear site.

For the next interaction, it was suggested the following outline be considered.

Plenary Meeting:

- Important issues for each country and work of the corresponding advisory committee during the last three years,
- Sharing on specific topics, and
- Proposed emerging topics for exchange at the next hybrid meeting.

Candidate Topics for Hybrid Exchange

- Selected committee practices (e.g., publication of meeting transcripts, findings, and recommendations, ability to take self-initiated proactive actions, communication avenue with regulatory agency management) and resources (e.g., funding for member labor, support staff, and travel for meetings and site visits)
- Aging (RPV embrittlement in particular)
- SMRs (LWR and Non-LWR) and microreactors and potential for international regulatory advisory committee collaboration to facilitate international licensing collaboration / cooperation
- Climate change considerations (reassessment of hazards associated with external events)
- Fuel behavior feedback (e.g., high burnup fuel, accident tolerant fuel)
- Severe accident prevention and mitigation measures (post-Fukushima actions)

6. REFERENCES

1. U.S. NRC, https://www.nrc.gov/reading-rm/basic-ref/glossary/international-nuclear-regulators-association-inra.html.
2. WENRA, Western European Regulators Association, https://www.wenra.eu/.
3. OECD, "Regulators Reflect on Lessons Learnt 10 Years on from Fukusihma Accident" https://www.oecd-nea.org/jcms/pl_76532/regulators-reflect-on-lessons-learnt-10-years-on-from-fukushima-accident.
4. IAEA, "International Nuclear Safety Advisory Group" (INSAG), https://www.iaea.org/topics/nuclear-safety-and-security/committees/insag.
5. International Nuclear Safety Group, 2017 Ensuring Robust National Nuclear Safety Systems – Institutional Strength in Depth, INSAG-27, IAEA Publication 1779, Vienna (2017).
6. "Nuclear Energy Act (990/1987)", http://www.ilo.org/dyn/natlex/natlex4.detail?p_lang=&p_isn=85507&p_classification=14.01.
7. Government Decree on Advisory Committee on Nuclear Safety (1015/2016)", 24 November 2016.
8. Rules & Procedures, Advisory Committee on Nuclear Safety.
9. ASN GPE requests and responses www.asn.fr
10. "Act for Establishment of the Nuclear Regulation Authority", Act No. 47 published in the Extra Official Gazette of June 27, 2012; Final Revision: Act No. 82 of November 22, 2013. (see https://www.nra.go.jp/english/legislative/acts.html)
11. Supplementary Resolution to the Bill for Establishment of the Nuclear Regulation Authority (in Japanese only), https://www.sangiin.go.jp/japanese/gianjoho/ketsugi/180/f073_062001.pdf.
12. RSEC operational policy (in Japanese only), https://www.nra.go.jp/data/000337732.pdf.
13. NFSEC operational policy (in Japanese only), https://www.nra.go.jp/data/000337733.pdf.
14. IAEA, "Integrated Regulatory Review Service (IRRS) Follow-Up Mission to Japan", 14-21 January 2020, https://www.nra.go.jp/data/000305635.pdf
15. "Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactor," Issuance: Act No. 166 of June 10, 1957, Final revision: Act No. 82 of November 22, 2013, https://www.nra.go.jp/english/legislative/acts.html
16. Office of Nuclear Regulation Expert Panels, https://www.onr.org.uk/external-panels/index.html.
17. Atomic Energy Act of 1954, as amended, https://www.govinfo.gov/content/pkg/COMPS-1630/pdf/COMPS-1630.pdf.
18. Advisory Committee on Reactor Safeguards (ACRS) Letter Reports, https://www.nrc.gov/reading-rm/doc-collections/acrs/letters/index.html.
19. Federal Advisory Committee Act, https://uscode.house.gov/view.xhtml?path=/prelim@title5/title5a/node2&edition=prelim,.
20. Advisory Committee on Reactor Safeguards, https://www.nrc.gov/about-nrc/regulatory/advisory/acrs.html.
21. Ministry of Economy, Trade and Industry, "Green Transformation - Basic Policy for Realization ~ Future Roadmap for 10 years", December 2022, https://www.meti.go.jp/press/2022/02/20230210002/20230210002_1.pdf

22. Atomic Energy Society of Japan, “Code on Implementation and Review of Nuclear Power Plant Ageing Management Programs :2015 (AESJ-SC-P005E：2015”, https://www.aesj.net/publish-1717.

23. Advisory Committee on Reactor Safeguards, report from Joy Rempe, ACRS Chairman, to Christopher T. Hanson, NRC Chairman, Subject: Rulemaking Plan for the Revision of Embrittlement and Surveillance Requirements for High-Fluence Nuclear Power Plants in Long-Term Operation, April 28, 2022. (https://www.nrc.gov/docs/ML2210/ML22105A325.pdf)

24. Advisory Committee on Reactor Safeguards, Letter from Matthew W. Sunseri, ACRS Chairman, to Daniel H. Dorman, NRC Executive Director for Operations, Subject: Research Information Letter (RIL) 2021-13 on Interpretation of Research on Fuel Fragmentation, Relocation, and Dispersal at High Burnup, December 20, 2021. (https://www.nrc.gov/docs/ML2134/ML21347A940.pdf)

25. Advisory Committee on Reactor Safeguards, Report from Dennis C. Bley, ACRS Chairman, to Stephen G. Burns, NRC Chairman, Subject: Draft Final Rule 10 CFR 50.46c, “Emergency Core Cooling System Performance During Loss-Of-Coolant Accidents (LOCA)” and Associated Regulatory Guides, February 23, 2016. (https://www.nrc.gov/docs/ML1604/ML16048A522.pdf)

26. Advisory Committee on Nuclear Safety, “Opinion on Development Needs in Finland Associated with Small Modular Reactors”, October 9, 2019 (in Finnish).

27. Nuclear Energy Act (990/1987), http://www.ilo.org/dyn/natlex/natlex4.detail?p_lang=&p_isn=85507&p_classification=14.01.

28. Autorité de Sûreté Nucléaire, “Guide ASN N° 22: Conception des réacteurs à eau sous pression”, July 18, 2017 , (https://www.asn.fr/l-asn-reglemente/guides-de-l-asn/guide-de-l-asn-n-22-conception-des-reacteurs-a-eau-sous-pression), in French.

29. Official Journal of the European Union, “Council Directive 2014/87/EURATOM of 8 July 2014 amending Directive 2009/71/Euratom establish a Community framework for the Nuclear Safety of Nuclear Installations”, July 2014, (https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32014L0087).

30. U.S. Nuclear Regulatory Commission, “Proposed Rule: Risk-Informed, Technology-Inclusive Regulatory Framework for Advanced Reactors (RIN 3150-AK31)”, SECY-23-0021, March 1, 2023.

APPENDIX A

MEETING AGENDAS AND ATTENDEE LISTS

December 5, 2022, Planning Meeting Agenda

International Regulatory Advisory Committee Meeting

Meeting Agenda
December 5, 2022

<u>MS Teams Meeting ID:</u> Meeting ID: 215 642 888 758 Passcode: ofS44Y

Time relative to Start:
6:00 am US EST/8:00 pm JST/1:00 pm Finland/ 12:00 noon France/11:00 am UK/

00:00	Introductions and Meeting Objectives	J. Rempe, US NRC ACRS
00:15	Finland - Overview of Advisory Committee Structure - Method(s) for Accomplishing Mission - Current Topics under Review - Challenges - Suggested Topics for March 2023 Meeting - Q&As (allow 10 -15 minutes)	L. Reiman, STUK ACSN
00:45	France – Overview of Advisory Committee Structure - Method(s) for Accomplishing Mission - Current Topics under Review - Challenges - Suggested Topics for March 2023 Meeting - Q&As (allow 10 -15 minutes)	T. Charles, ASN GPN
01:15	Japan – Overview of Advisory Committee Structure - Method(s) for Accomplishing Mission - Current Topics under Review - Challenges - Suggested Topics for March 2023 Meeting - Q&As (allow 10 -15 minutes)	A. Sekimura, NRA RSEC and A. Yamamoto NRA NSFEC
01:45	*Break*	*All*
02:00	United Kingdom – Overview of Advisory Committee Structure - Method(s) for Accomplishing Mission - Current Topics under Review - Challenges - Suggested Topics for March 2023 Meeting - Q&As (allow 10 -15 minutes)	P. Garesse, L. Easterbrook, and A. Parkes, ONR CHIAP

December 5, 2022, Planning Meeting Agenda (Continued)

International Regulatory Advisory Committee Meeting

Meeting Agenda
December 5, 2022

02:30	United States – Overview of Advisory Committee Structure - Method(s) for Accomplishing Mission - Current Topics under Review - Challenges - Suggested Topics for March 2023 Meeting - Q&As (allow 10 -15 minutes)	J. Rempe, US NRC ACRS
03:00	Future Actions - Topics for March 2023 meeting - Meeting Format/Agenda/Documentation	*All*
04:00	*Adjourn*	*All*

December 5, 2022, Planning Meeting Attendees

Name	Position
Finland –Advisory Committee on Nuclear Safety to the Radiation and Nuclear Safety Authority (STUK)	
Lasse Reiman	Chairman
Timo Vanttola	Vice Chairman
Juhani Hyvärinen	Member
Petri Kinnunen	Member
Petri Kotiluoto	Member
Heli Talja	Member
Liisa Heikinheimo	MEAE Staff
Karin Rantamäki	Technical Secretary
France - Groupe Permanent Réacteurs (GPR) and Groupe permanent d'experts pour les équipements sous pression Nucléaires (GPESPN) to the Autorité de sûreté nucléaire (ASN)	
Thierry Charles	Chairman, GPR
Jean-François Bossu	Member, GPR
Etienne Courtin	Member, GPR
Alain Ehrlacher	Member, GPR
François Billon	Member, GPESPN
Denis Buisine	Member, GPESPN
Damien Couplet	Member, GPESPN
François Champigny	Member, GPESPN
Marie-Bernadette Degeye	Member, GPR
Jacques Devos	Member, GPR
Jean-Louis Francard	Member, GPR
Jean-Philippe Longin	Member, GPESPN
Philippe Lorino	Member, GPR
José Ángel Martinez	Member, GPESPN
Hervé Mbonjo	Member, GPR
Jean-Marc Miraucourt	Member, GPR
Norbert Nicaise	Member, GPR
Patrick Raymond	Member, GPR
Guy Roussel	Member, GPESPN
Philippe Saint-Raymond	Member, GPR

December 5, 2022, Meeting Attendees (Continued)

Name	Position
France - GPR and GPESPN to ASN (continued)	
Jean- François Sidaner	Member, GPR
Béatrice Tombuyses	Member, GPR
François Toutlemonde	Member, GPR
Marc Vincke	Member, GPR
Eero Virtanen	Member, GPR
Franck Lebrun	Member, ASN
Japan – Reactor Safety Examination Committee (RSEC) and Nuclear Fuel Safety Examination Committee (NFSEC) to Nuclear Regulation Authority (NRA)	
Naoto Sekimura	Chairman, RSEC
Akio Yamamoto	Chairman, NFSEC
Shinji Kinjo	NRA Staff
United Kingdom	
Paul Garesse	Principal Inspector and ONR Chief Nuclear Inspector's Independent Advisory Panel Secretariat
Richard Fowler	Principal Inspector
Andria Gilmour	Superintending Inspector
Aidan Parkes	Inspector and Co-chair, ONR Expert Panel on Natural Hazards
Lee Easterbrook	Principal Inspector
United States - Advisory Committee on Reactor Safeguards (ACRS) to U.S. Nuclear Regulatory Commission (NRC)	
Joy Rempe	Chairman
Walter Kirchner	Vice Chairman
Dave Petti	Member-At-Large
Ronald Ballinger	Member
Charles Brown	Member
Vesna Dmitrijevic	Member
Vicki Bier	Member
Greg Halnon	Member
Jose March-Leuba	Member
Scott Moore	ACRS Executive Director
Quynh Nguyn	ACRS Lead Engineer for International Regulatory Advisory Committee Activity

March 14-15, 2023, Meeting Agenda

International Regulatory Advisory Committee Meeting

March 2023 Meeting Agenda

Microsoft Teams meeting

Join on your computer, mobile app or room device

Click here to join the meeting

Meeting ID: 250 956 332 227

Passcode: YuEXo9

Download Teams | Join on the web

Or call in (audio only)

+1 301-576-2978,,401629547# United States, Silver Spring

Phone Conference ID: 401 629 547#

Tuesday March 14, 2023 Session 1 Operating Fleet

12:30	Welcome and Introductions Meeting Logistical Information	J. Rempe NRC ACRS
12:45	Session 1 Chair Opening Remarks	N. Sekimura NRA RSEC
13:00	Finland Aging Management in Finnish NPPs - Q&As (allow 10 -15 minutes)	K. Rantamäki, P. Kinnunen, and H. Talja STUK ACNS
13:45	France Operating Fleet in France: -Lessons Learnt from the NPPP's Operation - Periodic Safety Revies and LTO - Q&As (allow 10 -15 minutes)	B. de L'Epinois ASN GPR
14:30	*Break*	*All*
14:45	Japan - Regulation for Current Fleet in Japan - Current Status of Regulation and Ageing Management and Safe Long Term Operation of Nuclear Power Plant in Japan - Q&As (allow 10 -15 minutes)	T. Ichimura NRA N. Sekimura NRA RSEC
15:30	United States -Materials Aging-Related Issues -High Burnup Fuel Issues - Q&As (allow 10 -15 minutes)	R. Ballinger US NRC ACRS
16:15	General Discussion – Facilitated by Session 1 Chair	*All*
17:00	*Adjourn*	*All*

March 14-15, 2023, Meeting Agenda (continued)

International Regulatory Advisory Committee Meeting

March 2023 Meeting Agenda

Microsoft Teams meeting

Join on your computer, mobile app or room device

Click here to join the meeting

Meeting ID: 261 472 746 844

Passcode: RvnrKq

Download Teams | Join on the web

Or call in (audio only)

+1 301-576-2978,,843779976# United States, Silver Spring

Phone Conference ID: 843 779 976#

Wednesday March 15, 2023 Session 2 New Challenges

08:15	Welcome and Meeting Logistical Information Session 2 Chair Opening Remarks	J. Rempe NRC ACRS
08:30	Finland - Recent new build experience and outlook on SMRs in Finland - Q&As (allow 10 -15 minutes)	J. Hyvärinen STUK ACNS
9:15	France - Design of PWRs: The Guide of N°22 of ASN and IRSN - Q&As (allow 10 -15 minutes)	B. de L'Epinois ASN GPR
10:00	Japan - Session 2 – Country Presentation Development/Construction of Next-generation Advanced Reactors Advisory Committee Structure and Topics discussed Nuclear Regulatory Human Resource Development Project A Model of a Robust National Nuclear System - Q&As (allow 10 -15 minutes)	T. Ichimura NRA N. Sekimura, NRA RSEC
10:45	*Break*	*All*
11:00	United Kingdom - Challenges for New Reactors - Q&As (allow 10 -15 minutes)	T. Parkes ONR CHIAP
11:45	United States - Considerations related to licensing FOAK Reactors when there is little or no operating experience - Risk Surrogates (Safety Goals) for Small Modular LWRs and Non-LWRs - Q&As (allow 10 -15 minutes)	D. Petti V. Bier US NRC ACRS
12:30	General Discussion – Facilitated by Session 2 Chair	*All*
13:00	*Adjourn*	*All*

March 14-15, 2023, Meeting Attendees

Name	Position
Finland –Advisory Committee on Nuclear Safety to the Radiation and Nuclear Safety Authority (STUK)	
Lasse Reiman	Chairman
Timo Vanttola	Vice Chairman
Juhani Hyvärinen	Member
Petri Kinnunen	Member
Petri Kotiluoto	Member
Heli Talja	Member
Liisa Heikinheimo	Ministry of Economic Affairs and Employment (MEAE) Staff
Karin Rantamäki	Technical Secretary
France - Groupe Permanent Réacteurs (GPR) and Groupe permanent d'experts pour les équipements sous pression Nucléaires (GPESPN) to the Autorité de sûreté nucléaire (ASN)	
Thierry Charles	Chairman, GPR
Jean-François Bossu	Member, GPR
Etienne Courtin	Member, GPR
Alain Ehrlacher	Member, GPR
François Billon	Member, GPESPN
Denis Buisine	Member, GPESPN
Damien Couplet	Member, GPESPN
François Champigny	Member, GPESPN
Marie-Bernadette Degeye	Member, GPR
Jacques Devos	Member, GPR
Bertrand de L'Epinois	Member, GPR
Karine Herviou	Member, GPR
Jean-Louis Francard	Member, GPR
Jean-Philippe Longin	Member, GPESPN
Philippe Lorino	Member, GPR
José Ángel Martinez	Member, GPESPN
Hervé Mbonjo	Member, GPR
Jean-Marc Miraucourt	Member, GPR
Norbert Nicaise	Member, GPR
Patrick Raymond	Member, GPR

March 14-15, 2023, Meeting Attendees (continued)

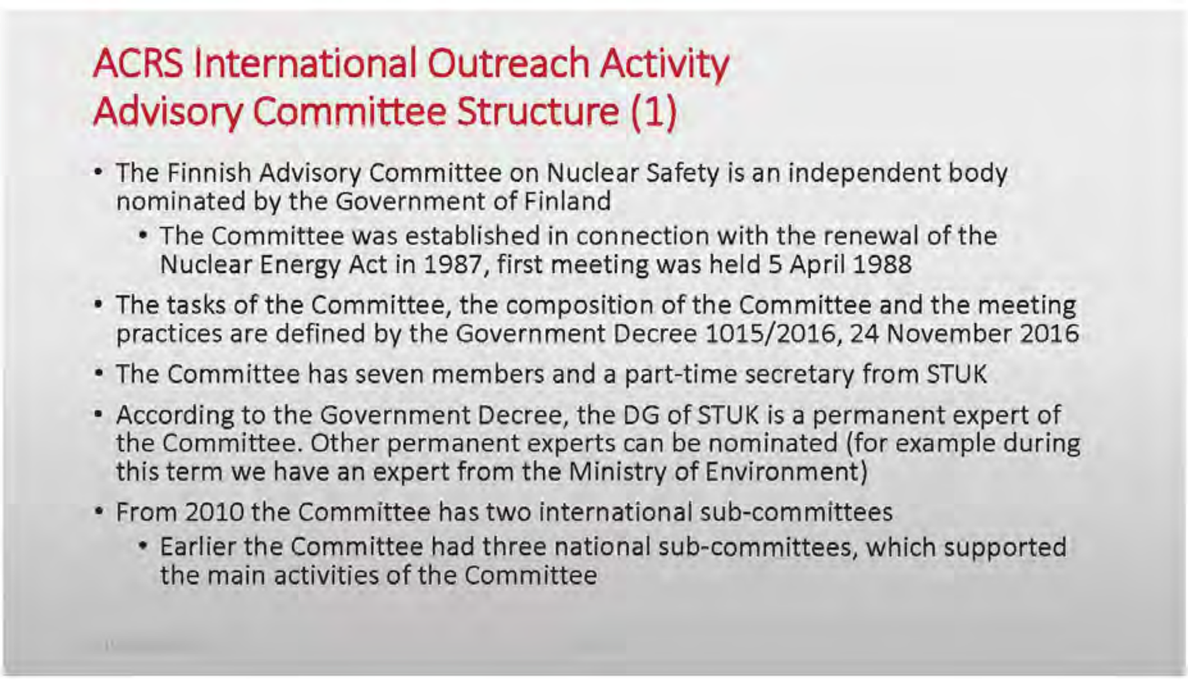
Name	Position
France - GPR and GPESPN to ASN (continued)	
Guy Roussel	Member, GPESPN
Philippe Saint-Raymond	Member, GPR
Jean- François Sidaner	Member, GPR
Béatrice Tombuyses	Member, GPR
François Toutlemonde	Member, GPR
Marc Vincke	Member, GPR
Eero Virtanen	Member, GPR
Franck Lebrun	Member, ASN
Japan – Reactor Safety Examination Committee (RSEC) and Nuclear Fuel Safety Examination Committee (NFSEC) to Nuclear Regulation Authority (NRA)	
Naoto Sekimura	Chairman, RSEC
Tomoya Ichimura	NRA Staff
Shinji Kinjo	NRA Staff
United Kingdom	
Tim Parkes	Superintending Inspector, Head of Safety Regulation – Sizewell C, Advanced Nuclear Technologies and Innovation
Rachel Curtis	Inspector – External Hazards
Paul Garesse	Principal Inspector – Executive Suport Office
United States - Advisory Committee on Reactor Safeguards (ACRS) to U.S. Nuclear Regulatory Commission (NRC)	
Joy Rempe	Chairman
Walter Kirchner	Vice Chairman
Dave Petti	Member-At-Large
Ronald Ballinger	Member
Charles Brown	Member
Vesna Dmitrijevic	Member
Vicki Bier	Member
Greg Halnon	Member
Jose March-Leuba	Member
Scott Moore	ACRS Executive Director
Quynh Nguyn	ACRS Lead Engineer for International Regulatory Advisory Committee Activity

APPENDIX B

DECEMBER 5, 2022, PLANNING MEETING PRESENTATIONS

B.1 Finland


ACRS International Outreach Activity
Virtual meeting, 5 December 2022
Overview of the activities of the Finnish Advisory Committee on Nuclear Safety
Lasse Reiman
Finnish Advisory Committee on Nuclear Safety
Chair


ACRS International Outreach Activity
Advisory Committee Structure (1)
• The Finnish Advisory Committee on Nuclear Safety is an independent body nominated by the Government of Finland
• The Committee was established in connection with the renewal of the Nuclear Energy Act in 1987, first meeting was held 5 April 1988
• The tasks of the Committee, the composition of the Committee and the meeting practices are defined by the Government Decree 1015/2016, 24 November 2016
• The Committee has seven members and a part-time secretary from STUK
• According to the Government Decree, the DG of STUK is a permanent expert of the Committee. Other permanent experts can be nominated (for example during this term we have an expert from the Ministry of Environment)
• From 2010 the Committee has two international sub-committees
• Earlier the Committee had three national sub-committees, which supported the main activities of the Committee

ACRS International Outreach Activity
Advisory Committee Structure (2)

- The composition (7) of the present Committee:
  - The chair, vice-chair and one member of the Committee are retired persons (one from STUK, two from VTT)
  - Three members are representing research organizations
  - One member is a professor in nuclear engineering
- The Committee has two international sub-committees (reactor safety, nuclear waste safety)
- The chair of a subcommittee has to be a member of the main Committee, the other members (5) of the sub-committees come from different nuclear regulatory organizations in Europe representing important references to STUK
- The subcommittees discuss and give recommendations to STUK concerning important topical safety issues, the main committee reviews (and typically confirms) their recommendations

ACRS International Outreach Activity
Methods for Accomplishing Mission (1)

- The main tasks of the Committee are (GD 1015/2016):
  - To give statements on license applications concerning construction and operation of a nuclear facility, and on other important applications concerning the use of nuclear power
  - To give statements on regulations and guides concerning safe use of nuclear power
  - To give statements on important issues related to the regulatory oversight of safe use of nuclear power
  - To follow development of nuclear safety and related research
  - To promote national co-operation and follow international co-operation concerning safe use of nuclear power
  - To make initiatives to competent authorities for necessary actions concerning safe use of nuclear power

ACRS International Outreach Activity
Methods for Accomplishing Mission (2)

- For its daily activities the Committee has Rules and Procedures, which define the tasks of the sub-committees, meeting practices of the Committee and its sub-committees, handling of matters in the Committee, and reporting practices
- For each term of the Committee an Action Plan is established, based on the tasks of the Committee defined in the Government Decree (1015/2016).
- The Committee nowadays prepares all its statements by itself
- As concerns license applications, the Committee makes an assessment of STUK's review related to the application, and selected parts of the application
  - The experts of STUK and the licensee or license applicant make presentations to the Committee concerning important topics the Committee has selected for license application review
  - The Committee makes visits to the related nuclear facilities
- The work of the Committee is public; all meeting minutes are published on STUK's website, no public meetings are held

ACRS International Outreach Activity
Current Topics under Review

- The Committee has at the moment two main license applications under review:
  - Renewal of the Operating License of the Loviisa NPP until 2050
    - The existing operating licenses expire in 2027 (Loviisa 1) and 2030 (Loviisa 2) at which time the units have been in operation for 50 years
  - Operating License of the final disposal facility and encapsulation plant for spent fuel (ONKALO facility)
- The Committee follows the progress of the overall renewal of the legislation related to nuclear safety and reviews the progress of the revision of STUK's regulations and regulatory guides (2022-2028)
- According to the Action Plan the Committee reviews regularly for example the following topics:
  - Important operating experiences and events at Finnish nuclear facilities
  - Implementation of STUK's strategy
  - Development of on-site emergency preparedness arrangements
  - Experiences from safeguards oversight

ACRS International Outreach Activity
Topics reviewed by the Committee

- The present and previous Committee have reviewed for example the following topics:
  - Review and statement concerning the OL 3 operating license application
  - Review and statement concerning the PSRs for the Loviisa NPP and the final disposal facility for low and medium level waste of Loviisa NPP (2021-2022)
  - Review of STUK's revised regulations (2018 versions) and some revised YVL Guides (for example related to nuclear security)
  - STUK's new Project (2022-2028) to revise its regulations and regulatory guides
  - Effects of COVID-19 on nuclear safety in Finland
  - Approval of standard equipment for safety related applications (KELPO Project)
  - Modernisation of I&C systems at operating NPPs
  - National reports to safety convention review meetings (nowadays only for information)
  - Major events at the operating NPPs, progress in the OL 3 and Fennovoima NPP project (terminated) and in the Posiva ONKALO project

ACRS International Outreach Activity
Topics reviewed by the Committee

- The previous Committee (2019-2021) made an initiative concerning preparations for the possible use of SMR's in Finland and gave altogether 19 statements mostly related to proposed changes in legislation and STUK's regulations and YVL Guides
- SMR Initiative:
  - SMRs meant for district heating or combined district heating should be sited adequately close to district heating networks, which means adequately close to population centres
  - EP and security arrangements for this kind of siting need to be assessed
  - New type of solutions may be needed in the construction, operation and ownership of SMRs meant for district heating
  - Recommendations were presented both to the responsible Ministry and STUK to prepare for the possible use of SMRs: to renew the licensing process, to ensure adequate national competence and knowledge of SMRs, and to ensure adequate research resources, analysis capabilities and facilities for both theoretical and experimental work

ACRS International Outreach Activity
Challenges

Resources

- The Committee nowadays prepares all statements by itself, which may be a problem as concerns the resources of the Committee, especially if more than one license application would be under review in the Committee

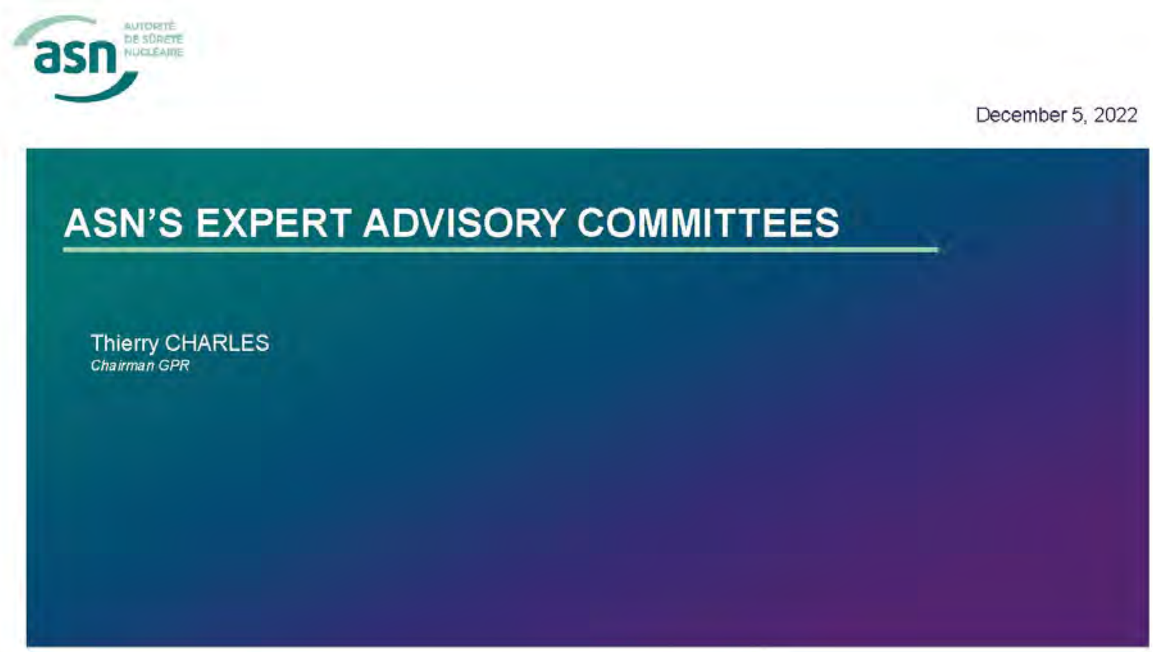
Members of the Committee

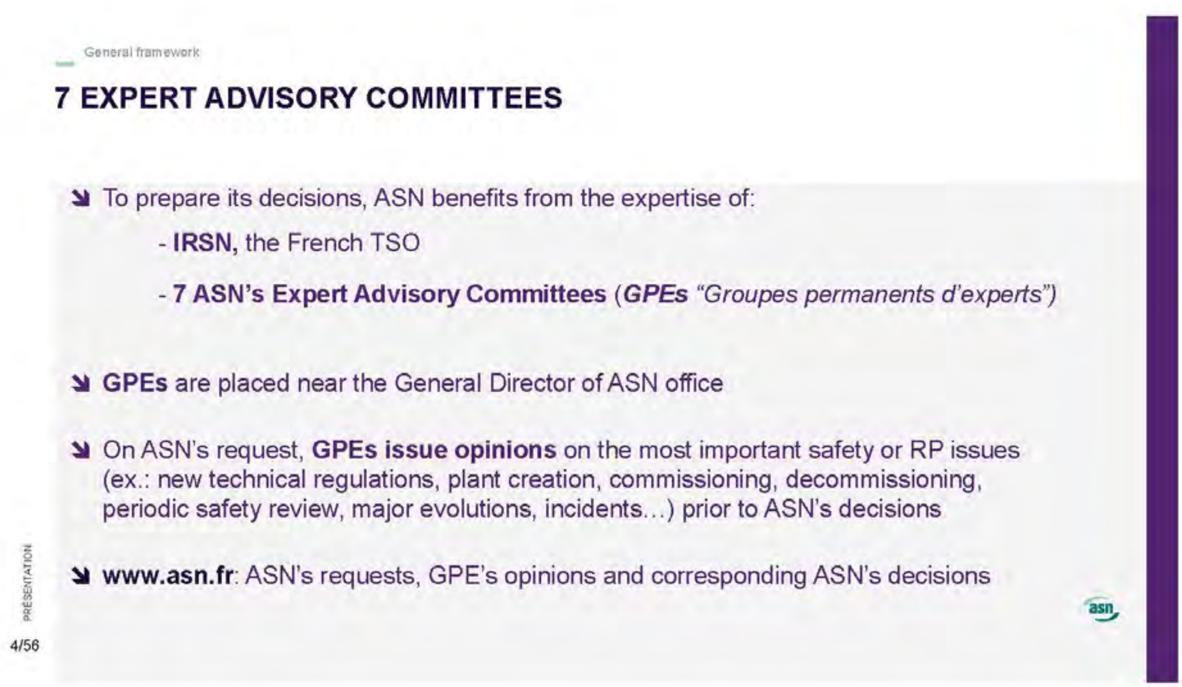
- The membership brings quite a lot of work to some members, high motivation is needed
  - The work is not visible to public
  - Members still working actively may have difficulties to find time for this work
  - Retired members may have difficulties to follow developments in nuclear safety
  - Independence requirements may limit possibilities for membership
  - Practical knowledge concerning regulatory and/or operational practices may be limited in research organizations

ACRS International Outreach Activity
Suggested Topics for the March 2023 meeting

- Approval practices and processes (for example plant and systems design maturity in construction license phase, qualification practices for equipment approvals including approval of standard products)
- Near-future nuclear technologies and their regulatory challenges
- Regulatory oversight of organizational issues

B.2 France


asn
AUTORITÉ DE SÛRETÉ NUCLÉAIRE
December 5, 2022
ASN'S EXPERT ADVISORY COMMITTEES
Thierry CHARLES
Chairman GPR


General framework
7 EXPERT ADVISORY COMMITTEES
To prepare its decisions, ASN benefits from the expertise of:
- IRSN, the French TSO
- 7 ASN's Expert Advisory Committees (GPEs "Groupes permanents d'experts")
GPEs are placed near the General Director of ASN office
On ASN's request, GPEs issue opinions on the most important safety or RP issues (ex.: new technical regulations, plant creation, commissioning, decommissioning, periodic safety review, major evolutions, incidents…) prior to ASN's decisions
www.asn.fr: ASN's requests, GPE's opinions and corresponding ASN's decisions
PRÉSENTATION
4/56

General framework

7 ADVISORY COMMITTEES OF EXPERTS

Advisory Committees are thematic:

- Nuclear Reactors (GPR),
- Laboratories and Plants (GPU)
- Waste (GPD)
- Radiation Protection (GPRP)
- Nuclear Pressure Equipment (GPESPN)
- Decommissioning (GPDEM),
- Transport (GPT)

The GPEs appropriate the information made available to them and form an informed and independent opinion in answer to the ASN request

They act as guarantors of the doctrine in nuclear safety and radiation protection and contribute to its development

More information on ASN website

PRÉSENTATION

4/56

Members of GPE

EXPERTS APPOINTED

4-year mandates, renewable.

Nota: the 6 safety GPEs will be renewed on January 1st , 2023. A selection process with public call for applications (published on ASN website).

Experts appointed individually for their competence, mainly from :

- risk assessment and research organizations,
- nuclear and industrial sectors, from France (with deontological rules) and abroad
- foreign regulators and TSOs, for international experience (They need to speak French !)
- the civil society

GPEs Rules of procedure (in French on ASN website)

PRÉSENTATION

4/56

EXPERTS APPOINTED

GPR / GPU / GPD / GPDEM : mainly experts of design and operation of concerned plants (PWR for GPR), experts of technical concerned fields (neutronics, thermohydraulic… for GPR), experts of general risks (fire, HOF…)

GPESPN : experts mainly in the field of nuclear pressure equipment (materials, mechanics, corrosion, welding, non-destructive control…)

GPT : experts in the field of transport and associated risks, with in particular representatives from the French committee for certification of companies in training and monitoring of personnel working with ionizing radiations.

GPRP : experts in the field of radiation protection of workers, the public and patients and for medical, industrial and research applications of ionizing radiations, including natural ionizing radiations.

WORKING METHODS

- 1 chair, 1 vice-chair, ~ 30-35 experts/group
- Opinions produced on ASN request (main cases) or GPE's initiative
- All opinions are published on ASN website (in French)
- Plenary meetings with opinions (5 to 10 meetings/year for GPR):
  - 1 or 2 day's meeting
  - 2 phases:

    (1) **discussions**, on the basis of the IRSN assessment report of the concerned files and with the presence of operator representatives

    (2) **opinion drafting** (experts only)
- Information meetings, visit of plants (to prepare future meetings)
- specific WGs (to prepare specific GPE meetings)

Members of GPE

WORKING METHODS

➘ Interactions with other GPEs on specific issues – for example :

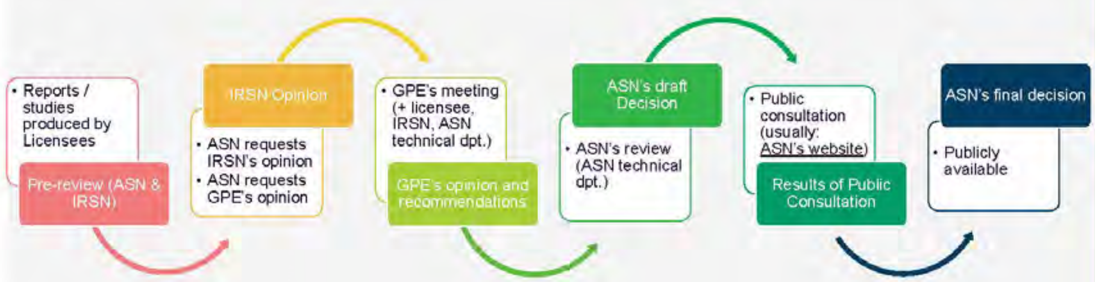
- GPR + GPESPN: on common issues dealing with reactors (ex: current stress corrosion cracking on several French reactors, IGSCC).
- GPR + GP RP: for annual review of EDF operation experience feedback.
- GPU + GPR + GPD + GPT: for periodic review of the fuel cycle of the EDF nuclear fleet.

PRÉSENTATION

4/56

GPE's Working process

PART OF ASN'S REVIEW PROCESS



PRÉSENTATION

4/56

CURRENT TOPICS AND REVIEWS

French operating fleet:

- Long term operation and periodic safety reviews:
  - Ageing management
  - Safety reassessment: accident analyses, internal and external hazards, severe accidents, probabilistic safety assessment, modifications to improve safety
- Lessons learnt from operation
- Lessons learnt from Fukushima Daiichi accident

New reactors

- EPR Flamanville 3: more than 20 meetings of GPR and GPESPN about the safety case and the deviations
- EPR2: general safety options, design and safety case

PRÉSENTATION

CHALLENGES

- **Operating fleet**:
  - Conformity of the plants with their safety requirements
  - Human and organizational factors
  - Plant safety management
  - Ageing management,
  - Ageing of RPV, methods for the safety case
  - Lifetime extension and safety improvement
  - Severe accident mitigation
  - Climate change

CHALLENGES

New reactors:

- Control of the quality and reliability of industrial equipment
- Project management and safety requirements integration
- Implementation of break preclusion approach
- Defense in depth
- Passive systems
- General safety objectives for SMRs

SUGGESTED TOPICS FOR MARCH 2023

Operating fleet:

- Lessons learnt from the NPP's operation
- Long term NPP's operation

New challenges:

- General safety objectives for new reactors

PRESENTATION

PROPOSED MEETING FORMAT FOR MARCH 2023

- **A two-days meeting with two thematic sessions of about 4 hours each:**
  - **1st day: session 1 dedicated to operating fleet**

    Ageing, experience feedback, long term operation…
  - **2nd day: session 2 dedicated to new challenges**

    New reactors, ATR, advanced safety methods/approaches...

With **two possibilities** for the detailed program

PRÉSENTATION

asn

PROPOSED MEETING FORMAT FOR MARCH 2023

1. **Each session is thematic, and each country is free to present a related topic**
2. **Each thematic session includes two specific topics, for which each country presents its point of view. Example :**
   - **Session 1 (operating fleet)**
     - NPP's operating feedback
     - NPP's operating lifetime
   - **Session 2 (New challenges)**
     - Safety objectives for new PWR reactors
     - Other new reactors, SMR, new subject (ATR for example), advanced safety method

PRÉSENTATION

asn

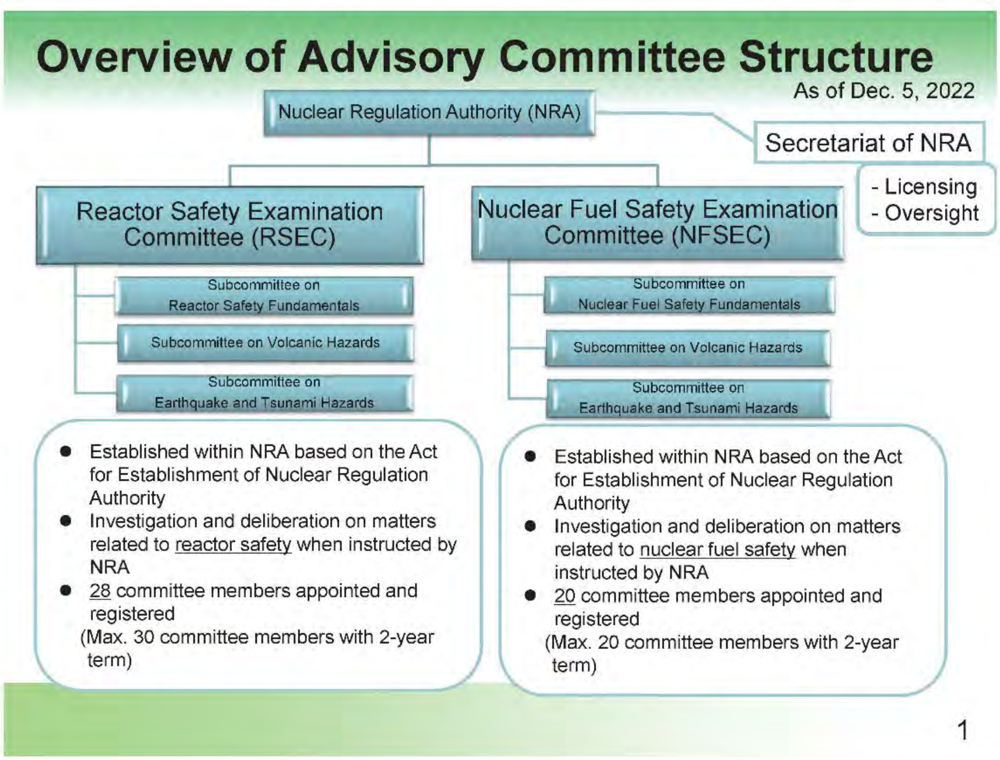
Thanks for your attention

…

Now, it's discussion time

B.3 Japan

B.3.1 Overview Presentation



Methods for Accomplishing Mission

Decided by NRA on Feb. 5, 2014

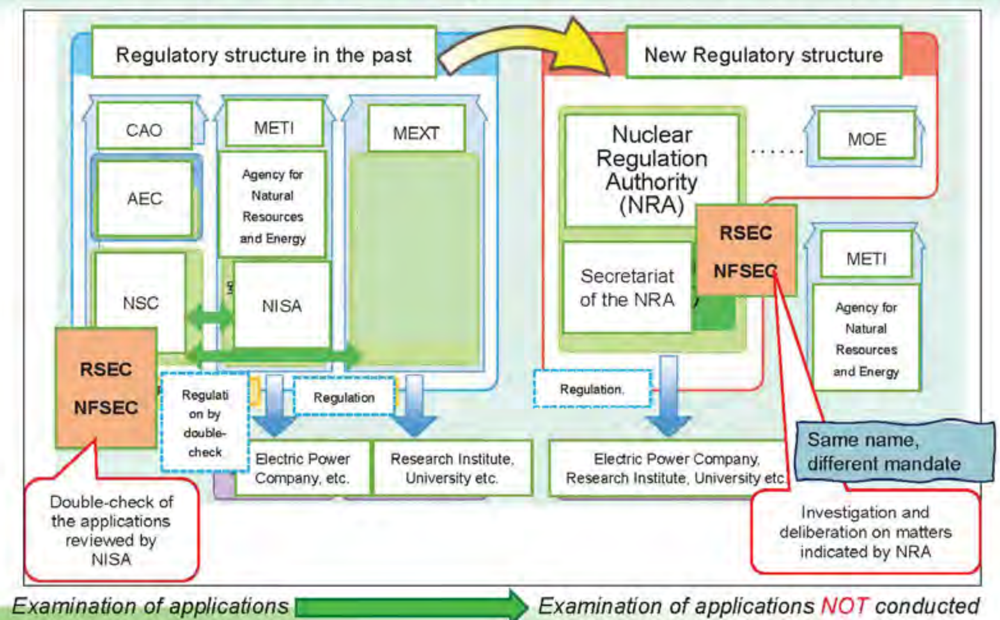
- RSEC and NFSEC
  - ✓ conduct investigation and deliberation on matters related to reactor safety and nuclear fuel safety when indicated by NRA,
  - ✓ do not act as a substitute for decision making of NRA, and
  - ✓ provide advisory information to NRA for its own decision making.

Operational Policy decided by the Committees on May 12, 2014

- Committee meetings are open to the public and minutes of meetings and materials used in these meetings are publicly disclosed, in principle.
- Deliberation status is reported to NRA.

2

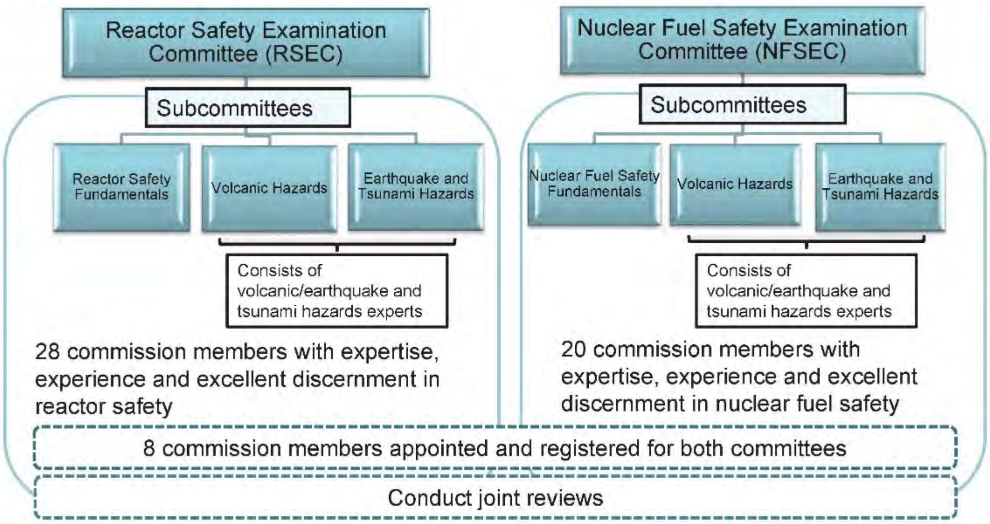
Overview of Advisory Committee Structure



3

Overview of Advisory Committee Structure (Cont'd)

As of Dec. 5, 2022



Challenges

- ✓ Human resource development (academia)
- ✓ Gender balance

4

Overview of Advisory Committee Structure (Cont'd)

The committee and subcommittee meetings held in the last two years

- **The 21st RSEC meeting & The 27th NFSEC meeting *(2020-12-15)***
- **The 7th RS Fundamentals Subcom. meeting & The 1st NFS Fundamentals Subcom. meeting *(2021-5-21) (web)***
- **The 8th RS Fundamentals Subcom. meeting & The 2nd NFS Fundamentals Subcom. meeting *(2021-9-16) (web)***

<Visit to inspection sites>

Mihama NPS (2021-12-17), Genkai NPS (2022-1-6), Ohi NPS (2022-1-7)

- **The 9th RS Fundamentals Subcom. meeting & The 3rd NFS Fundamentals Subcom. meeting *(2022-1-14) (web and in-person)***
- **The 10th RS Fundamentals Subcom. meeting & The 4th NFS Fundamentals Subcom. meeting *(2022-3-15) (web and in-person)***
- **The 11th RS Fundamentals Subcom. Meeting & The 5th NFS Fundamentals Subcom. meeting *(2022-6-10) (web and in-person)***
- **The 22nd RSEC meeting & The 28th NFSEC meeting *(2020-6-10) (discussion by correspondence)***
- **The 12th RS Fundamentals Subcom. Meeting & The 6th NFS Fundamentals Subcom. meeting *(to be held within 2022) (web and in-person)***

5

Current Topics under Review and Challenges

Decided and revised by NRA on Sept. 30, 2020

Eight topics NRA has indicated for investigation and deliberation:

(1) To conduct investigations and deliberations on the necessity of responses based on the collection and analysis of information on accidents and troubles that have occurred in Japan and overseas, as well as trends in regulations overseas, and provide advice.

(2) To evaluate and advise on the response status of the NRA in response to the conclusions (including conclusions related to transportation) of the IRRS (Integrated Regulatory Review Service of the IAEA) follow-up mission conducted in January 2020.

(3) To conduct investigations and deliberations on the implementation status of the new nuclear regulatory inspection system (ROP-type inspection) enforced in April 2020 by regulatory bodies and operators, and provide advice.

(4) To hear from operators about evaluation report for improving the safety of power reactor, based on the provisions of Article 43-3-29 of the Act on the Regulation of Nuclear Source Materials, Nuclear Fuel Materials and Reactors, and provide advice on how to utilize them.

6

Current Topics under Review and Challenges (Cont'd)

Topics identified for subcommittees on Volcanic Hazards and Earthquake and Tsunami Hazards

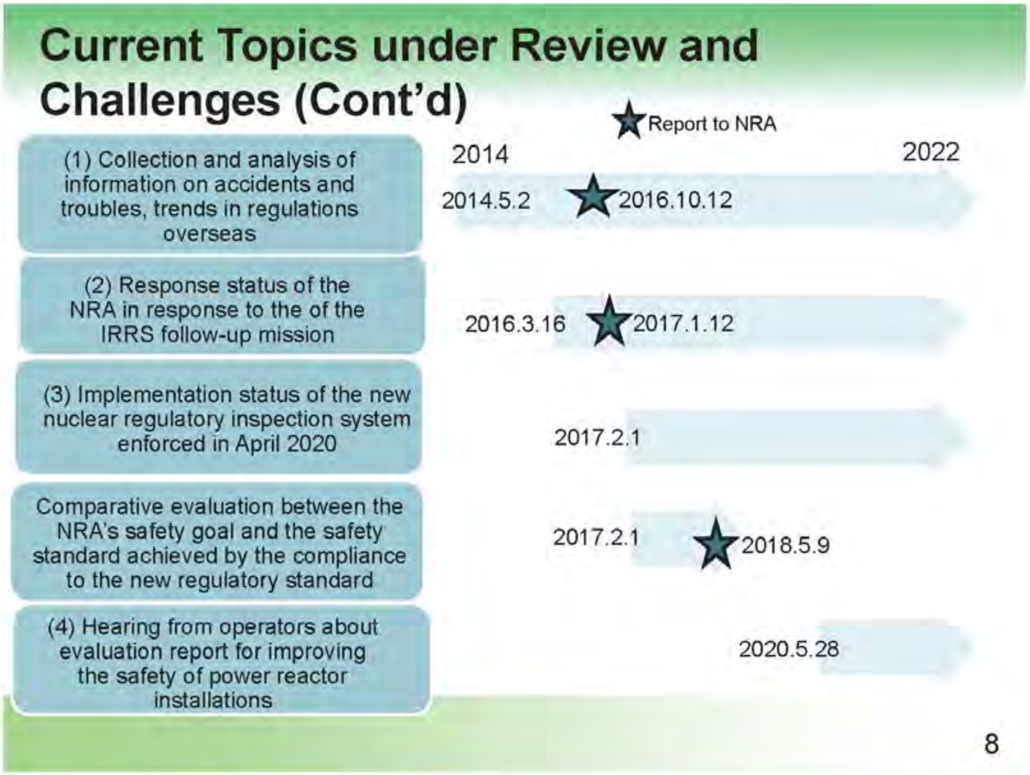
(5) To conduct investigations and deliberations on the NRA's evaluation of the volcano monitoring results of nuclear power generation operators, and provide advice. *<Instructions only to the RSEC>*

(6) To conduct investigations and deliberations on the NRA's evaluation of the volcano monitoring results of nuclear fuel facility operators, and provide advice. *<Instructions only to the NFSEC>*

(7) To conduct investigations and deliberations on the necessity of regulatory responses and provide advice, based on the results of collection and analysis of information related to earthquakes, tsunamis, and other events, disasters that have occurred in Japan and overseas, knowledge announced by administrative agencies, etc.

(8) To conduct investigations and deliberations on the necessity of regulatory responses and provide advice, based on the results of collection and analysis of information related to volcanic events, such as disasters that have occurred in Japan and overseas, and findings announced by administrative agencies, etc.

7



Current Topics under Review and Challenges (Cont'd)

Committees' report to NRA regarding the NRA's safety goal

1. The NRA's safety goal is based on the posture that under the determination not to cause the serious accident like the Fukushima Daiichi Nuclear Power Station ever again, without falling into a myth of safety and making efforts for continuous improvement of safety. In addition, NRA should refer to the safety goal on the development of the regulatory standard.
2. Comparative evaluation between the NRA's safety goal and the safety standard achieved by the compliance to the new regulatory standard cannot be directly performed or explained by using only a standard of probability at present, and it should not be done.
3. Regarding NRA's safety goal, these are the points should be explained to the nation.

9

Suggested Topics for March 2023 Meeting

Participation in the March meeting is under consideration.

10

Thank you for your attention!

ご静聴ありがとうございました。

11

B.3.2 Supplementary Presentation during Closing Discussion

July, 2022

Global Perspective on Continuous Improvement of Nuclear Safety : 10 years after the Fukushima Daiichi Accident

Naoto Sekimura, Prof., Dr.

Vice President, The University of Tokyo
Professor, Department of Nuclear Engineering and Management

Chairperson, Nuclear Reactor Safety Examination Committee, NRA Japan

Member of Science Council of Japan
Chairperson of Sub-Committee on Nuclear Safety

A Model of a Robust National Nuclear System

INSAG-27 (IAEA, 2017)

Regulation' includes all regulatory activities and controls, but a prime method of interaction and feedback is regulatory inspection activities.

32

Layer 1 : Components of a Strong Nuclear Industry Sub-system

Layer 1.1 Licensee and Operator level	Layer 1.2 Peer Pressure at State/Regional level	Layer 1.3 Peer Pressure/Review at International Industry level	Layer 1.4 Review at International Institutional level
• Suitably qualified and experience staff to ensure safety • Technical, design or operational capability including sub-contractors • Strong management systems multiple checks and balances • Company Nuclear Safety committee with external members • Company board that holds the executive to account • Vibrant safety culture led from the top • Independent nuclear safety assessment review and inspection	• National/Regional Industrial High Level Forums/ Associations (JANSI、ATENA?) • Other Organizations involved in Emergency Preparedness and Response	• WANO missions and Requirements • Bilateral and Multilateral Organization (e.g. BWR Owners Group)	• IAEA OSART missions • IAEA SALTO missions

OSART: Operational Safety Review Team
SALTO: Safety Aspects of Long Term Operation

Nuclear leadership, culture and values

33

Layer 2 : Components of a Strong Regulatory Sub-system

Layer 2.1 Regulatory Authority	Layer 2.2 Special Outside Technical Advice	Layer 2.3 International Peer Pressure	Layer 2.4 International Peer Reviews

• World class technical /regulatory capability and competencies, including assessment, licensing, inspection, enforcement and influencing
• The inherent technical capabilities are sometimes augmented by TSO
• Organizational structure with internal standards, assurance, operating experience feedback, policy, strategy, decision reviews, etc.
• Regulatory safety culture with openness and transparency as core values
• Formal Accountability to internal governing body
	• Standing Panel of experts
	• Special Expert Topic Groups on such as;
	  • Natural hazards (Seismic, Tsunami, Volcanic, ….)
	  • Aircraft crash
	  • Probabilistic safety assessment
	  • Human intervention
	  • Digital instrumentation and control
		• OECD/NEA committees and WGs (CNRS & CSNI)
		• IAEA Convention on Nuclear Safety
		• WENRA reference levels, reviews, groups, stress tests
		• HERCA
		• INRA (top regulators)
		• IAEA Safety Standards Commission and Committee meetings
			• IAEA IRRS missions

WENRA : Western European Nuclear Regulators' Association
HERCA : Heads of the European Radiological protection Competent Authorities
INRA : International Nuclear Regulators Association

IRRS : Integrated Regulatory Review Service

Nuclear leadership, culture and values

34

B.4 United Kingdom

Office for Nuclear Regulation

International Regulatory Advisory Committee Meeting

5 December 2022

Office for Nuclear Regulation (ONR)

Independent Advisory Committees and Expert Panels

1. Introduction to ONR
2. Expert Panels on Natural Hazards
3. Graphite Technical Advisory Committee
4. Chief Nuclear Inspector's Independent Advisory Panel

26/12/2022 Footer 2

Introduction to United Kingdom's Office for Nuclear Regulation (ONR)

- Created in 2011 as an arm of the Health and Safety Executive (HSE)
- Established as statutory corporation in 2014
- Offices in Liverpool, Cheltenham and London
- Single, independent regulator for nuclear safety, security and safeguards
- Three independent expert panels

Mission: To protect society by securing safe nuclear operations

Vision: To be a modern, transparent regulatory delivering trusted outcomes and value

Expert Panel on Natural Hazards
Overview

- The panel was first formed in 2010.
- ONR's Expert Panel on Natural Hazards is a group of independent academics and specialist consultants covering a range of skill areas relevant to seismic hazards, meteorological and coastal flooding hazards, and climate change.
- The Panel provides ONR External Hazards inspectors with a valuable source of authoritative **technical and independent expertise**. This supports ONR's mission to protect society by securing safe nuclear operations (now and into the future).

Expert Panel on Natural Hazards
Overview

ONR formed the expert panel on natural hazards in recognition of the following:

- External hazards represent significant safety challenges to nuclear facilities at levels of safety demanded in the UK.
- External hazards are generally very uncertain in terms of likelihood and severity and many remain active areas of academic research.
- External hazards generate significant public / stakeholder interest.
- Nuclear regulatory judgements are increasingly likely to be debated / challenged in the public arena. Judgements based on poor technical advice may undermine ONRs reputation as a regulator.

5

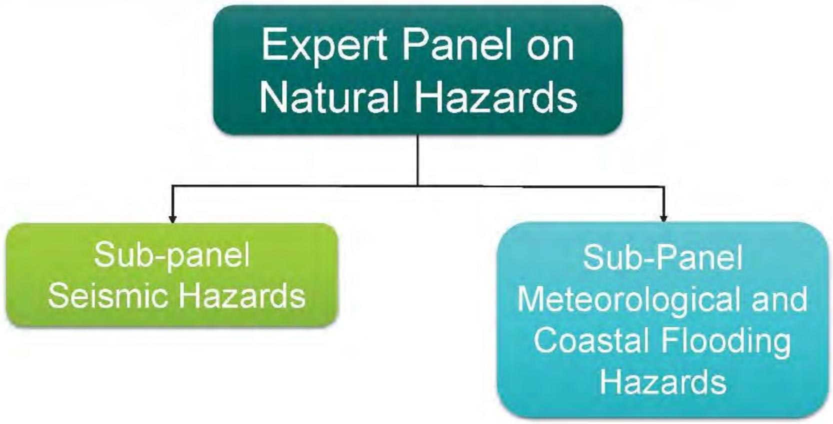
Expert Panel on Natural Hazards
Overview

The basis for selection of panel members ONR considered the following:

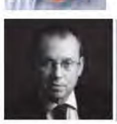
- The technical pedigree of experts should ideally be internationally recognised.
- Experts must be prepared to provide the necessary services to ONR.
- Experts should be independent of involvement with dutyholders so as to avoid conflict of interest.
- Experts should be prepared to make a long-term commitment to working with ONR (typically 3-5 year contracts).

6

Expert Panel on Natural Hazards
Panel Structure



ONR Expert Panel on Natural Hazards
Composition - Seismic Sub-panel

	Prof. Peter Stafford	Professor of Engineering Seismology, Department of Civil & Environmental Engineering, Imperial College London *[Engineering seismology, seismic hazard analysis]*
	Prof. Bob Holdsworth	Professor of Structural Geology, Durham University *[Structural geology, regional geology of British Isles, capable faulting analysis]*
	Prof. Ian Main	Professor of seismology and rock physics, University of Edinburgh *[Seismology, statistical seismology, rock physics]*
	Dr Julian Bommer *[Honorary Member]*	Consultant, formerly Professor of Earthquake Risk Assessment at Imperial College *[Engineering seismology,* seismic hazard analysis, SSHAC framework]

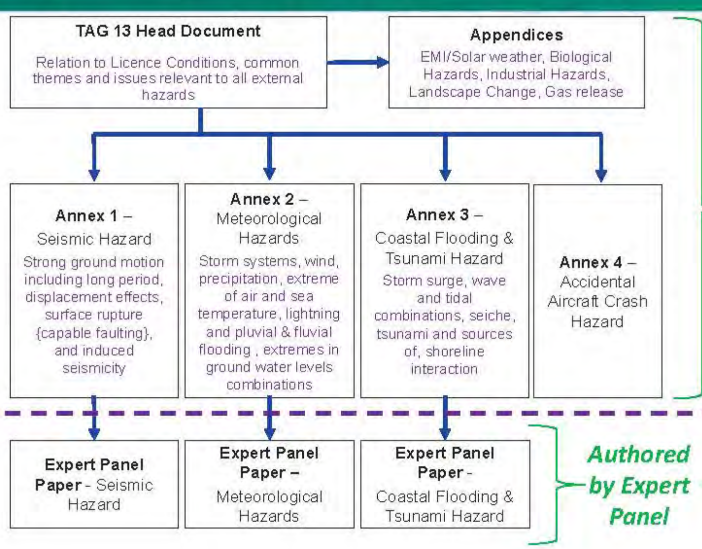
8

ONR Expert Panel on Natural Hazards
Composition - Meteorological & Coastal Flooding Sub-panel

	Prof. Stephan Harrison	Professor of Climate and Environmental Change, University of Exeter, and Director of Climate Change Risk Management *[Climate science, climate change impacts, earth systems and environmental change]*
	Prof. Alan Gadian	Professor of Dynamical Meteorology, National Centre of Atmospheric Science, University of Leeds *[Meteorology, dynamical meteorology, atmospheric processes and physics]*
	Prof. Ivan Haigh	Professor of Sea-Level Rise and Coastal Oceanography, University of Southampton *[Sea-level rise, extreme sea levels and coastal flooding, coastal flooding impacts]*
	Paul Sayers	Partner, Sayers and Partners LLP *[Flooding, coastal processes, coastal defences and adaptation strategies]*

9

ONR Expert Panel on Natural Hazards
Outputs - ONR TAG 13 Expert Panel Papers



http://www.onr.org.uk/operational/tech_asst_guides/ns-tast-gd-013.htm

ONR Expert Panel on Natural Hazards: provides credible, independent advice to support ONR's own regulatory specialists in their decision making, including assessment of safety cases

ONR Expert Panel on Natural Hazards
Outputs - ONR TAG 13 Expert Panel Papers

- These recognise that analysis of natural hazards is generally undertaken by dedicated experts.
- Each natural hazards Annex has support of one EPP.
- These provide advice and interpretation of Relevant Good Practice for experts and the ONR External Hazards team.
- EPPs do not conform to a standard format but rather support and are heavily referenced from Annexes.
- It is envisaged that these papers will be updated more regularly than the other TAG 13 documents. This reflects appropriately the need to keep pace with the technology e.g. climate science.

<u>NOT</u> intended as formal ONR guidance or to express ONR views

11

ONR Expert Panel on Natural Hazards
Outputs - Project Reviews

- The panel provide expert advice to support ONR assessment of site licensing applications and design of potential new NPPs. Example sites have included Hinkley Point C, Wylfa Newydd, Sizewell C and Bradwell B. The scope of the panels work covers:

- Capable Faulting
- Coastal Flooding
- Probabilistic Seismic Hazard Analysis
- Meteorological hazards
- Coastal Flooding hazard analysis and flood protection
- Climate change impacts

- The panel also support appraisal of existing nuclear facilities that covers the periodic review and update of external hazard analysis.
- Overall, the expert panel has been influential in bolstering ONR's credibility and regulatory effectiveness.

12

ONR Expert Panel on Natural Hazards
Outputs - Research Briefings and Stakeholder Engagement

- The Met. & Coastal Flood sub-panel produce research briefings, which are externally focused documents.
- The purpose of the Research Briefings is to highlight recently published research that ONR may consider when developing regulatory guidance.
- The Expert Panel on Natural Hazards also support ONR's response to relevant Freedom of Information requests and other General Enquiries.
- The panel carries out targeted research activities directed by ONR sepcialists.

ONR Advisory Groups on Graphite

Magnox Reactors

Calder Hall	1956-2003
Chapelcross	1959-2004
Bradwell	1962-2002
Hunterston A	1964-1990
Trawsfynydd	1965-1991
Dungeness A	1965-2006
Hinkley Point A	1966-1999
Sizewell A	1967-2006
Oldbury A	1967-2012
Wylfa	1971-2015

AGR Reactors

Hinkley Point B	1976-2022
Hunterston B	1976-2022
Dungeness B	1983-2021
Hartlepool	**1983-...**
Heysham 1	**1983-...**
Heysham 2	**1988-...**
Torness	**1988-...**

ONR Advisory Groups on Graphite
Function versus Ageing

- Key safety function:
  - ***Maintain free movement of fuel and control rods.***
- Graphite ageing erodes its structural integrity, distorting the core.
- Enhancing the challenge to free movement.
- A direct influence on major fault scenarios.

15

ONR Advisory Groups on Graphite
Unique Problem

- Unique problem with little or no operational experience.
- Licensee is the expert and funds much of the academic research.
- Emergent issues require a tool base.
- ONR must form "an independent and informed view".
- Achieved through independent expertise.
- But such expertise is rare.
- Expertise independent from the licensee is rarer.
- Development of a pool of expertise began around 20 years ago to support ONR graphite regulatory decisions.

16

ONR Advisory Groups on Graphite
Network of Advisors

Graphite Technical Advisory Committee

- Formed of academics, ex-inspectors, ex-station heads and consultants.
- Questions: "What is their view of…"
- Advice is formally reported through tiers of recommendations, interpreted to regulatory actions or decisions by the inspector.

Brick Cracking Network

- Formed of university groups and industry consultants.
- Targeted work programme of analysis and testing.
- Conclusions directly influence inspectors decisions on regular regulatory activities.

Emergent

- University groups and consultants.

MANCHESTER 1824
The University of Manchester

HSE
Health & Safety Executive

Graphite Technical Advisory Committee

UNIVERSITY OF BIRMINGHAM

Chief Nuclear Inspector's Independent Advisory Panel
Overview

- Established in 2016 provide independent advice to ONR on nuclear related matters, including regulatory strategy, policy, developments in technology.
- **Ensures that ONR has access to independent external advice on a diverse range of nuclear matters**.
- Not responsible for providing expert advice on specific technical matters
- Chaired by the ONR Chief Nuclear Inspector
- Membership comprises experts from the nuclear industry, academia, NGOs and government departments.

Chief Nuclear Inspector's Independent Advisory Panel
Approach

- Meets twice a year
- Topics for discussion selected by CNI and presented by ONR lead
- IAP members provide perspectives and advice, focussing on:
  - Development of regulatory priorities and strategies
  - Future developments in nuclear technologies and their potential implications for nuclear regulation
  - Advise on research needs
  - Facilitate engagement with external centres

Chief Nuclear Inspector's Independent Advisory Panel
Topics Under Consideration and Challenges

- Topics from previous April 2022 meeting:
  - **Regulation of innovation**
  - **Climate change**
- Recent candidate topics for next meeting:
  - **National shortage of personnel in industry**
  - **Drive for efficiencies in how we regulate**
- Topics previously discussed:

UK Nuclear Sector Deal

Regulation of Cyber Security

Feedback from the IAEA IRRS Mission to the UK

ONR's Research Strategy

Nuclear Integrated Management Maturity Model

ONR Organisational Effectiveness Framework & Performance Indicators.

Regulatory Response and Recovery to Covid-19

Strategic Work Force Planning

ONR Strategic Improvement Project - WIReD

Consideration of Ethics in Regulatory Decision Making

Regulation of Supply Chain

Thank you for listening and any questions?

B.5 United States

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

U.S. NRC ADVISORY COMMITTEE ON REACTOR SAFEGUARDS (ACRS) OVERVIEW AND INPUT ON MEETINGTOPICS

International Meeting of Nuclear Regulatory Advisory Committees
December 5, 2022

ACRS Overview

- Statutorily mandated by Atomic Energy Act of 1954, as amended.
- Independent of NRC staff. Reports directly to the Commissioners, which appoint its members
- Issues letter reports that provide the Commissioners independent technical reviews of, and advice on, safety of proposed or existing reactor facilities, adequacy of proposed safety standards, and adequacy of NRC safety research program
- Periodically brief Commissioners on topics of interest

2

Current Topics under Review

- Operating Fleet
  - Subsequent license renewals (e.g., aging management, concrete degradation due to alkali silica reactivity, improved understanding of vessel embrittlement at high fluence)
  - New analytical methods (e.g., loss-of-coolant accidents, spent fuel pool heatup)
  - Fuel performance (e.g., fuel fragmentation dispersal and relocation, increased accident tolerance, high burnup)
  - Digital I&C implementation guidance
  - Emerging technologies (e.g., digital twins, artificial intelligence) and new issues (e.g., high energy arc faults, vessel embrittlement, cyber security)

3

Current Topics under Review (continued)

- Licensing and Operation of New Reactors
  - 10 CFR Part 53 development (optional new licensing pathway)
  - Alignment and lessons learned for current licensing pathways (10 CFR Part 50 for applicants pursuing separate Construction Permits and Operating Licenses and 10 CFR Part 52 for applicants pursuing Certified Designs)
  - Special topics (e.g., emergency planning, operator licensing, licensing basis event selection, fuel performance, source term development, probabilistic risk assessment acceptability)
  - Design center submittals

4

ACRS Challenges

- Numerous (potential) applications from design developers
  - Licensing basis event identification and evaluation of designs with little (or no) operating experience
  - Lack of data to validate fuel and reactor system performance and methods to evaluate event progression
- Industry concerns about cost/schedule for regulatory reviews
  - Increasing effectiveness without impacting safety
  - Leveraging reviews from other countries
- Appropriate membership succession
  - Different perspectives from new members
  - Knowledge transfer

5

ACRS Input on Meeting Topics

- Operating Fleet
  - Aging related issues
  - High burnup fuels
- Licensing and operation of First-of-a-Kind (FOAK) reactors
  - Achieving safety with little or no operating experience
  - suitability of current frameworks
  - Treating uncertainties
  - Applying defense in depth
- Risk surrogates (Safety Goals) for small modular Light Water Reactors (LWRs) and non-LWRs

6

ACRS Desired Interaction Outcomes

- What emerging issues are being identified in other countries and what advice is being given to address such issues?
- How other advisory committees address issues associated with new FOAK reactors?

B.5 Closing Discussion

Future Actions

- Objectives
- Topic Selection
- Meeting Date Selection
- Documentation of Meeting Findings, Conclusions, and Recommendations

Proposed Interaction Objectives

- To gain a working understanding of differences in advisory committee roles and organizations
- To share experience on common issues of interest and discuss effective advisory committee solutions to address these challenges (recognizing nuclear reactor regulation is a national responsibility).
- To increase advisory committee effectiveness by:
  - Gaining knowledge about emerging issues and new technologies of interest
  - Identifying, gaining from, and contributing to international regulatory advisory group 'best practices' and 'safety perspectives'
  - Strengthening the role of advisory committee experts (INSAG-27; Layer 2.2)

PROPOSED MEETING FORMAT FOR MARCH 2023

A two-days meeting with two thematic sessions of about 4 hours each:

- 1st day: session 1 dedicated to operating fleet

Ageing, experience feedback, long term operation…

- 2nd day: session 2 dedicated to new challenges

New reactors, ATF, advanced safety methods/approaches

PROPOSED MEETING FORMAT FOR MARCH 2023

Each thematic session includes two specific topics, for which each country presents its point of view. Example:

- Session 1 (operating fleet) (generic, then specific)

- NPP's operating feedback
- NPP's operating lifetime – ageing of non-replaceable equipment (ie vessel)
- Modernization of regulatory activities (risk-informing)

- Session 2 (New challenges)

- Safety objectives for new LWR & FOAK reactors
- International perspectives pertaining to emerging technical issues
- Strengthen the role of advisory committee experts (methods to address diverse opinions)

March 2023 Meeting

- Meeting Date Selection (Virtual Capability also)
  - Tues afternoon, March 14 (starting at 1:00-5:00 pm EST)
  - Wed morning, March 15 (starting at 8:30-12:30 am EST)
- Documentation
  - Session chairs draft summary slides for each session
  - Multiple leads from each country draft & review major discussion points, findings, conclusions, and recommendations at each meeting (planning meeting, Session 1, and Session 2)
  - White paper (includes meeting summary, slides); possible journal article?

APPENDIX C

MARCH 14, 2023, SESSION 1 PRESENTATIONS

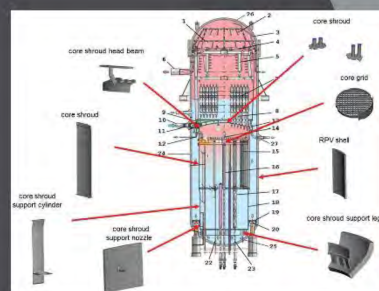
C.1 Finland

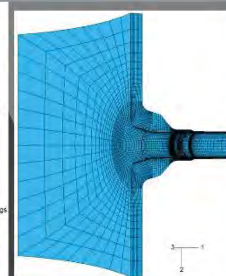
Ageing Management in Finnish NPPs

Karin Rantamäki (STUK)

Petri Kinnunen (VTT Technical Research Centre of Finland Ltd.)

Heli Talja (VTT, ret.)





Reminder of the Finnish NPP fleet (1/2)

Finland has four nuclear power plant units in electricity production. Two of these are located in Olkiluoto, Eurajoki, and two in Loviisa. Finland's fifth nuclear power plant unit is in Olkiluoto.

Loviisa Nuclear Power Plant: Loviisa 1 and Loviisa 2

Two nuclear power plant units in Hästholmen, Loviisa, owned by Fortum Power and Heat Oy.

Russian type pressurised water reactors (VVERs)

The net electric power of both units was 507 MWe at the end of 2018.

The current operation licenses end in 2027 and 2030.

Fortum was granted the license for continued operation of both units until 2050 by the Finnish government.

Plant unit	Start-up	Commercial use	Nominal electric power (gross/net, MW)	Type, supplier
Loviisa 1	8 February 1977	9 May 1977	531/507	Pressurised water reactor (PWR), Atomenergoexport
Loviisa 2	4 November 1980	5 January 1981	531/507	Pressurised water reactor (PWR), Atomenergoexport

Reminder of the Finnish NPP fleet (2/2)

Olkiluoto nuclear power plant:
Olkiluoto 1, Olkiluoto 2 and Olkiluoto 3

The three nuclear power plant units in Olkiluoto, Eurajoki, owned by Teollisuuden Voima Oyj (TVO).

Olkiluoto 1 and Olkiluoto 2 Swedish type boiling water reactors taken into commercial use in 1979 and 1982.

The net electric power of both units was 890 MWe at the end of 2018.

OL3 EPR type pressurised water reactor in commissioning phase.

The net electric power will be ~ 1600 MWe.

Plant unit	Start-up	Commercial use	Nominal electric power (gross/net, MW)	Type, supplier
Olkiluoto 1	2 September 1978	10 October 1979	920/890	Boiling water reactor (BWR), Asea Atom
Olkiluoto 2	18 February 1980	1 July 1982	920/890	Boiling water reactor (BWR), Asea Atom
Olkiluoto 3			A net electrical output approx. 1600 MW	Pressurised water reactor (EPR), Areva

General approach to the Ageing management in Finland

"We know our plants"

Understanding the functioning of the plant as a whole

+

All relevant components

+

Their risk assessment

+

Understanding of types of ageing mechanisms

+

Co-operation between NPP owner, regulator and research institutes

=

Comprehensive ageing management programme for each reactor and NPP

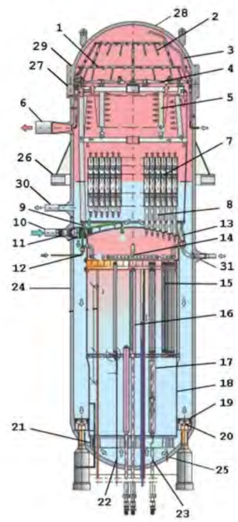
ID	Component
1	Flange cooling spray piping
2	Long nozzle pipes in cooling spray piping
3	Evacuation pipe
4	Spring beams and support brackets
5	Steam dryer
6	Steam outlet nozzles
7	Steam separator stand pipes
8	Steam separator pipe bundles
9	Steam separator support legs
10	Feedwater nozzles
11	Feedwater spargers
12	Boron spray nozzles and piping
13	Core spray piping outside core shroud cover
14	Core spray piping inside core shroud cover
15	Fuel assembly

ID	Component
16	Control rods
17	Control rod guide tubes
18	Core shroud, Core shroud support
19	Pump deck
20	Main circulation pump nozzles
21	Core shroud support legs
22	Instrumentation guide tubes and nozzles
23	Control rod guide tubes and nozzles at RPV bottom
24	Cylindrical RPV shell
25	RPV bottom
26	RPV support skirt
27	RPV flange
28	RPV-head
29	RPV-head bolts
30	Shutdown cooling nozzles
31	Core spray nozzles

= austenitic SS

= ferritic steel

= nickel-base alloy



Ageing phenomena: irradiation embrittlement, fatigue, thermal fatigue, stress corrosion cracking (intergranular, transgranular), corrosion, etc.

O. Cronvall, Susceptibility of boiling water reactor pressure vessel and its internals to degradation, Doctoral dissertation, 2020. https://aaltodoc.aalto.fi/handle/123456789/46577

Screening of Components:

ID	Component	IE	TE	CUF	IGSCC	IASCC	GC	E/C, FAC	MW	Screen In/Out
4	Spring beams, Support brackets	No	No	No	No	No	No	No	No	Out
6	Steam outlet nozzles	No	Yes	No	No	No	No	No	No	In
9	Steam separator support legs	No	No	No	No	No	No	No	No	Out
10	Feedwater nozzles	Yes	Yes	Yes	Yes	No	No	No	No	In
11	Feedwater spargers	No	No	Yes	Yes	No	No	No	No	Out
14	Core spray piping inside core shroud cover	No	No	No	No	No	No	No	No	Out
16	Control rods	No	No	Yes	No	Yes	No	No	No	In
17	Control rod guide tubes	No	No	Yes	No	Yes	No	No	No	In
18	Core shroud, Core shroud support	No	No	Yes	No	No	No	No	No	In
19	Pump deck	No	No	Yes	Yes	No	No	No	No	In
21	Core shroud support legs	No	No	Yes	Yes	No	No	No	No	In
22	Instrumentation guide tubes and nozzles	No	No	No	No	Yes	No	No	No	In
23	Control rod guide tubes and nozzles at RPV bottom	No	Yes	Yes	Yes	No	No	No	No	In
24	Cylindrical RPV shell	Yes	Yes	Yes	No	No	No	No	No	In
30	Shutdown cooling nozzles	Yes	Yes	Yes	Yes	No	No	No	No	In
31	Core spray nozzles	Yes	Yes	Yes	Yes	No	No	No	No	In

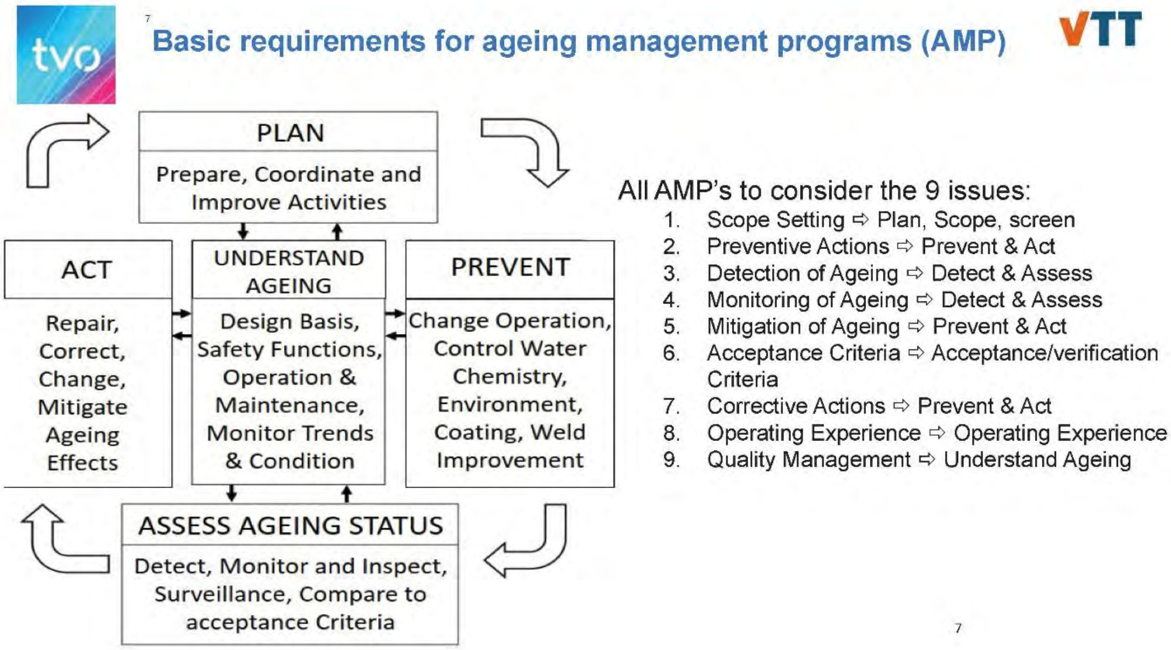
O. Cronvall, Susceptibility of boiling water reactor pressure vessel and its internals to degradation, Doctoral dissertation, 2020. https://aaltodoc.aalto.fi/handle/123456789/46577

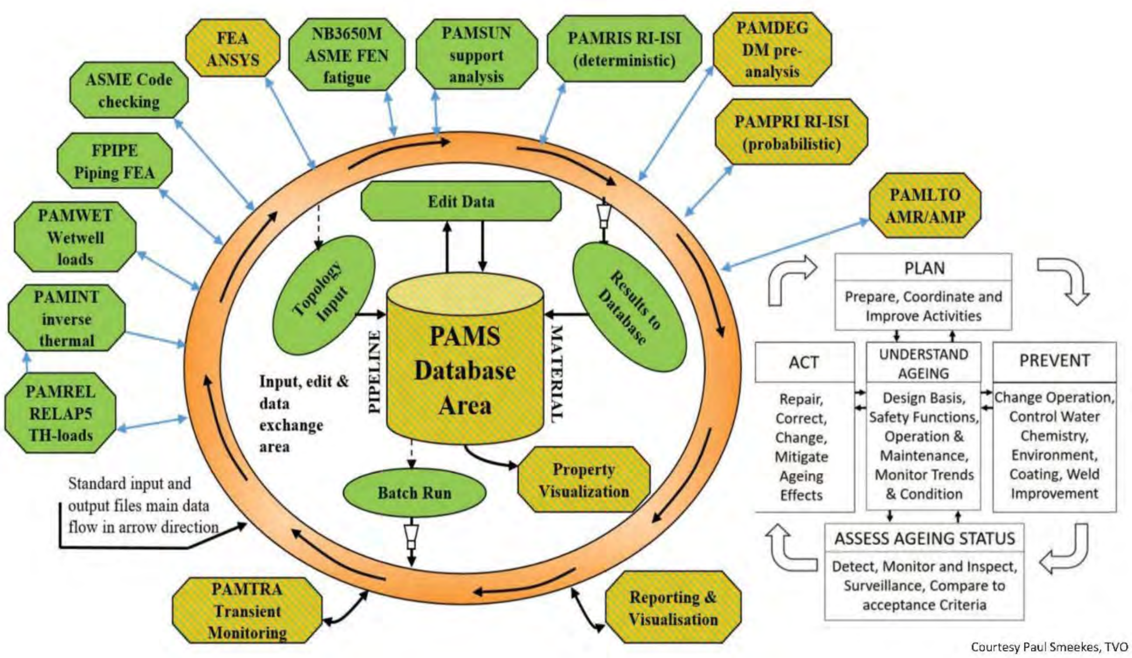
mitigation

inspection

Degradation mechanism	Mitigation action											
	irradiation flux reduction	Component repair, e.g. weld inlay and onlay	thermal annealing	pre-stressing and warm pre-stressing	power reduction	reduction of magnitude of applied loads	reduction of number of load cycles	water chemistry control	surface treatment	stress state improvement	temperature control	surface treatment, protective coating
Irradiation embrittlement	X	X	X	X	X	na	na	na	na	na	na	na
Thermal embrittlement	na	X	X	na	na	na	na	na	na	na	na	na
Fatigue	na	X	na	na	na	X	X	na	na	na	na	na
IGSCC	na	X	na	na	na	X	na	X	X	X	na	na
IASCC	X	X	na	na	na	X	na	X	X	X	na	na
General corrosion	na	X	na	na	na	na	na	X	na	na	na	na
Erosion-corrosion, FAC	na	X	na	na	na	na	na	X	na	na	X	X
Mechanical wear	na	X	na	na	na	X	na	na	na	na	na	X

Degradation mechanism	Inspection action						
	surveillance capsules	NDT, UT, most techniques	NDT, Eddy current	NDT, liquid penetrant	NDT, UT, phased array	NDT, acoustic emission	NDT, visual examination
Irradiation embrittlement	X	na	na	na	na	na	na
Thermal embrittlement	na	na	na	na	na	na	na
Fatigue	na	X	X	X	X	na	X
IGSCC	na	X	X	X	X	X	X
IASCC	na	X	X	X	X	X	X
General corrosion	na	na	na	na	na	na	X
Erosion-corrosion, FAC	na	X	X	X	na	na	X
Mechanical wear	na	na	na	na	na	na	X


tvo
7
Basic requirements for ageing management programs (AMP)
VTT
PLAN
Prepare, Coordinate and Improve Activities
ACT
Repair, Correct, Change, Mitigate Ageing Effects
UNDERSTAND AGEING
Design Basis, Safety Functions, Operation & Maintenance, Monitor Trends & Condition
PREVENT
Change Operation, Control Water Chemistry, Environment, Coating, Weld Improvement
ASSESS AGEING STATUS
Detect, Monitor and Inspect, Surveillance, Compare to acceptance Criteria
All AMP's to consider the 9 issues:
1. Scope Setting ⇨ Plan, Scope, screen
2. Preventive Actions ⇨ Prevent & Act
3. Detection of Ageing ⇨ Detect & Assess
4. Monitoring of Ageing ⇨ Detect & Assess
5. Mitigation of Ageing ⇨ Prevent & Act
6. Acceptance Criteria ⇨ Acceptance/verification Criteria
7. Corrective Actions ⇨ Prevent & Act
8. Operating Experience ⇨ Operating Experience
9. Quality Management ⇨ Understand Ageing
7


FEA ANSYS
NB3650M ASME FEN fatigue
PAMSUN support analysis
PAMRIS RI-ISI (deterministic)
PAMDEG DM pre-analysis
ASME Code checking
PAMPRI RI-ISI (probabilistic)
FPIPE Piping FEA
PAMLTO AMR/AMP
PAMWET Wetwell loads
PAMINT inverse thermal
PAMREL RELAP5 TH-loads
Edit Data
Topology Input
Results to Database
PIPELINE
PAMS Database Area
MATERIAL
Input, edit & data exchange area
Batch Run
Property Visualization
Standard input and output files main data flow in arrow direction
PAMTRA Transient Monitoring
Reporting & Visualisation
PLAN
Prepare, Coordinate and Improve Activities
ACT
Repair, Correct, Change, Mitigate Ageing Effects
UNDERSTAND AGEING
Design Basis, Safety Functions, Operation & Maintenance, Monitor Trends & Condition
PREVENT
Change Operation, Control Water Chemistry, Environment, Coating, Weld Improvement
ASSESS AGEING STATUS
Detect, Monitor and Inspect, Surveillance, Compare to acceptance Criteria
Courtesy Paul Smeekes, TVO

Loviisa 1 & Loviisa 2 Russian type pressurised water reactors (VVERs)

Main components/places for ageing management:

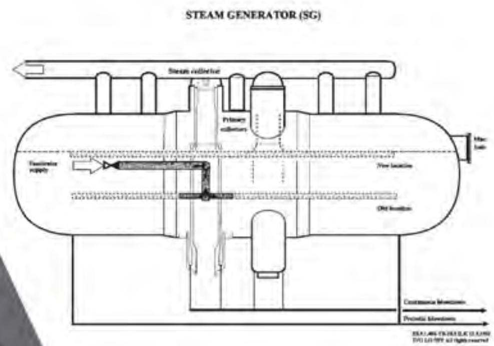
- Reactor pressure vessel
- Steam generators
- Dissimilar metal welds in overall

Steam generators:

- Design is such that they cannot be replaced (horizontal SGs located in concrete bunkers).
- Water chemistry changes performed on the secondary side caused flaking of the oxidised surfaces
  - -> needed to remove the flakes from the SGs not to cover the pipes with them.
- Some problems with the steam generator tubes exist as part of them have been plugged, but the plugging rate is not at all at a critical level.

Dissimilar welds:

- These are always complicated in demanding environments
- Exist in many locations in various systems

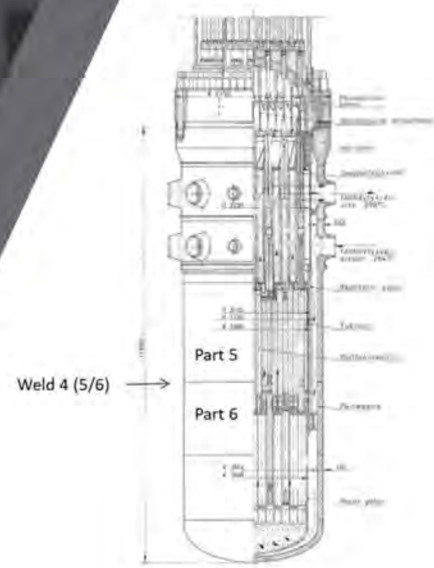


Loviisa 1 & 2: Reactor pressure vessel

Special focus is on the welds at various locations of the vessel

- Unexpectedly rapid irradiation embrittlement was identified in early operation, which yielded to modifications in core geometry and plant operation processes to mitigate the phenomenon.
- The most critical weld is the circumferential core region weld, where constant surveillance is on-going
- In 1996, an annealing was conducted in Loviisa 1 to recover material properties

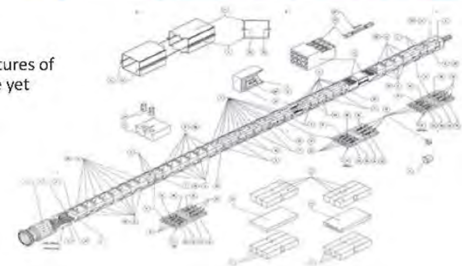
As a result, Loviisa's reactors are in overall in a much better condition than the reference reactors (VVER) in Europe mainly and the operation can be safely continued far beyond the designed lifetime

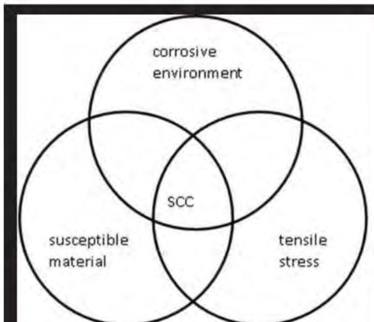


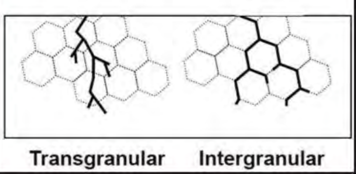
Surveillance capsules and samples

OL1/OL2:

OL3:
No real pictures of the capsule yet







Olkiluoto 1 and Olkiluoto 2 Boiling water reactors (BWR)

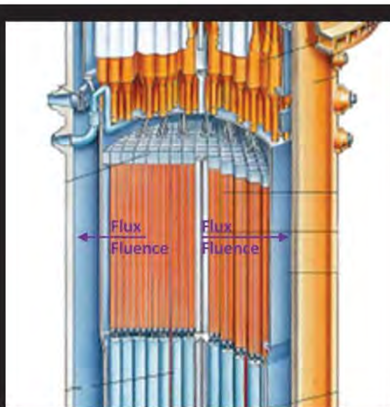
Active co-operation with the Swedish nuclear industry as there exist several sister plants.

Main components/places for ageing management:

- RPV and internals, passive components
- **Dissimilar metal welds** in various locations
  - E.g. moderator tank welds
    -> surveillance samples in frequent inspections

Good reference for ageing is currently obtained from Barsebäck NPPs in Sweden:

- During decommissioning trepans from the reactor pressure vessel and its surrounding have been taken and are analysed at VTT.
- The results will finally indicate the level of ageing on materials as well as comparative results for the original design values.



Degradation mechanisms at OL1/OL2

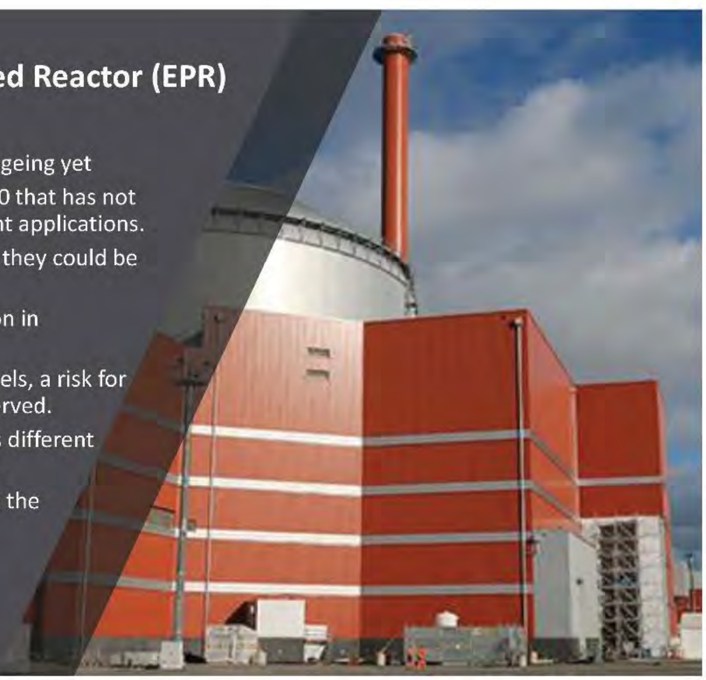
In TVO, the following degradation mechanisms are considered in the screening process:

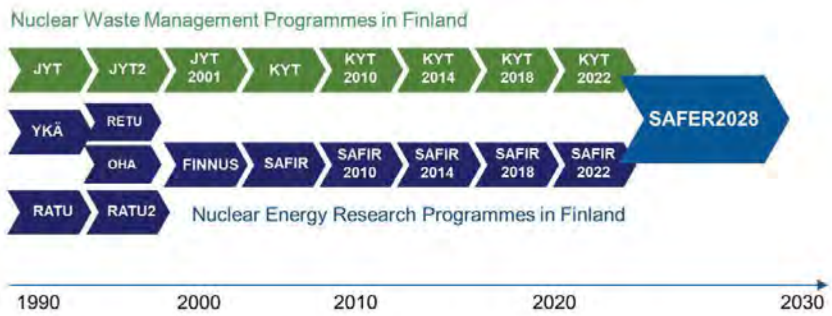
- Flow accelerated corrosion (FAC) => Wall thinning
- Intergranular stress corrosion cracking (IGSCC) => Crack growth
- Transgranular stress corrosion cracking (TGSCC) => Crack growth
- Irradiation assisted SCC (IASCC) => Crack growth
- Low-cycle fatigue crack growth (LCFCG) => CUF, Crack growth
- High-cycle fatigue crack growth (HCFCG) => CUF, Crack growth
- Irradiation embrittlement => Decrease of fracture toughness
- Thermal embrittlement => Decrease of fracture toughness

Degradation mechanisms significant to OL1/OL2 RPV & internals

Olkiluoto 3: European Pressurised Reactor (EPR)

- In the start-up phase, so no experience on ageing yet
- **Steam generator piping** material is Alloy 690 that has not indicated any problems in other power plant applications.
- **Steam generators** are also designed so that they could be replaced, if needed.
- **Emergency cooling system** (EDF presentation in Fontevraud 10)
  - In other NPPs using similar stainless steels, a risk for stress corrosion cracking has been observed.
  - However, in OL3 the design geometry is different so it remains to be seen what happens.
- In any case OL3 will be closely surveyed and the amount of data that can be achieved from the surveillance systems is enormous.





Ageing management in research in Finland

- In Finland, we use national research programmes in addition to the power companies' own assignments to develop theories, technologies and educate people for the benefit of the whole society.
- History of these programmes starts from 1990's.
- **Ageing management topics have always been in a key role in these programmes.**
- For the current programme structure, please visit

https://safer2028.fi/

Thank you!

C.2 France

C.2.1 Operational Feedback Presentation

THE GLOBAL APPROACH TO ENHANCING SAFETY IN FRANCE

Consolidating and enhancing safety relies on available knowledge resulting from :

- operational experience and accident feedback (both national and international)

- Nuclear accidents : TMI accident, Tchernobyl accident, Fukushima accident
- Significant events: flooding event in Blayais NPP in 1999, stress-corrosion cracking, operating events...
- Manufacturing events: carbon segregation in forgings...

- results from studies and research programs (both national and international)

- Shutdown states, safety criteria related to fuel behavior have been reviewed in 2017,

PRÉSENTATION 3

OEF : WHAT IS EXPECTED FROM OPERATORS ?

Licensees shall register, evaluate and document internal and external safety significant operating experience

EDF reports to ASN approx. 800 events / year (for a fleet of 56 reactors):

~ 10 000 "interesting" events identified by EDF → ~ 800 events reported → ~ 100 reports to IRS (IAEA) prepared by EDF and IRSN

When an event triggers one out of 10 defined criteria, the licensee must report a safety significant event to ASN, within 2 days

The licensee has 2 months to transmit a report on this event, in which a thorough analysis of root causes of the event is expected

*** : Order dedicated to the safety of nuclear installations of 7th February 2012**

PRÉSENTATION 4

OPERATIONAL EXPERIENCE FEEDBACK : DIFFERENT TIMESCALES

- After each safety significant event :

- An analysis is performed by the licensee (EDF) in order to implement corrective measures, another by the French TSO (IRSN) and, whenever deemed necessary, decisions are made by the regulator (ASN)

- On a yearly basis :

- Based on a report prepared by the French TSO (IRSN), an analysis of trends regarding safety significant events, of the most important interesting events (including a probabilistic evaluation) and of the action plans of the licensee (EDF) is discussed during a "Groupe permanent" meeting

- Long term actions regarding the OEF:

- During the generic phase of 10-year Periodic Safety Reviews, the OEF is taken into account,
- Every 5 to 10 years (depending on needs), a "Groupe permanent" meeting is dedicated to the OEF regarding the fuel behavior

- Specific OEF actions :

- After Fukushima accident, several "Groupe permanent" meetings took place (in 2011 / 2012), dedicated to the assessment of the robustness of NPPs to extreme events and to the necessity of subsequent improvements
- Following the stress corrosion cracking phenomena affecting some reactors of the French fleet discovered in September 2021, several "Groupe permanent" meetings took place recently

PRÉSENTATION 5

THE YEARLY PROCESS OF OEF IN FRANCE

The yearly process to assess the operational experience feedback of EDF NPPs : each year, a meeting of the Groupe Permanent is dedicated to :

- the analysis of the safety significant events of the previous year performed by the licensee (EDF) and completed by a second level analysis performed by IRSN including a specific method called "A2N-T" (risk control model structured by activity, see **appendix**)

- relevant international OEF is also considered

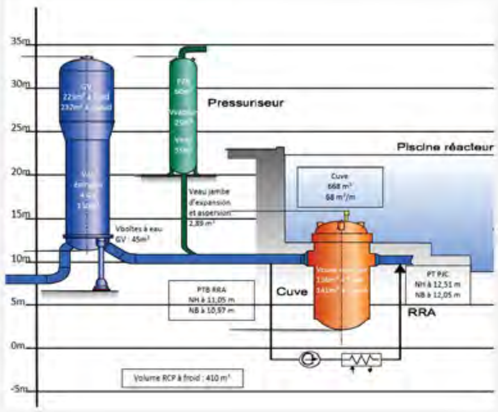
- some in-depth analyses of specific events, themes or trends performed by IRSN are discussed:

- in 2021: in-depth analysis of the INES 2 event that occurred on October 8, 2019 in Golfech 2 reactor (draining of the primary circuit while the blowhole was not open, see slides below)
- in 2022 : management of the COVID pandemic from the point of view of safety in EDF NPPs
- recently, the SCC phenomena led to long periods of shutdown for some reactors. The consequences for safety of theses long periods of shutdown will be examined during a future meeting of the Groupe Permanent

➔ Conclusions and the action plans of EDF are examined

PRÉSENTATION 6

AN EXAMPLE: INES LEVEL 2 SAFETY SIGNIFICANT EVENT IN GOLFECH 2 (OCTOBER 2019)



- During shutdown, the primary circuit is partially drained before opening the vessel
- A vent valve located at the top of the pressurizer must be opened to enable draining
- The operator in charge did not open the valve (line-up error)
- During the gravity draining, the pressure in the primary circuit became lower than the atm pressure
- The transient was worsened by malfunctions affecting the sensors measuring the water level in the vessel, and by subsequent inadequate decisions made by operators
- The initial corrective actions mainly aimed at preventing the line-up error to happen again

PRESENTATION

7

AN EXAMPLE: INES LEVEL 2 SAFETY SIGNIFICANT EVENT IN GOLFECH 2 (OCTOBER 2019)

The A2NT method was used by IRSN to analyze the failing lines of defence in planning, preparation, performance and experience feedback

LINE OF DEFENCE PREPARATION :

- DUE TO A PROCEDURE CHANGE IN 2007, DOCUMENTS TO PREPARE THE OPERATION WERE IMPRECISE AND INCOMPLETE
- THE TEMPORARY PROCEDURE WAS NOT ENOUGH UNDERSTOOD AND NOT WELL IMPLEMENTED ON SITE

LINE OF DEFENCE PERFORMANCE:

- INFORMATION TO SURVEY THE DRAINING WERE NOT SUFFICIENT FOR OPERATORS
- THE NEW ORGANIZATION OF THE SHIFT PERSONNEL LED TO CONFUSION OF ROLES AND A LACK OF EXPERIENCED OPERATORS SURVEYING THE TRANSIENT

The GP reviewed the analysis with an in-depth discussion on the human factors

PRESENTATION

8

FUKUSHIMA DAIICHI ACCIDENT FEEDBACK

- after the stress tests performed by operators, several "Groupe permanent" meetings took place (in 2011, 2012…), dedicated to the assessment of the robustness of NPPs to extreme events,

- taking into account the measures proposed by the licensee (for example the creation of a Nuclear rapid intervention force) the result is :

- the increase of the level of external hazards taken into account (earthquakes, flooding…)
- the definition of a **"hardened safety core"** which comprises measures to **avoid** the fusion of the core and to **mitigate** the fusion, with the aim of preserving the integrity of the containment without opening the venting system in case of core fusion

PRÉSENTATION 9

FUKUSHIMA DAIICHI ACCIDENT FEEDBACK

Fukushima Daiichi accident feedback: most important measures implemented

Backup diesel generators (1 per reactor)

Ultimate water source (1 per reactor)

New emergency situation management premises (1 per site)

PRÉSENTATION 10

CONCLUSION ON OPERATIONAL EXPERIENCE FEEDBACK

Operational Experience Feedback is a key process to improve safety in the long run

OEF must take into account safety significant events, as well as major accidents

Relevant analyses of OEF require the identification of root causes and the implementation of proper action plans

The result of OEF is considered during 10-year periodic safety reviews

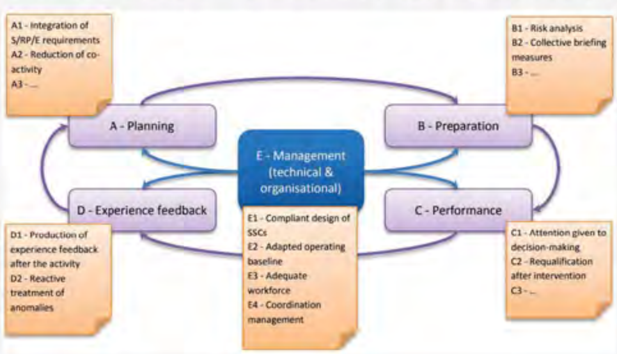
PRÉSENTATION

11

APPENDIX : THE A2NT METHO USED BY THE FRENCH TSO (IRSN)

The "A2NT" (= second level transversal analysis of events) method

- the goal is to perform a 2nd level analysis, independent of the analysis of the operator (EDF)
- the method is based on a risk control model structured by activity :



- Around 30 "lines of defence" have been identified and split into 5 categories
- The analysis of an event consists of identifying, for the scenario in question, the LDDs that turned out to be deficient or effective, in order to obtain a "picture of how the risk control measures are working" through the quantitative and qualitative analysis of these LDDs
- The model has been validated

PRÉSENTATION

12

C.2.2 PSRs and LTO Presentation

PERIODIC SAFETY REVIEWS AND LTO

In France, there is **no limit fixed for the lifetime** of a commercial nuclear power plant

The **hypothesis of a 40 years lifetime has been considered for the** design of many components (for instance, the reactor pressure vessel (RPV)), 60 years for EPR

Based on up-to-date knowledge, **a Periodic Safety Review (PSR) is conducted every 10 years** and involves two parts:

- a compliance program (controls, tests, specific investigations, ageing control, consequences of Operational Experience Feedback…)
- a safety improvement program in order to meet (possibly increased) safety objectives defined by the regulator (ASN)

For each series of reactors (900 MWe, 1300 MWe, 1450 MWe), the PSR comprises two phases : **a generic phase** of studies for the series, and **an implementation phase** for each reactor

Safety assessment is based on a **deterministic approach** complemented by **PSAs**

PRÉSENTATION 3

THE 4TH PERIODIC SAFETY REVIEW OF 900 MWE REACTORS IN FRANCE

Compliance program:

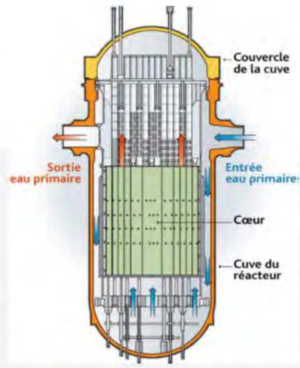
- Safety relies on requirements concerning structures, systems and components of the plant
- As the plant ages, these requirements have to be maintained, and checked by:
  - Periodic inspections, tests
  - Specific investigations
  - Ageing management

PSRs are particular moments to « look beyond » with a wider approach for the 4th 10-year PSR of 900 MWe reactors in France :

- Extended field of investigations
- Design review on main safety systems
- Controlling Testing and investigating differently
- Specific test to check specific functions (as it was done at the first start of the reactor)

PRÉSENTATION 4

THE 4TH PERIODIC SAFETY REVIEW OF 900 MWE REACTORS IN FRANCE



Compliance program: focus on the RPV

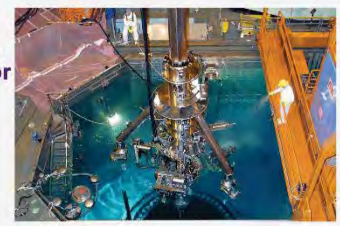
- In France, a **deterministic** demonstration is expected, **crack arrest is currently not accepted, no benefit of warm pre-stress (WPS)…**

- EDF introduces **Hafnium rods in peripheral fuel assemblies** in order to limit the irradiation embrittlement effect

- Based on IRSN's reports, three meetings of the Groupe Permanent took place in 2018, 2019, 2020 and examined the **irradiation surveillance program**, the **pressurized thermal shock** studies…

- Based on the initial file of EDF supplemented during the assessment, the Groupe Permanent concluded **that vessels of 900 MWe reactor are fit for another 10 years service after 40 years**

- This conclusion assumes that the non-destructive testing of the vessels performed during each 10 yearly examination reveals no defects, except previously known ones, and that previously known defects are stable



PRESENTATION
5

THE 4TH PERIODIC SAFETY REVIEW OF 900 MWE REACTORS IN FRANCE

Safety improvement programme: considers the safety objectives defined for new (3rd generation) reactors and implements reasonable improvements to approach this target as much as possible :

- **Preventing fuel melting** in spent fuel pool with a high level of confidence
- Making very unlikely the risk of accidents with core melt which would lead **to early and large releases** and **avoid long lasting effects** in the environment :
  - ➢ Containment heat removal without venting in case of severe accident (see next slides)
  - ➢ Ex-vessel molten core coolability in case of accident with core fusion (see next slides)

- Making sure design basis accidents consequences do not require population protection measures

- Checking that the core damage frequency including **external hazards** is in the order of magnitude of 10^{-5} / year / reactor

And finalizing the implementation of improvements resulting from the Fukushima feedback

PRESENTATION
6

THE 4TH PERIODIC SAFETY REVIEW OF 900 MWE REACTORS IN FRANCE

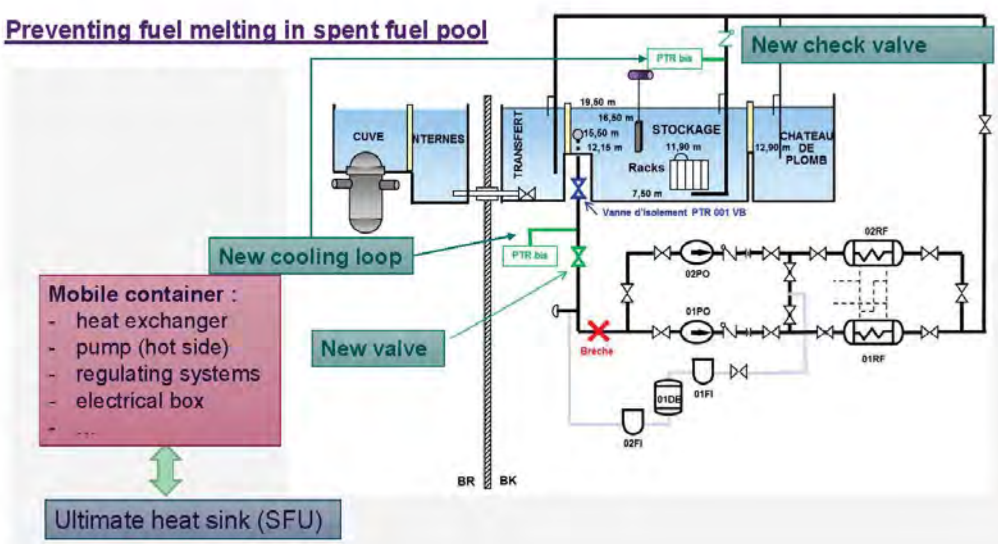
Many topics examined during "Groupe permanent" meetings :

- Internal and external hazards (2019, February 20 and 21)
- Severe accidents (2019, March 27 and 28)
- PSA (2019, July 11 and 12)
- DBC and DEC-A accidents (2019, January 30 and 31)
- Demonstration concerning the possibility to extend the lifespan of RPV from 40 to 50 years (2018, 2019, 2020)
- Generic phase of the 4th periodic safety review of 900 MWe reactors (2020, November 12 and 13)
- Ageing of stainless-steel cast components (2019, May 25)
- Safety case of Reactor Primary System (2019, October)
- …

PRÉSENTATION 7

THE 4TH PERIODIC SAFETY REVIEW OF 900 MWE REACTORS IN FRANCE:

Preventing fuel melting in spent fuel pool



PRÉSENTATION 8

THE 4TH PERIODIC SAFETY REVIEW OF 900 MWE REACTORS IN FRANCE

Fuel melting risk in the spent fuel pool :

EDF demonstrated the possibility of reaching a safe state (no more pool boiling) in case of loss of normal spent fuel pool cooling systems or in case of accidental drainage, except for some residual probability scenarios

➔ EDF committed to study these residual scenarios and to propose solutions that could be implemented after such accidents to reach a safe state

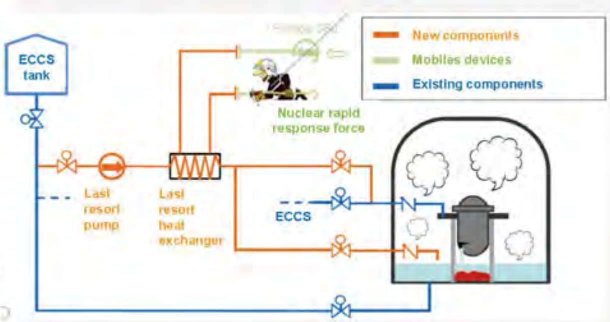
➔ Probability of fuel melting in pool: residual

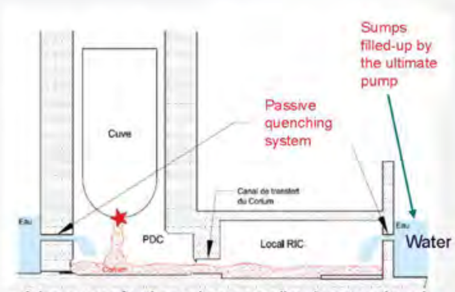
PRÉSENTATION 9

THE 4TH PERIODIC SAFETY REVIEW OF 900 MWE REACTORS IN FRANCE:

Prevention and mitigation of core melt accident consequences

In case of severe accident, modifications implemented to cool the corium, control the pressure in the containment (avoid venting) and limit base mat concrete ablation to avoid melt-through





- A large area for the corium spreading (reactor pit and adjacent in-core instrumentation system area)
- Dry areas until vessel failure to ensure efficient corium spreading

PRÉSENTATION 10

THE 4TH PERIODIC SAFETY REVIEW OF 900 MWE REACTORS IN FRANCE

Mitigation of core melt accident consequences

Last resort heat sink (SFU)

"Plug-and-play" connection by the nuclear rapid response force after 24 h

Using the river, or the sea…

Special pumps able to pump water even if there are debris or sediments in the water

Pumps circulate cold water directly into the new "EASu" exchanger

PRESENTATION

11

THE 4TH PERIODIC SAFETY REVIEW OF 900 MWE REACTORS IN FRANCE

Robustness to external hazards: the example of the flooding risk

- following different events, and especially the flooding of Blayais in 1999, ASN edited the Guide n°13 : Protection of Basic Nuclear Installations against external flooding, and a report listing all its scientific basis

- the guide was considered by EDF for the 4th PSR of 900 MWE reactors

Gravelines (6 reactors of 900 MWe on the sea-side) : recent reinforcement of the dikes

asn

PRESENTATION

12

THE 4TH PERIODIC SAFETY REVIEW OF 900 MWE REACTORS IN FRANCE

Conclusions

- the objectives of the 4th periodic safety review of 900 MWe reactors are **ambitious**

- modifications were designed and are being implemented by EDF **to reach these objectives**

- during a “Groupe permanent” meeting on 2019, 22 May, similar objectives have been retained for the 4th periodic safety review of **1300 MWe reactors**

- The generic phase of this PSR of 1300 MWe reactors is ongoing. Several “Groupe permanent” meetings will take place in the 2nd half of 2024 (priory to ASN decisions and public consultation regarding the possibility to extend the lifespan of 1300 MWe reactors from 40 to 50 years)

- A preliminary reflection of the Groupe Permanent on **the preliminary guidelines for the 5th PSR of 900 MWe reactors** will take place in 2023

PRÉSENTATION 13

C.3 Japan

C.3.1 Regulation for Current Fleet

Regulation for Current Fleet in Japan

March 14, 2023

International Regulatory Advisory Committee Meeting

ICHIMURA Tomoya
Deputy Secretary-General for Technical Affairs
Nuclear Regulation Authority, Japan

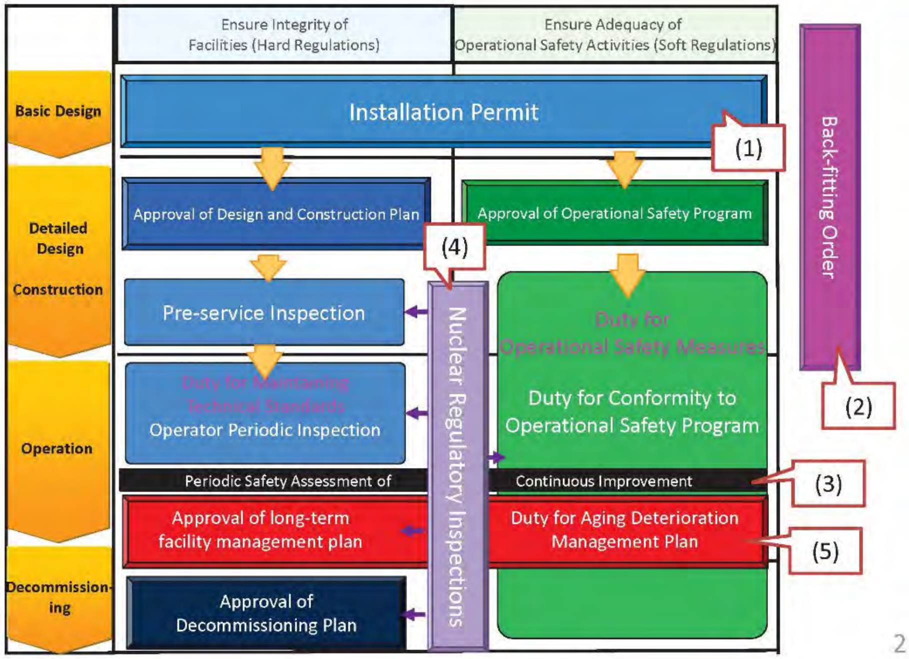
Contents

- Status of Japanese Fleets
- New Regulatory Requirements.....(1)
- Continuous Improvement
  - Back-Fitting.....(2)
  - PSACI.....(3)
- Nuclear Oversight Program.....(4)
- Long-Term Operation.....(5)

Disclaimer:
The opinions/views expressed in this presentation and on the following slides are solely those of the presenter and not necessarily those of the organization.

1

Framework of Reactor Regulation Act



Regulatory Changes
After
TEPCO's Fukushima Daiichi NPS Accident

3

Regulatory Changes

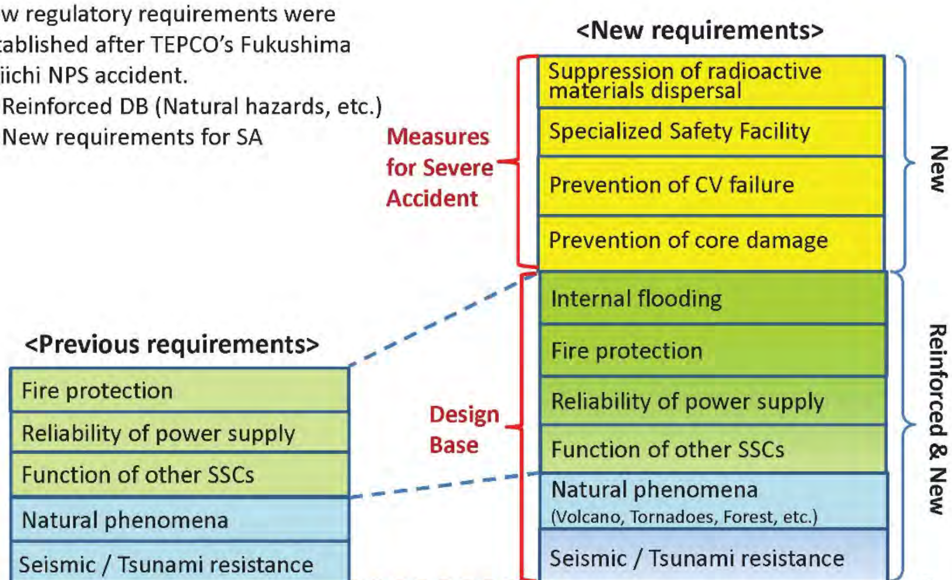
- Strengthen regulatory requirements
- Introduce back-fitting: NPPs to be operated or in operation should satisfy all the latest regulatory requirements
- Limit operational period to 40 years, and introduce approval system for extension, one-time, up to 60 years

4

New Regulatory Requirements

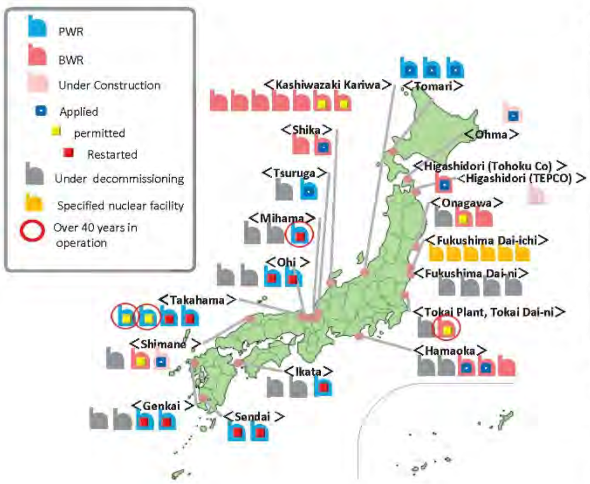
New regulatory requirements were established after TEPCO's Fukushima Daiichi NPS accident.

・Reinforced DB (Natural hazards, etc.)
・New requirements for SA



5

Status of Conformity Reviews



As of February 2023

Total[*1]	**60**	
Applied	27	PWR 16 BWR 11
Permitted	17	PWR 12 BWR 5
Restarted	*10*	*PWR 10* *BWR 0*
Under decommissioning	24	PWR 8 BWR 15 GCR 1
Others	9	PWR 0 BWR 9

*1 Including NPPs under construction (3 reactors) and Fukushima Daiichi unit 1-6

* The NRA granted permission of change in reactor installation to comply with the new regulatory requirements in relation to Shimane NPS Unit 2 of Chugoku Electric Power Co., Inc. on September 15, 2021.

6

Continuous Improvement
- Back-fitting -

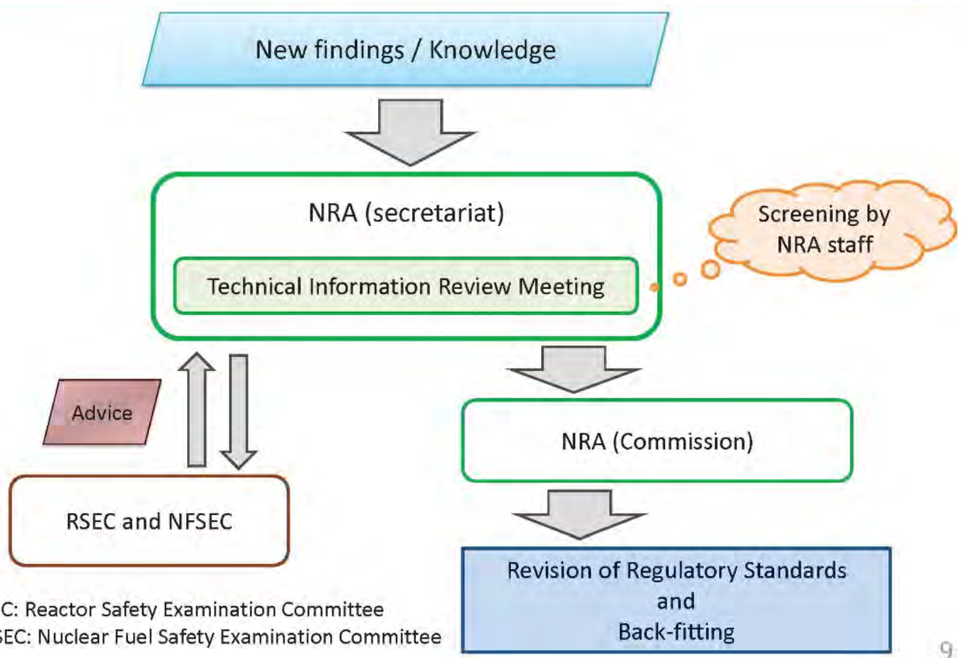
7

Back-fitting 1

- "Continuous improvement" is the most important lesson learned from TEPCO's Fukushima Daiichi NPS accident.
- Up-to-date knowledge should always be applied to current fleets ("back-fitting").
- The rule is firstly to apply new regulatory requirements - all existing reactors are required to satisfy the new requirements before restarting them.
- NRA continues to work on continuous improvement - collect and review new knowledge, revise requirements if necessary, and require back-fitting.

8

Back-fitting 2



RSEC: Reactor Safety Examination Committee
NFSEC: Nuclear Fuel Safety Examination Committee

9

Back-fitting 3

List of back-fitting cases

No.	Enforcement date	Case
1	(Nuclear facilities for power generation) 2013.7.8 (Nuclear fuel cycle facilities) 2013.12.18	New regulatory requirements (including installation of special facility for severe accident management)
2	(Nuclear facilities for power generation) 2014.7.9 (Reprocessing facilities) 2014.10.29	One-phase open measures for power supply system
3	2017.5.1	Protection from toxic gases
4	2017.8.8	High energy arc damage (HEAF) countermeasures
5	2017.9.11	Measures for the confinement function of radioactive materials in fuel cladding during earthquakes

10

Back-fitting 4

No.	Enforcement date	Case
6	2017.11.15	Clarification of dynamic equipment required to retain functionality during or post- earthquakes
7	2017.12.14	Measures against falling pyroclastic material
8	2017.12.14	Reflection of technical knowledge obtained through the conformity to the new regulatory requirements review of reactors No. 6 and 7 at the Kashiwazaki-Kariwa Nuclear Power Station
9	2018.2.20	Prevention of leakage outside the controlled area due to overflow
10	2019.2.13	Actions related to clarification of fire detector installation requirements
11	2019.6.19	Re-evaluation of eruptive volume of Daisen-Namatake Tephra (DNP)
12	2019.7.31	Countermeasures for Tsunamis that may not be accompanied by a tsunami warning
13	2021.4.21	Formulation of standard response spectra for seismic motions formulated without specifying the epicenter

11

Continuous Improvement

- PSACI –

Periodic Safety Assessment of Continuous Improvement

12

PSACI 1

- Licensees have roles and responsibility to operate safely
- Continuous improvement by them is crucial, in addition to satisfy regulation
- The amended law introduced "Periodic Safety Assessment of Continuous Improvement"
- Ask licensees to conduct periodic safety assessment, compile the results, report to NRA, and open to the public

13

PSACI 2

- PSACI should be done in every operation cycle
- Submit 1st report, and when modified
- Would include,
  - ✓ measures taken to enhance safety
  - ✓ status of latest SSCs
  - ✓ PSR (IAEA/SSC-25): 10-year term
  - ✓ PRA on the current system : 5-year term
  - ✓ Stress test : 5-year term

14

PSACI 3

List of submissions of report (1/2)

Kansai Electric Power Co., Inc		
Takahama NPS, Unit 3		
1st report	2nd report	3rd report
2018.1.10	2019.6.10	2021.10.6
Modified: 2018.9.26		
Takahama NPS, Unit4		
1st report	2nd report	3rd report
2019.3.29	2020.8.27	2021.11.15
Ohi NPS, Unit 3		
1st report	2nd report	
2020.1.24	2022.1.31	
Ohi NPS, Unit 4		
1st report	2nd report	
2020.4.13	2021.8.6	

Shikoku Electric Power Co. Inc.	
Ikata NPS, Unit 3	
1st report	2nd report
2019.5.24	2022.7.22

15

PSACI 4

List of submissions of report (2/2)

Kyushu Electric Power Co., Inc.				
Genkai NPS, Unit 3				
1st report	2nd report			
2020.2.20	2021.6.22			
Genkai NPS, Unit 4				
1st report	2nd report			
2020.5.20	2021.10.15			
Sendai NPS, Unit 1				
1st report	2nd report	3rd report	4th report	5th report
2017.7.6	2019.1.7	2020.5.11	2021.6.15	2022.7.15
Modified：2017.7.28				
Modified：2018.3.30				
Sendai NPS, Unit 2				
1st report	2nd report	3rd report	4th report	
2017.9.25	2019.3.28	2020.7.22	2021.7.26	
Modified：2018.3.30				

16

PSACI 5

- NRA asked RSEC and NFSEC to provide advice on how to better utilize the system
- RSEC and NFSEC conducted series of hearings from licensees who submitted the reports
- Various opinions were made by the member of RSEC and NFSEC, e.g., the timing of conducting the assessment, contents, and utilization of them as a tool for communicating with society
- Referring to the opinion, NRA further asked RSEC and NFSEC to work on improving the system and operation

17

Nuclear Oversight Program

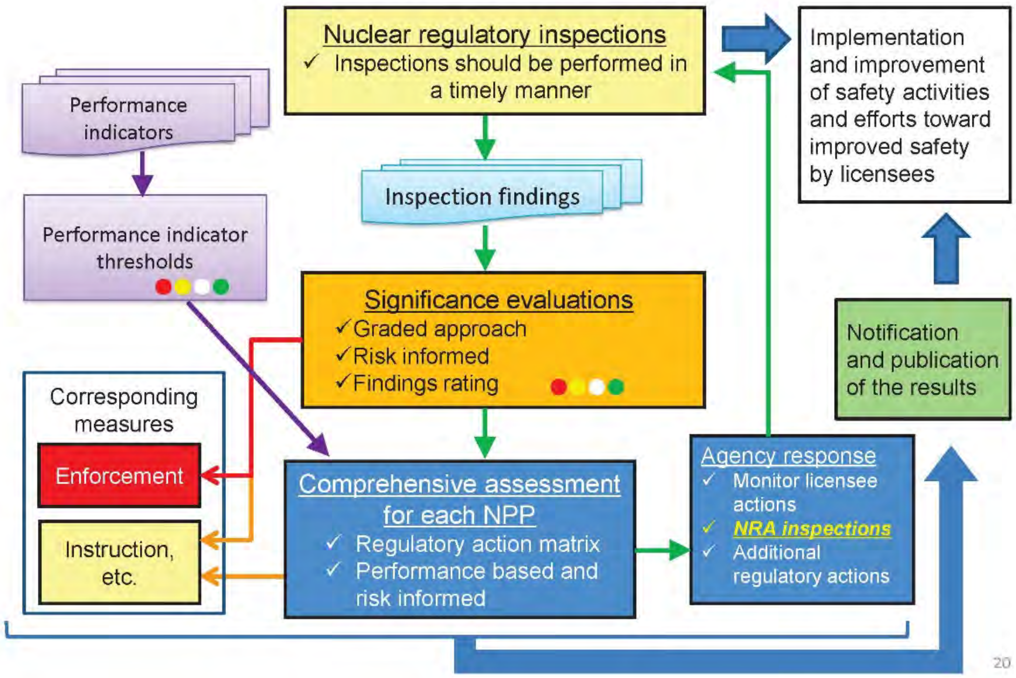
18

Nuclear Oversight Program 1

- The Act amended in 2017 making inspection program flexible and covering whole licensees' activities relevant to safety and security
- Make clear licensees have obligation to check compliance to regulatory requirements
- Performance-based regulation by assessing the level of safety and security and reflecting it to the next year inspection plan
- The results are reported to the NRA Commission Meeting in each quarter
- NRA conducts a comprehensive assessment and makes the results public annually for each nuclear facility
- Trial carried out from 2018 to 2019, full-scale operation in April 2020

19

Nuclear Oversight Program 2



Nuclear Oversight Program 3

Since the full-scale operation started in April 2020, there have been 69 GREEN, one RED and one WHITE findings. (Eleven GREEN-equivalent findings at nuclear fuel facilities)

- RED finding

  Partial loss of function of equipment for physical protection

  Function of physical protection equipment was partially lost, and the operator was aware of the need to restore it.

  I took a long time to restore the function and no effective alternative measures had been taken.
- WHITE finding

  ID card fraud

  At an NPS, electric power company employee used another person's ID card to enter the central control room located in a protected area.

Classification according to the inspection findings and the performance indicators (Nuclear Power Plants)

Green	Very low and limited impact on Safety function and performance. Green significance indicates that the licensee performance is acceptable. It can be improved through licensee's corrective action. (Including no performance deficiency for performance indicators)
White	Low impact on Safety function and performance. Cornerstone objectives are met with minimal reduction in safety margin. NRA should monitor the corrective action of licensee.
Yellow	Substantial impact on Safety function and performance. Yellow significance indicates a decline in licensee performance that is still acceptable with cornerstone objectives met, but with significant reduction in safety margin.
Red	High impact on Safety function and performance.

21

Long-term Operation

22

Long-term Operation 1

In the new law amended after Fukushima accident,

- Legally set the limit for NPP's operation up to 40 years after operation start.
- The NRA can give permission to extend operational period, only once, up to 60 years.
- This permission is given only if NPPs comply with all the regulatory requirements.

23

Long-term Operation 2

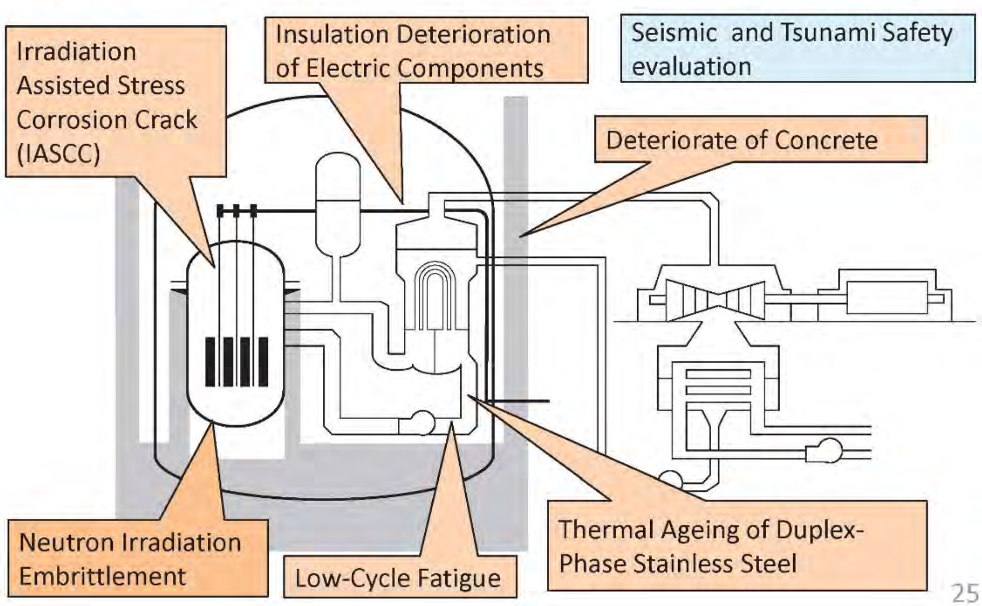
Requirement for Extension

- Satisfy the latest **Regulatory Standards**
- Conduct **Special Inspection**
- Conform with **Technical Criteria** throughout extended period (up to 60 years)
  - ✓Evaluation of deterioration
  - ✓Development of LTMP (Long-Term Mgmt Plan)

24

Long-term Operation 3

Ageing deterioration in technical evaluation



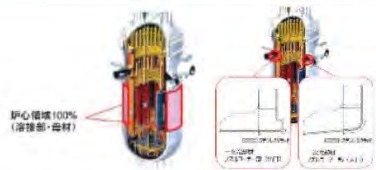
25

Long-term Operation 4

Special Inspection

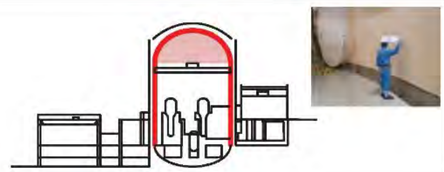
<Reactor Vessel>

Base material and weld (100% core zone) (UT)
Corner parts of primary coolant nozzle (PT or ECT)
Bottom Mounted Instrumentation (VT and ECT)



<Containment Vessel>

Steel plates of containment vessel (VT)



<Concrete Structures>

Core samples
(strength/neutralization/salt permeation/
alkali aggregate/shielding capability)

26

Long-term Operation 5

- **Code on Implementation and Review of Nuclear Power Plant Ageing Management Program**
- **This code (AESJ-SC-P005) was published by Standard Committee of Atomic Energy Society of Japan (AESJ) in 2008 and continuously updated every year by 2022.**

✓ **Qualitative risk-informed approach to make cross-links between degradation modes and safety-related components, including interaction between degradation and external hazard**

✓ **Major input to IAEA knowledge-base; IGALL (SRS-82)**

27

Long-term Operation 6

Background

- The Japanese government decided the "Basic Policy for the Realization GX" in December, 2022, which included "New system regarding the operation period".

New system regarding the operation period

- While maintaining the current regulation system (the operating period is 40 years in principle and can be extended only once for up to 20 years), additional extensions will be allowed only for a suspension period.
- It is assumed that this will be corresponded to the suspended period due to conformity review to new regulatory requirements established after the Fukushima Daiichi accidents.

28

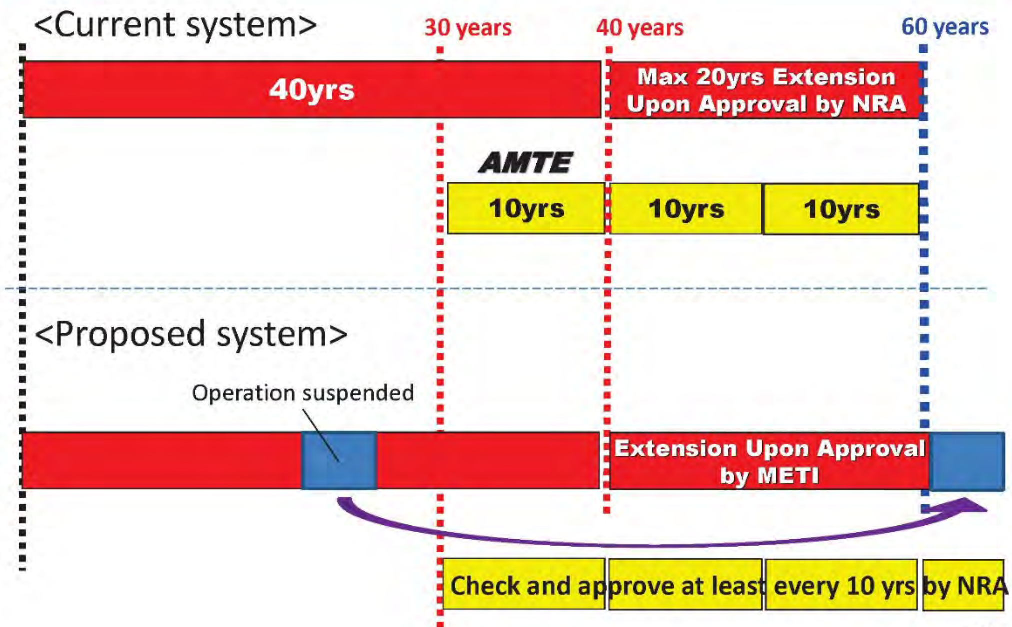
Long-term Operation 7

Response of the NRA

- NRA discussed, asked public comments, and decided to stipulate the following provisions in the Nuclear Regulation Act.
  - If the operator continues to operate the plant for more than 30 years after the start of operation, a technical evaluation of aging degradation must be conducted not exceeding 10 years.
  - The operator must prepare a long-term facility management plan based on this result and obtain approval from the NRA.
- The bill for this revision of the act will be discussed in the current Diet session.
- NRA continues to discuss the detail of the regulation while basic technical elements are considered remaining unchanged.

29

Long-term Operation 8



30

https://www.nra.go.jp/english/index.html

31

C.3.2 Current Status of Regulation, Aging Management and LTO

東京大学
THE UNIVERSITY OF TOKYO

March 14, 2023
International Regulatory Advisory Committee Meeting

Current Status of Regulation and Ageing Management and Safe Long Term Operation of Nuclear Power Plants in Japan

Naoto Sekimura, Prof., Dr.

Vice President, The University of Tokyo
Professor, Department of Nuclear Engineering and Management

Member of Science Council of Japan
Chairperson of Sub-Committee on Nuclear Safety

Chairperson, Nuclear Reactor Safety Examination Committee, NRA Japan

Contents

1. Introduction to Regulatory Systems in Japan
2. Regulatory Requirements for Current LWR Fleets
3. Recent Updates of Nuclear Policies
4. Current Status of LWR Fleets
5. Periodic Safety Assessment of Continuous Improvement (PSACI) and Nuclear Oversight Programs
6. Ageing Management Technical Evaluation (AMTE) and Long Term Operation (LTO)
7. Knowledge-base and R&D for Ageing Management and Safe Long Term Operation

2

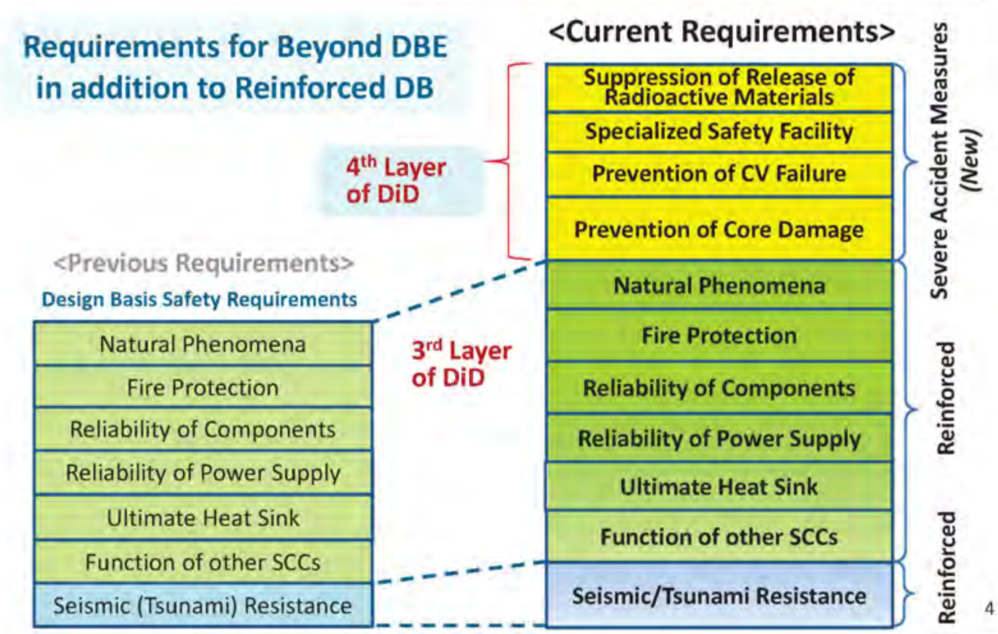
Nuclear Regulation Systems after the Fukushima Daiichi Accident

The NRA (Nuclear Regulatory Authority) implements new regulatory systems stipulated in the amended Nuclear Regulation Act, which became effective from July 8, 2013;

- **Regulation taking severe accidents into consideration**
  - Legally request severe accident measures to the licensees
- **Introduction of back-fitting system : Regulation applying latest scientific/technical knowledge on safety issues to existing facilities**
  - Apply new technical requirements to existing licensed nuclear facilities as a legal obligation
- **An operation limit of 40 years to deal with ageing of reactors**
  - As an exception, **extension (<20 years)** will be approved, only when compliance with the regulatory standards by the Government Order is confirmed.
- **Special safety regulation in the Fukushima Daiichi site**

3

Current Regulatory Requirements in Japan



4

Regulatory Requirements to Current LWR Fleets

- **Regulatory Requirements and Back Fitting**
- **Periodic Safety Assessment of Continuous Improvement**
- **Nuclear Oversight Program**

Dr. Ichimura (NRA)

- **Ageing Management and Long Term Operation**

following pages

5

6th Strategic Energy Plan in Japan : October 2021

- **Progress in the past decade after the accident at Fukushima Daiichi Nuclear Power Station,**
- **Policy responses towards 2030 looking ahead to 2050,**
- **Challenges and responses for achieving carbon neutrality,**
- **Tensions regarding international energy security**

➢ **Nuclear power contribution in 2030 : 20-22% of total electricity source**

➢ **Restart of operation of existing LWRs as top priority**

➢ **R&D for FBRs, SMRs and HTGRs as well as fusion**

✓ No statements for the replacements and life limits of existing LWRs fleets

6

Reconsideration of the Operation Period Limit

August 2022

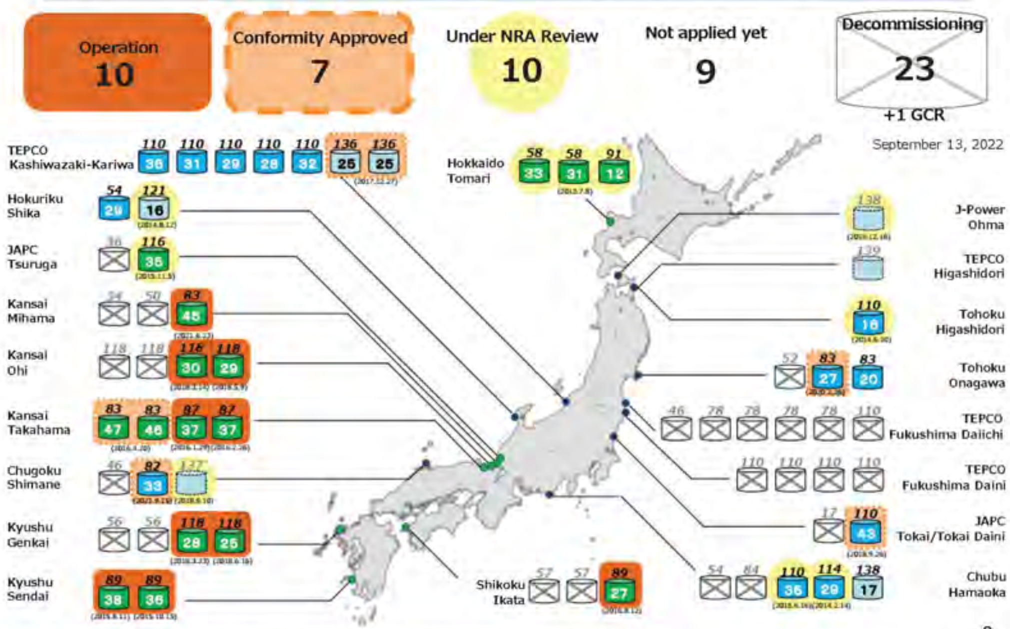
- **"Extension of Operation Period of NPPs with High Level of Safety"** is recognized as an important political decision in nuclear energy policy.
  - ✓ **Prime Minister Kishida's Statement in the GX promotion Council**

October 2022 -

- Ministry of Economy, Trade and Industry (**METI**) and Nuclear Regulation Authority (**NRA**) are planning to compile the policy and regulatory system framework.
  - ✓ METI has started to discuss operating period of nuclear power plants.
  - ✓ NRA has decided to consider how to confirm safety as a regulatory side after receiving an explanation from the METI.
  - ✓ Importance of knowledge accumulation has been discussed.

7

Current Status of Nuclear Power Plants in Japan

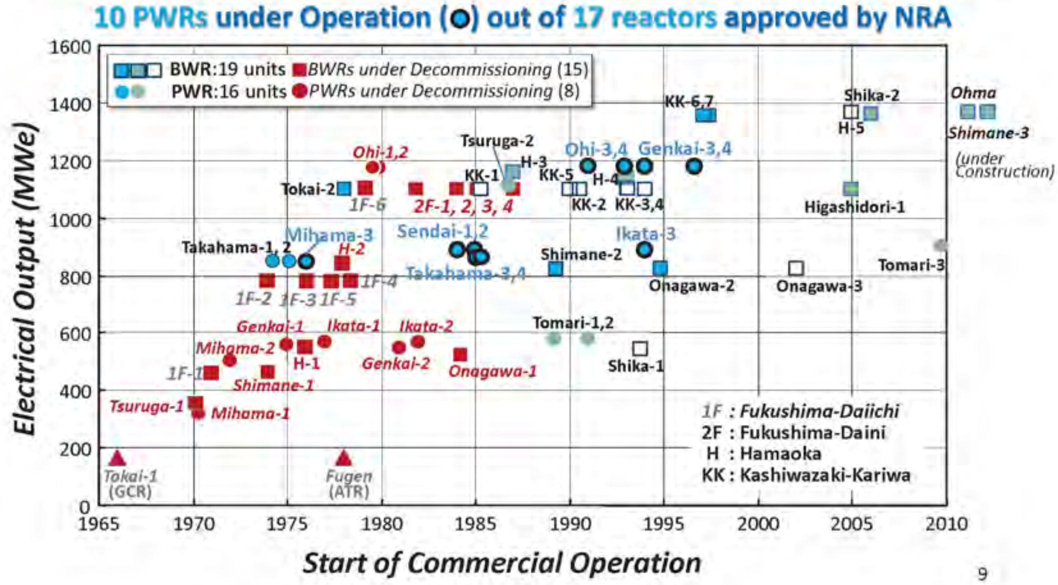


https://www.enecho.meti.go.jp/category/electricity_and_gas/nuclear/001/pdf/001_02_001.pdf

8

Current Status of Nuclear Power Plants in Japan

Update on January, 2023



9

Long Term Operation of Nuclear Power Plants in Japan

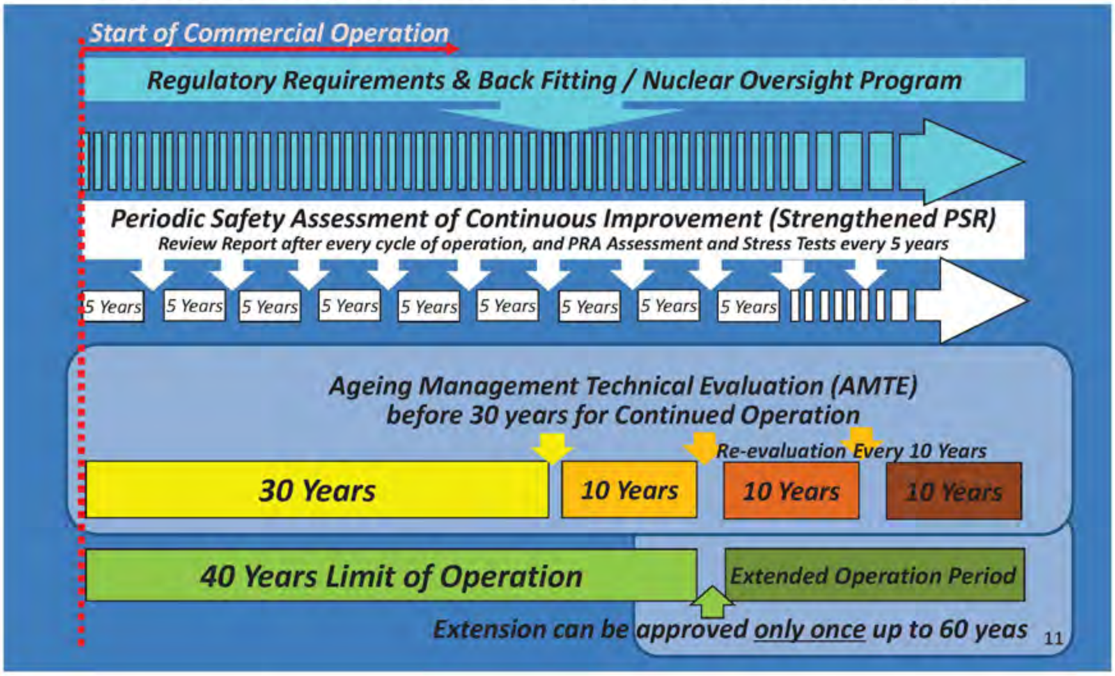
- LTO approval by NRA : Extension of operation period up to 60 years
  - ✓ 3 PWRs : **Takahama Units 1 & 2** **Mihama Unit 3** (Kansai Electric Power Co.)
  - ✓ 1 BWRs : **Tokai-Daini** (JAPC)

  * **Mihama Unit 3** has successfully started to operate beyond 40 years.
  * Kansai Electric Power invites IAEA SALTO peer review in 2024 Q2.

- Under Application and Preparation for LTO
  - ✓ **Sendai Units 1 & 2** (Kyusyu Electric Power Co.) : LTO application
  - ✓ **Takahama Units 3 & 4** (Kansai Electric Power Co.) : Special Inspection

10

Current Regulatory Systems for Inspection, Safety Improvement, Ageing Management and Extended Operation in Japan



Processes of Ageing Management Technical Evaluation

1. *Review Operational Experience and Possible Ageing Degradation in All the Safety-related SSCs*
2. *Reflect Latest Knowledge on Risk and Engineering Database*
3. *Evaluate Integrity of SSCs considering Ageing Degradation Assuming the Service for 60 years*
4. *Evaluate Seismic Safety and Tsunami Safety Analyses considering Ageing Degradation Assuming the Service for 60 years*
5. *Evaluate Validity of Current Maintenance Program*
6. *Establish Long-Term Maintenance Policies in the next 10 years*

12

Code on Implementation and Review of Nuclear Power Plant Ageing Management Program

- **This code (AESJ-SC-P005) was published by Standard Committee of Atomic Energy Society of Japan (AESJ) in 2008 and continuously updated every year by 2022.**

✓ **<u>Qualitative risk-informed approach</u> to make cross-links between degradation modes and safety-related components, including interaction between degradation and external hazard**

✓ **Major input to IAEA knowledge-base; IGALL (SRS-82)**

13

Major ageing phenomena to be evaluated in Ageing Management Technical Evaluation

Major Ageing Modes and Phenomena to be Evaluated	
Major 6 Ageing Phenomena	Low-cycle Fatigue
	Neutron Irradiation Embrittlement
	Irradiation Assisted Stress Corrosion Cracking
	Thermal Ageing of Duplex Stainless Steel
	Degraded Insulation of Electrical and Instrumentation Equipment
	Degraded Strength and Shielding Performance of Concrete and Degradation of Strength of Steel Frame
Evaluation on Seismic Safety considering Possible Ageing Degradation	
Evaluation on Tsunami Safety considering Possible Ageing Degradation	

AESJ-SC-P005 (2022)

14

Tables of Ageing Mechanisms with Safety Function, Materials and Environments

Example of Ageing Mechanisms in High Pressure Injection Pumps evaluated in Takahama -1

Required Function	Location	Easy to Replace ?	Material	Ageing Degradation: Reduced wall thickness		Cracking		Material Degradation		Others	Remarks
				Wear	Corrosion	Fatigue	SCC	Thermal ageing	Deterioration		
Pump Capacity and Head	Main shaft		Stainless steel	▲		● △					Fretting fatigue cracking and possible high cycle fatigue cracking in Main Shaft
	Vane wheel		Stainless cast steel		△						
	Casing ring		Stainless steel	▲							
	Bearing box		Cast iron		▲						
	Bearing (sliding)		Carbon steel White metal	▲							
	Gasket	◎	—								
	Shaft joint		Low alloy steel								
	Speed increasing gear		Low alloy steel	●							
	Bearing of speed increasing gear (sliding)		White metal	▲							
	Casing of speed increasing gear		Cast iron		▲						
Boundary	Casing		Low alloy steel								Possible cavitation in Vane wheel
	Casing cover		Low alloy steel								
	Casing bolt		Low alloy steel		△						
	Mechanical seal	◎	—								
	Gasket	◎	—								
	O-ring	◎	—								
	Casing drain tube		Stainless steel								
	Balancing tube		Stainless steel								
	Mechanical seal cooler		Stainless steel								
Support of components	Base plate		Carbon steel		▲						....
	Mounting bolt		Carbon steel		▲						....
	Foundation bolt		Carbon steel		●						

[Speed increasing gear] Although wearing of gear is prevented with lubrication oil at inside of the unit, wearing is possible when it is operated for a long time, Accordingly, evaluation is required on aging change.

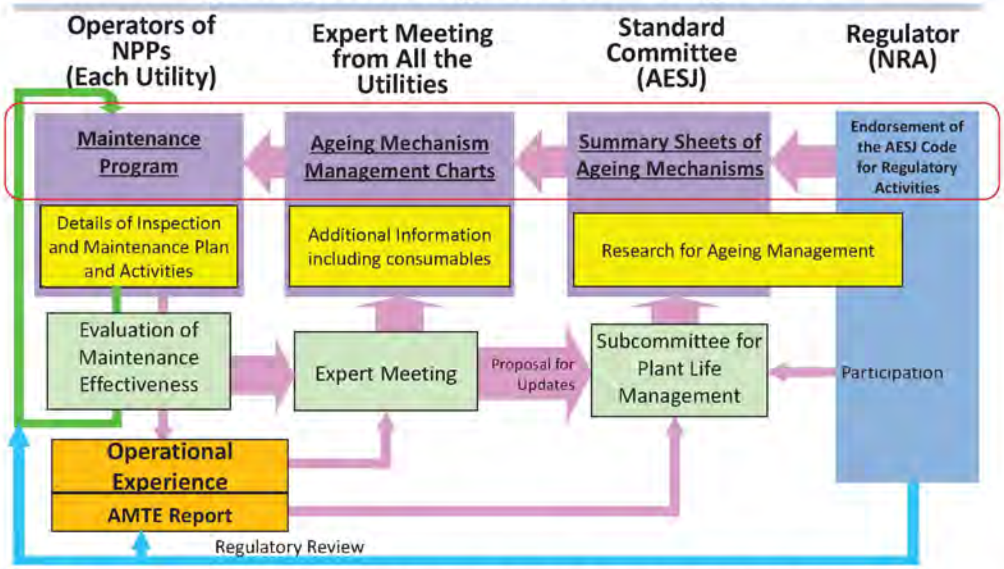
[Corrosion of speed increasing gear casing] Inside of the unit is exposed to atmosphere of lubrication oil. It is possible to say that no technical problem will occur by the operating condition and comparison with material testing data.

● : Ageing Degradation Mechanism Important for Long Term Operation

△, ▲ : Ageing Degradation Mechanism possible for Long Term Operation

15

Continual Improvements of Ageing Management Programs



AMTE : Ageing Management Technical Evaluation before 30 years for Continued Operation
JANSI : Japan Nuclear Safety Institute, AESJ : Atomic Energy Society of Japan

16

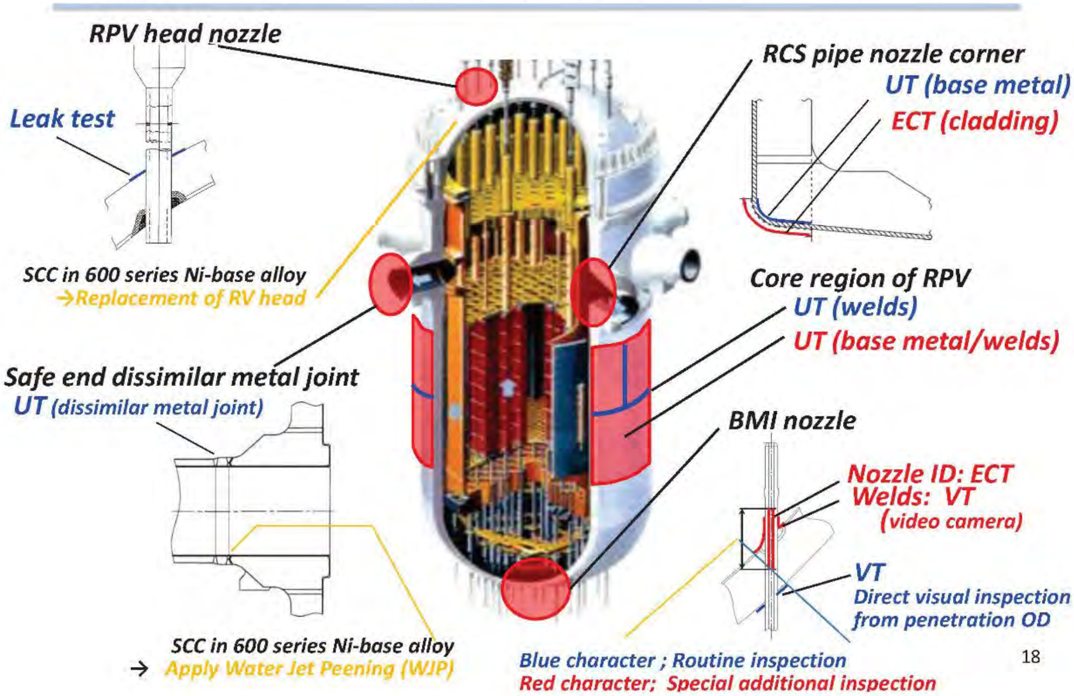
Special Additional Inspection for Long Term Operation beyond 40 years

Components	Current Inspection	Additional Inspection
Reactor Pressure Vessel	Ultrasonic Tests of Welded Zone	100% UT Examination of Base Metal in addition to Welded Zone
Primary Containment Vessel (Steel)	Leak Rate Tests	Visual inspection on coating condition
Civil Concrete Structure	Visual Tests & NDT	Core Sampling (Strength, Neutralization, Salt intrusion, etc.)

- ✓ Additional regulatory requirements for long term operation of existing plants do not utilize risk-information accumulated from Ageing Management Technical Evaluation in Japan.

17

Special Additional Inspection of Pressure Vessel



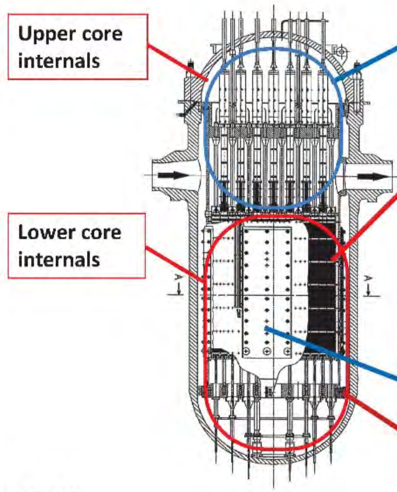
18

Operator's Initiative for LTO

Heavy Component Replacement

Core Internal Replacement in Mihama Unit 3 (3-Loop PWR, 826 MWe), 2020

・The whole core internals are replaced.



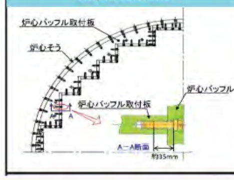
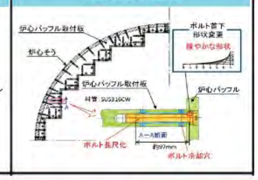
KEPCO

✓ **Structural change of upper core internals**

- To streamline the structure, the upper core support plate is replaced with the steel circular plate attached to the cylindrical shell, as adopted by the latest plant.

✓ **Structural change of baffle to improve <u>resistance to irradiation assisted stress corrosion cracking</u> (IASCC)**

- Adoption of square type baffle, longer baffle former bolts, and bolts with the under head shape modified to **<u>reduce stress</u>**, and introduction of bolt cooling holes to **<u>lower temperatures</u>**

Before Core Internal Replacement	After Core Internal Replacement
	

✓ **Structural change of thermal shielding material**

- To streamline the structure, the cylindrical type material is replaced with the separate type, as adopted by the latest plant.

✓ **Adoption of a larger radial support <u>improve the seismic resistance</u>.**

19

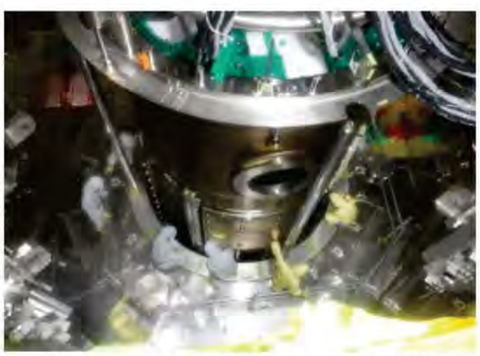
Operator's Initiative for LTO

Heavy Component Replacement

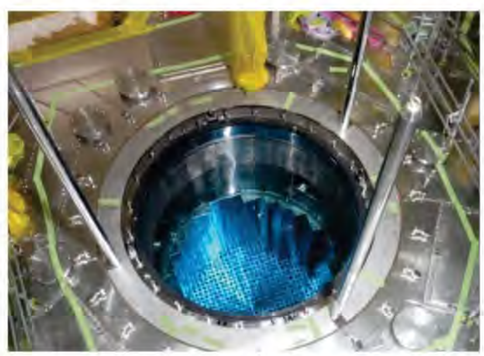
Core Internal Replacement in Mihama Unit 3 (3-Loop PWR, 826 MWe), 2020

Integrated replacement work of RVI

MITSUBISHI HEAVY INDUSTRIES



Install new RVI into RPV



Installed new RVI into RPV

	Plan		Result
total work dose	115.28 man・mSv	△50%	56.54 man・mSv

20

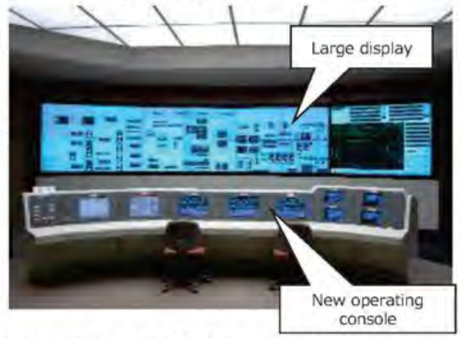
Operator's Initiative for LTO

Replacement of Main Control Panels

in Takahama 1, 2 and Mihama 3

Main control panels are replaced with the state-of-the-art digital type **to improve maintainability**.

Analog | **Fully Digitalized**



Previous main control panel before refurbishment

Current Digital main control panel

KEPCO

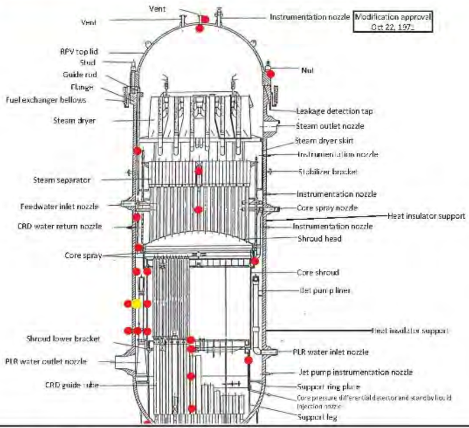
21

R&D Projects on Material Ageing for LTO

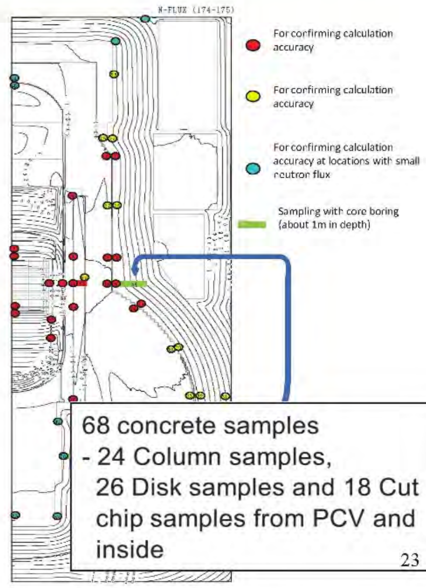
Project	*R&D Topics*	*Organizations*	*Duration (JFY)*
ANRE/ METI	• **Concrete radiation degradation for ageing management**	Mitsubishi Research Institute	2017-2022
	• **Ageing degradation of harvested materials from Hamaoka Units-1,2**	Chubu Electric Power Company	2015-2022
	• **Improvement of evaluation methods of irradiation effects on reactor pressure vessel and core internals**	CRIEPI	2015-2018
	• **Ageing management for LTO of nuclear power plants**	CRIEPI	2021-2025
NRA Harvested Materials	• **Irradiation embrittlement of RPV**	JAEA	2020-2024
	• **Cable degradation**	Waseda Univ.	2020-2024
	• **Thermal ageing* and toughness of core internals** utilizing materials harvested from decommissioning plants**	CRIEPI	*2021-2024 **2020-2024
Industry	• **Irradiation embrittlement of RPV,** • **Concrete degradation,** • **Cable degradation, SCC and IASCC**	Japanese Utilities, Plant fabricators, CRIEPI	2000-

22

Sampling of RPV Materials and Concrete Structure from the Decommissioning Plants : Hamaoka Unit 1



27 metal samples
- 5 Boat samples from RPV belt-line
- 5 Column samples from Shroud
- 10 Disc samples from Top guide etc.)
- 7 Cut chip samples from RPV top,bottom&side



68 concrete samples
- 24 Column samples, 26 Disk samples and 18 Cut chip samples from PCV and inside

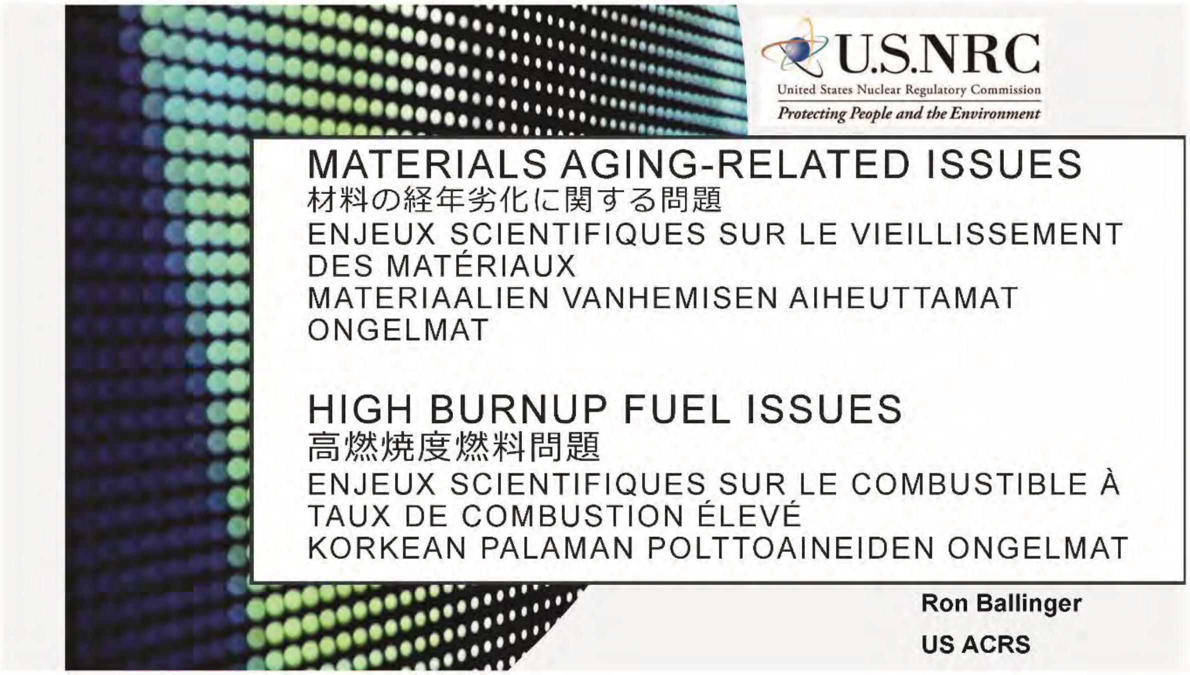
23

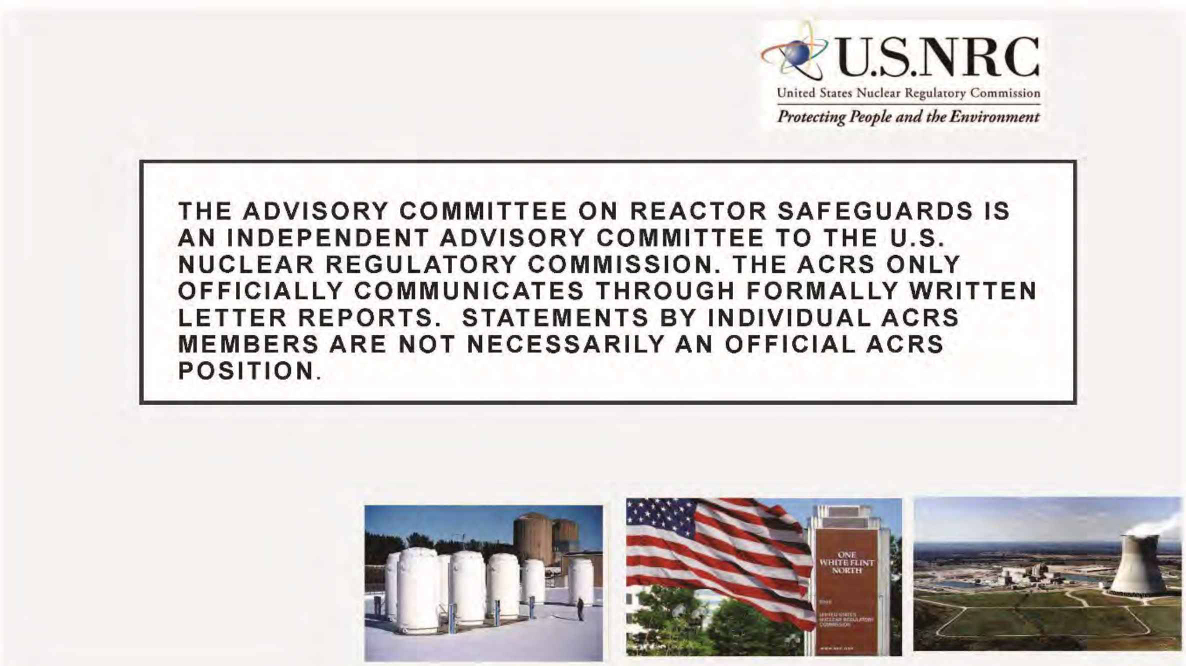
東京大学 THE UNIVERSITY OF TOKYO

Thank you very much for your attention.

sekimura@n.t.u-tokyo.ac.jp

C.4 United States



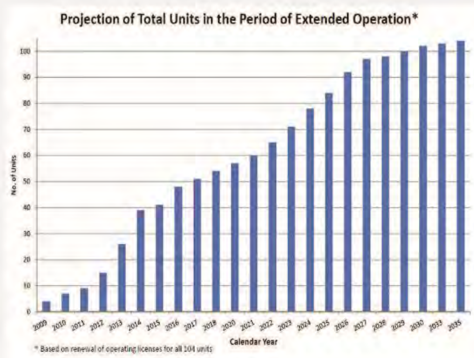


Background (US)

- Initial design life-40 Years (US)
- License Extension in place for essentially all operating plants to 60 years

- Subsequent License Renewal (SLR-80 Years)
- There is NO reason to believe that we will not encounter "Surprises"-new degradation mechanisms

- Degradation mechanisms that were unimportant (or unknown) @ 40 years may become important at longer times



Key Points

- o Materials choices MUST be made in the context of Design, Construction, and Operation
- o Environmental Degradation Risk EVOLVES with time and must be continuously evaluated
- o Design choices affect subsequent constructability and operation
- o Degradation management is an integral and essential part plant operation (Aging Management Plans-AMPs)

- o The ENTIRE Life Cycle must be considered
  - 40 Years is a LONG Time
  - 80 Years is a REALLY LONG Time
    - Remember: 10-15C ~ 2X

Important Components and Structures for Long Term Operation

Primary System
- Reactor Vessel Shell
- Bottom Mounted Instrumentation
- Reactor Nozzle
- PWR Reactor Internals
- Reactor Coolant Piping
- Reactor Coolant Pump Casing
- Steam Generator
- Pressurizer
- Unisolable Branch Piping

Steel Structures
- Reactor Vessel Support Steel
- Polar Crane
- Fuel Transfer Systems
- BWR Drywell
- Radioactive Waste Systems

Concrete Structures
- Foundations/Base Mat
- Pile
- Containment Shell and Liner
- Reactor Vessel Support Concrete
- Interior Structural Concrete
- Refueling Canal
- Spent Fuel Pools
- Intake Structure/Tunnels
- Cooling Towers

Others
- Cables
- Containment Penetrations
- Buried Piping and Tanks
- Dry Casks
- Fire Protection

From: T. Esselman, A. Kadak, J. Gaertner, R. Ballinger, Long Term Operation Workshop, February 17-18, 2010, Crystal City, VA

"The great tragedy of science, the slaying of a beautiful hypothesis by an ugly fact."

Thomas Huxley

SLR Safety Issues

- Each Plant Licensing Basis Must be Maintained
- Requires Additional Focus on Aging Management of Passive, Long Lived Structures and Components during period of Extended Operation

SLR Guidance

- Generic Aging Lessons Learned for SLR (GALL-SLR), NUREG-2191
  - Evaluation of aging effects (AMPs)
- Standard review Plan for Review of Applications (SRP-SLR), NUREG-2192

Derived, in part, from: "SLR Guidance Documents and Optimization of the SLR Safety Review Process", NRC Staff Presentation at ACRS, April 6, 2017

Selected Age-Related Materials Issues

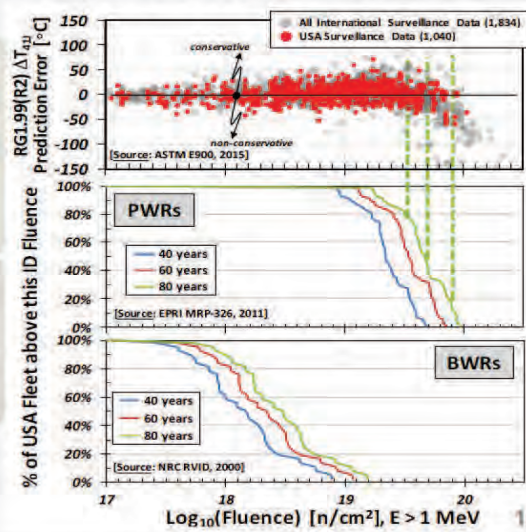
- Reactor Pressure Vessel (RPV) Embrittlement
- Environmentally Assisted Structural Materials Degradation

Pressure Vessel Embrittlement

- When US + International Surveillance Data are included, RG 1.99R2* prediction may not be conservative

- RG1.99 is currently being reevaluated to address this potential issue

* Regulatory Guide 1.99 Revision 2, Radiation Embrittlement of Reactor Vessel Materials, May 31, 1988 (ML003740284)



12

In Part From: M. Kirk, Sr. Materials Engineer, USNRC, ACRS Presentation, November 17, 2015

Insights from ACRS Letter

Continued use of the existing Regulatory Guide (RG) 1.99, Revision 2, correlation if a plant's end of life fluence to the RPV does not exceed a threshold of 6 x 10^{19} n/cm^2 (E>1 MeV).

For plants that will exceed this threshold, a new correlation, likely American Society for Testing and Materials (ASTM) E900-15, , "Standard Guide for Predicting Radiation-Induced Transition Temperature Shift in Reactor Vessel Materials," would become the new regulatory basis for estimating RPV embrittlement.

NOTE: Additional data are being obtained through modified surveillance programs

Stress Corrosion Cracking (SCC) of Stainless Steel Piping in PWRs (Emerging Issue?)

- Stress corrosion cracking has recently been observed in Type 316 stainless steel in PWR Piping
  - ***Base Metal***, (Heat Affected Zone) HAZ adjacent to welds
- Pipe ID, circumferential, at elbows
- Safety injection and residual heat removal lines
  - Non-isolable

Recall: Extensive SCC in BWR stainless steel piping early in life
-Caused by (Normal Water Chemistry) NWC (dissolved oxygen) and sensitization
-Addressed by (Hydrogen Water Chemistry) HWC/NobleChem(hydrogen injection, etc.)

NOTE: From "C. Moyer,USNRC Public Meeting, "EDF SCC Operating Experience Discussion", 5/25/22

Characteristics

- Regions of high residual/cyclic operating stress
  - HAZ-High Residual Stress
  - High surface hardness
  - Potentially thermally induced stresses
  - ***Stress Gradient is tensile***
    - ***Crack Arrest?*** → ***compressive***

ECP = Electrochemical Corrosion Potential

US Operating Experience

- Inspection mandated in 10CFR50.55a (ASME Section XI) or NRC-approved risk informed Inservice Inspection (ISI) plan as an alternative to Section XI
- US plants examine 10-15% of Class I SI and Residual Heat Removal (RHR) piping welds.
- NO SCC found as of yet

However, welds susceptible to thermal fatigue

- 10 incidents of thermal fatigue cracking since 2013 (Ultrasonic Testing (UT(7)), Leakage (3))
- EPRI updated MRP-146 in 2018 to enhance voluntary inspection programs.

NOTE: From "C. Moyer,USNRC Public Meeting, "EDF SCC Operating Experience Discussion", 5/25/22

In the US

- Class 1 pipes examined using multiple ultrasonic angles from multiple directions
- Personnel, procedures, equipment used on pipe welds-extensive demonstration testing (ASME Section XI, Appendix VIII)
- ***HOWEVER*** Examinations in US optimized for thermal fatigue flaws but capable of detecting SCC

- Current UT examinations capable of detecting 5-15% through wall- but very good probability of detecting larger cracks
- BUT-challenges with metal grain structure and geometric features

NOTE: From "C. Moyer,USNRC Public Meeting, "EDF SCC Operating Experience Discussion", 5/25/22

HOWEVER

"The great tragedy of science, the slaying of a beautiful hypothesis by an ugly fact."

Thomas Huxley

High Burnup Fuel

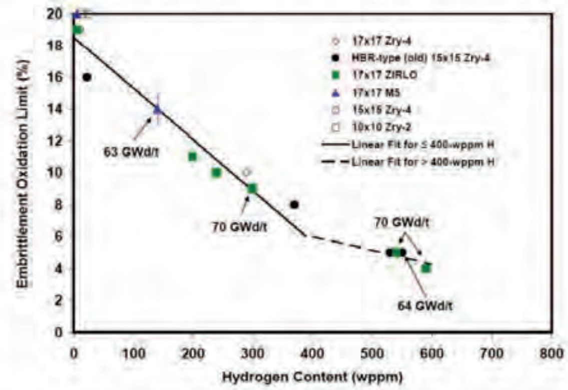
- Cladding Embrittlement
- Fuel Fragmentation and Relocation

Cladding Embrittlement LOCA (Loss-of-Coolant Accident) Research & Test Program Results

Significant Reduction in Cladding Ductility at High Burnup

- Hydrogen absorption effect on ductility

- Breakaway Oxidation During LOCA Transient
  - Transition from Adherent to Non-Adherent Oxide-accelerated hydrogen absorption



Ductile-to-brittle transition oxidation level (CP-ECR) as a function of pretest hydrogen content in cladding metal for as-fabricated, prehydrided, and high-burnup cladding materials. Samples were oxidized at ≤1,200 °C ±10 °C and quenched at 800 °C. For high-burnup cladding with about 550-wppm hydrogen, embrittlement occurred during the heating ramp at 1,160–1,180 °C peak oxidation temperatures

Note: The now exclusive use of advanced cladding materials (M5, Zirlo, etc.) results in greatly reduced hydrogen absorption. Zircaloy 4 is now no longer used

Proposed 10CFR50.46c Rule

- Maintains Peak Clad Temperature and Hydrogen Limits
  - Peak Clad Temperature: 2200°F
  - Maximum Cladding Reacted: 1%
- Adjusts Equivalent Cladding Oxidized (Cathcart-Pawel Equivalent Cladding Reacted; CP-ECR) to Reflect Burnup Effect

- Requires Analytical Limits for Peak Cladding Temperature and Integral Time-at-Temperature to be Developed that Account for the Effects of Exposure.
- Requires Accounting for “Breakaway” Oxidation

Note: The now exclusive use of advanced cladding materials (M5, Zirlo, etc.) results in greatly reduced hydrogen absorption. Zircaloy 4 is now no longer used.

Insights from ACRS Letter

- Revise Emergency Core Cooling System (ECCS) acceptance criteria to reflect extensive research findings
  - High Burnup Effects on Cladding Ductility

- Replace prescriptive criteria with performance-based requirements

Fuel Fragmentation and Relocation-Experimental Observations

- **Experimental data suggest that during some LOCA conditions fuel fragmentation and relocation can occur**
  - Fine Fragmentation
    - Not seen below 55,000 MWd/MTU
  - Fuel Axial Relocation
    - Not seen for cladding strain less than 3%
  - Fuel Dispersal
    - Fine fragmentation and relocation are prerequisites: BU>55,000 MWd/MTU, >3% cladding strain.
    - Requires Rupture
  - Transient Fission Gas Release
    - Important for Higher Burnup
  - Change in Axial Relocation
    - Local Packing Fraction

Insights from ACRS Letters

- There remains a significant degree of uncertainty in large part because the problem is multivariate and the experiments from which the data were developed did not always represent actual light water reactor (LWR) conditions.
- A risk informed approach should be undertaken that examines both the likelihood of expected event conditions combined with a more complete modeling evaluation of Report on Fuel Fragmentation, Relocation and Dispersion (FFRD) consequences. This activity could add substantial value to future research program development and to the regulatory decision-making process.

ACRS 2022	Advisory Committee on Reactor Safeguards, report from Joy Rempe, ACRS Chairman, to Christopher T. Hanson, NRC Chairman, Subject: Rulemaking Plan for the Revision of Embrittlement and Surveillance Requirements for High-Fluence Nuclear Power Plants in Long-Term Operation, April 28, 2022. (https://www.nrc.gov/docs/ML2210/ML22105A325.pdf)
ACRS, 2021	Advisory Committee on Reactor Safeguards, Letter from Matthew W. Sunseri, ACRS Chairman, to Daniel H. Dorman, NRC Executive Director for Operations, Subject: Research Information Letter (RIL) 2021-13 on Interpretation of Research on Fuel Fragmentation, Relocation, and Dispersal at High Burnup, December 20, 2021. (https://www.nrc.gov/docs/ML2134/ML21347A940.pdf)
ACRS, 2016	Advisory Committee on Reactor Safeguards, Report from Dennis C. Bley, ACRS Chairman, to Stephen G. Burns, NRC Chairman, Subject: Draft Final Rule 10 CFR 50.46c, "Emergency Core Cooling System Performance During Loss-Of-Coolant Accidents (LOCA)" and Associated Regulatory Guides, February 23, 2016. (https://www.nrc.gov/docs/ML1604/ML16046A522.pdf)

APPENDIX D

MARCH 15, 2023, SESSION 2 PRESENTATIONS

D.1 Finland

Recent new build experience and outlook on SMRs in Finland

Prof. Juhani Hyvärinen
LUT University, Nuclear Engineering
Member of STUK's Advisory Committee on Nuclear Safety

ACRS Outreach event, March 15, 2023

Contents

- Recent large nuclear new build project experiences
  - Olkiluoto 3, a 1600 MWe EPR
  - Hanhikivi 1, a 1200 MWe VVER
- ACNS initiative on SMRs, October 2019
- PIEMOS – University support to renewal of Nuclear Energy Act, 2022
- Finnish SMR developments
  - Large company activities
  - Domestic district heating reactor designs by LUT and VTT
  - Microreactor deployment plans
  - Known major issues
- Summary

Olkiluoto 3, a 1600 MWe EPR

- Owner: TVO, a successful boiling water reactor owner and operator
- Decision-in-Principle for a large reactor confirmed by Parliament in May 2002
  - Contract to Consortium Framatome-Siemens awarded in end of 2003 for a first-ever EPR; targeted commissioning in May 2009
- Construction License review 14 months, issued in February 2005
  - In retrospect, much too soon, with design too incomplete → construction start delayed
  - Design iterations ensued in practically all technical disciplines
    - E.g. safety I&C architecture had to be iterated many times over
  - Many issues with equipment supply chain: inadequate quality, failure to respond to supplier's, owner's or regulator's expectations


Figure: TVO

Olkiluoto 3, a 1600 MWe EPR

- Operating license granted in 2019
  - Commissioning delays due to equipment underperformance and emerging shortcomings, eg. pressurizer surge line vibration and various equipment failures both on nuclear and turbine island
- Commercial operation expected to start in April 2023
- Major lessons learned
  - Design should be proven, and ready before construction
  - Supply chain and regulatory expectation matching
  - Management of very long chains of sub-suppliers
  - Cultural differences between Supplier and Host country, rigorous (or not) adherence to procedure

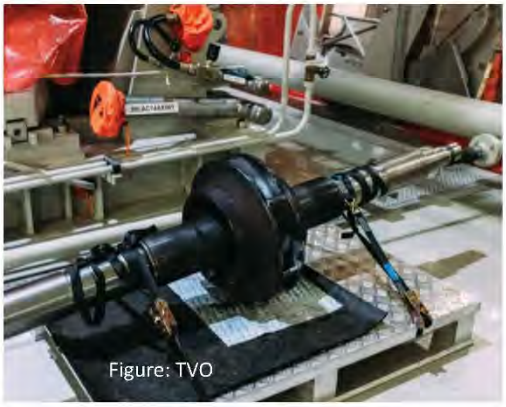


Figure: TVO

Hanhikivi 1, a 1200 MWe VVER

- Owner: Fennovoima, a startup backed up by Finnish industries and E.ON (Germany) (originally)
- Decision-in-Principle confirmed by Parliament in June 2010 for one large (1600 MWe) reactor
  - Site selected in October 2011, a greenfield site
- Delays in plant contracting; E.ON departed from Finland in 2012, leaving a technical support gap in Fennovoima → need to bring new Supplier on board as minority owner → rerun of the DiP process
  - Russian AES-2006 delivery contract signed at the end of 2014, Rosatom as Supplier
  - Several already being built in Russia at the time. Mature 1200 MWe design, generally compatible with international safety standards but not designed exactly to Finnish rules

Hanhikivi 1, a 1200 MWe VVER

- Lengthy iteration of design details
  - Initially attempted as "requirements compliance" exercise, with little success
  - Difficulty establishing regulatory approvals for design inputs such as earthquake loads on the new site
  - Revised attempt based on overall safety approach
- Fennovoima terminated the contract in May 2022, citing project delays and Supplier's failure to advance the project
  - Meanwhile, the reference plants have been constructed, commissioned, and operated at performance levels normal to the country of origin

- Lessons learned:
  - It's not just the requirements – all parties need to come to a common vision of what they are doing
  - Owner's role as an intermediary between Regulator and Supplier is challenging

ACNS initiative on SMRs, October 2019

View of the Advisory Committee on Nuclear Safety on the development needs of small modular reactors (SMR) in Finland, October 2019

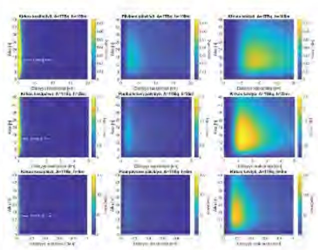
Motivated by
- Many difficulties in large reactor projects home and abroad
- Emergence of SMRs as promising means to tackle the issues

- Recognizes SMR impacts on nuclear community
  - Serial production of large parts of the plant, even full plants
  - Benefits and challenges of design certification
  - New uses, e.g. district heating supply and/or cogeneration; siting near population centers
  - Geographic dispersal of plants, new sites, near population centers
- Suggests revisions in the licensing process
  - Content of Decisions-in-Principle, both for energy generation and waste disposal facilities
  - Enabling separate site and technology reviews and approvals
- Recommends research into SMR safety features, in particular passive safety features and systems

https://www.stuk.fi/documents/12547/319501/1882563-YTN_SMR-aloite.pdf/566b1bfb-7500-0cff-ba34-b2ce2fa9478d?t=1575373387656 (in Finnish)

2.3.2023 Finnish New build experience and SMR Outlook – ACRS Outreach March 2023 7

PIEMOS – Support to renewal of Nuclear Energy Act, published May 2022



- The Ministry of Economy and the Employment contracted LUT University to provide technical fundaments for Nuclear Energy Act revision for SMRs
- Topics covered
  - Siting, in particular size of emergency protection zone, and underground siting
  - Land use planning, and environmental impact assessment of projects
  - Nuclear fuel and nuclear waste management as well as nuclear safeguards
  - Technology: effects of modularity on applications & implementation, use of commercial technologies and avoidance of expensive special products, passive safety and impact of unit size on the licensing system
- Conclusions
  - Nuclear energy act should be complemented with separate approval processes for both reactor technology and plant site, to ensure the benefits of serial production
  - Clarify the intent and purpose of the Government Decision-in-Principle
  - Safety assessment and protection zone sizing should be performance based
  - Use of high-quality "conventional" equipment should be possible, and specialty products avoided

https://tietokayttoon.fi/-/pienet-modulaariset-sarjavalmisteiset-ydinreaktorit-eli-smr-t-piemos- (in Finnish)

2.3.2023 Finnish New build experience and SMR Outlook – ACRS Outreach March 2023 8

Large company SMR activities in Finland

- Fortum, owner of Loviisa, Finland 2 x 500 MWe, and large owner of Oskarshamn 3, Sweden (1450 MWe)
- TVO, majority owner of Olkiluoto 1-3, altogether about 3400 MWe
- Helsinki Energy (Helen), a major provider of cogenerated electricity and heat, minority owner of TVO. Owns cogeneration capacity of 1070 MWe electricity and 1300 MW district heating, and additional around 2000 MWth heat-only capacity

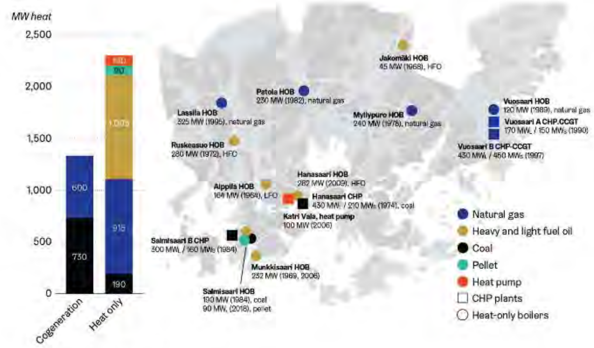
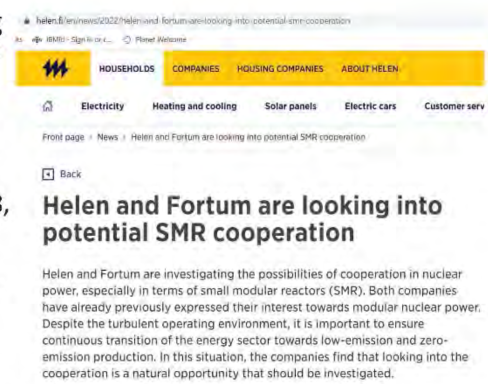


Figure: Helen

Large company SMR activities in Finland

- Fortum and TVO have been actively studying new build options, including SMRs, for some time
  - Until February 2023, Fortum's one major focus has been Loviisa operating license renewal until 2050. This was granted in Feb 16, 2023)
  - TVO is also considering its options. All Olkiluoto units are currently licensed to operate until 2038, at which time units 1 and 2 will have operated nearly 60 years
- Fortum and Helen have a joint nuclear/SMR study underway
- Fortum supports SMR projects in the Baltic region, e.g. in Estonia


HOUSEHOLDS COMPANIES HOUSING COMPANIES ABOUT HELEN

Electricity | Heating and cooling | Solar panels | Electric cars | Customer serv

Front page › News › Helen and Fortum are looking into potential SMR cooperation

Back

Helen and Fortum are looking into potential SMR cooperation

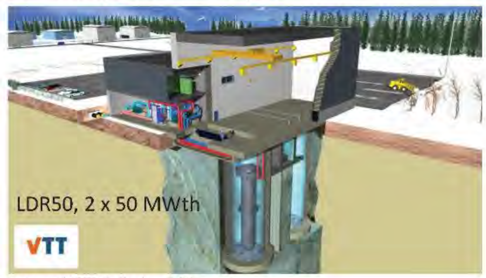
Helen and Fortum are investigating the possibilities of cooperation in nuclear power, especially in terms of small modular reactors (SMR). Both companies have already previously expressed their interest towards modular nuclear power. Despite the turbulent operating environment, it is important to ensure continuous transition of the energy sector towards low-emission and zero-emission production. In this situation, the companies find that looking into the cooperation is a natural opportunity that should be investigated.

Finnish district heating reactor designs by LUT and VTT

LUT University and Technology research center VTT are developing dedicated low-temperature small power district heating reactors

Finnish district heating market averages 4300 MWth in ~50 municipalities, so most customers prefer power range << 100 MWth

Industrial ecosystem to deliver these is not quite there yet



Finnish Microreactor deployment plans

LUT University works with City of Lappeenranta to introduce high-temperature gas-cooled research reactor in Lappeenranta by 2029

- Research topics: energy system sector integration (heat, electricity, fuels) in a distributed energy system
    - Intermediate circuit buffer capacity for variable renewable balancing
    - Education and training of staff
- University projects in the US and Canada
    - UIUC, startup 2027

Known major issues

- The focus of safety assessments, review and inspection
  - Design review for construction license / design approval *before construction*: due recognition to natural processes and design performance goes deeper than "requirement compliance"
  - Delivery oversight: how components and structures are regulated *during the construction and installation*
- Communication of Expectations and Capabilities
- Perception of State as the provider of last resort regarding liability and waste management

For avoidance of doubt: in Finland, there are no issues related to

- Public acceptance: majority of politicians and public favor nuclear
- Waste management: disposal facilities and capabilities exist for all types of waste, including used fuel. Used fuel disposal due to start in 2025 at the latest
- Technical competence: high skills are available

Summary

- Many interesting developments underway in Finland
- SMRs widely viewed as promising alternative to large plants , due to not-so-successful large projects
- SMRs necessitate significant rethinking of regulatory focus, practices and licensing / oversight paths
  - New technologies in both design features and manufacturing methods
  - New use cases, new owners
  - New sites, proximity to population centers
- STUK's ACNS has been at the forefront of development
- All this rethinking would be beneficial to large reactors as well → general revitalization of the nuclear community is within reach

Thank you!

juhani.hyvarinen@lut.fi

D.2 France

DESIGN OF PRESSURISED WATER REACTORS THE GUIDE N°22 OF ASN AND IRSN

Karine HERVIOU
Member of the « Groupe permanent réacteurs »

THE APPROACH TO ENHANCING NUCLEAR SAFETY IN FRANCE

Enhancing safety by :

- assessing the safety level thanks to a deterministic approach completed by a probabilistic vision, giving priority to safety improvements commensurate with the issues

- taking into account all available relevant knowledge

- improving safety as much as reasonably possible after continuous technical exchanges between the licensees (EDF for NPPs), the regulator ASN (and its permanent groups of experts) and the TSO (IRSN)

PRÉSENTATION 2

THE PROCESS THAT LED TO THE GUIDE

The process that led to the guide reflects the above-mentioned approach

The guide's development is based on the former technical guidelines for EPR, the **knowledge** resulting from many safety studies concerning reactors (especially the design of the EPR), including those examined during meetings of the Groupe Permanent
➔ as a result, the guide clearly states **the content of the expected safety demonstration for new PWRs**

The guide has been written under the supervision of ASN and IRSN: experts' groups from IRSN (French TSO) proposed drafts for each topic, which were discussed and amended by working groups with experts of IRSN and of different operators and designers (EDF, Framatome, Westinghouse…), with ASN participation

The guide underwent a **public consultation**

The guide underwent **a review by the Groupe Permanent** which led to ~400 comments considered during two meetings

PRÉSENTATION

asn

THE PROCESS THAT LED TO THE GUIDE

The recommendations defined in the guide reflects also the consideration of operating experience feedback and of relevant regulatory/guidance/standards document such as:

- the technical guidelines for the design and construction of the next generation of NPPs with PWRs in France and Germany

- the feedback of the Fukushima Daiichi accident

- the European Safety Directive (Council Directive 2014/87/Euratom of 8th July 2014)

- the WENRA safety objectives for new reactors

- the IAEA safety standards (especially the revision 1 of IAEA SSR-2/1 : "Safety of Nuclear Power Plants: Design")

- several French orders or decrees, especially the order dedicated to the safety of nuclear installations of 7th February 2012, and the Public Health Code

- …

PRÉSENTATION

asn

PROCESS THAT LED TO THE GUIDE

The GP concluded:

"the final version of the guide is a robust basis for technical exchanges and a useful tool to present, in an international context, the French practices in the field of nuclear safety"

Note that:

- The guide applies to new PWRs, and can be used as a reference for periodic safety reviews of existing reactors
- The guide does not aim at being exhaustive : "*if there are no recommendation on a specific subject, the acceptability of the licensee's proposal for a given project will be assessed in the examination of the file concerning that project*"

PRÉSENTATION

asn

STRUCTURE OF THE GUIDE

After defining the **general safety objectives and principles** for the design, the guide contains recommendations regarding :

- **The demonstration of nuclear safety**
- **The general recommendations for the design**
- **The design of barriers**
- **The design of safety functions**
- **Other specific topics** (heat sink, electrical power supply, fuel handling, instrumentation and control…)

PRÉSENTATION

asn

GENERAL SAFETY OBJECTIVES AND PRINCIPLES FOR THE DESIGN

General objectives of the design :

- **Safety objectives to be targeted for normal operation and in case of incident/accident**
- Minimizing as much as economically possible the radiological consequences during normal operation
- Optimizing effluent and waste production by using the best available techniques
- **Preventing and limiting the occurrence and consequences of possible incidents/accidents**

General principles of the design :

- Defence in depth principle consistent with WENRA structure
- Barriers: implementation of three barriers sufficiently mutually independent
- Safety functions: implementation of design measure to ensure safety functions

PRÉSENTATION

GENERAL SAFETY OBJECTIVES AND PRINCIPLES FOR THE DESIGN

EU Nuclear Safety Directive Article 8a

Article 8a

Nuclear safety objective for nuclear installations

1. Member States shall ensure that the national nuclear safety framework requires that nuclear installations are designed, sited, constructed, commissioned, operated and decommissioned with the objective of preventing accidents and, should an accident occur, mitigating its consequences and avoiding:

   (a) early radioactive releases that would require off-site emergency measures but with insufficient time to implement them;

   (b) large radioactive releases that would require protective measures that could not be limited in area or time

2. Member States shall ensure that the national framework requires that the objective set out in paragraph 1:

   (a) applies to nuclear installations for which a construction licence is granted for the first time after 14 August 2014;

   (b) is used as a reference for the timely implementation of reasonably practicable safety improvements to existing nuclear installations, including in the framework of the periodic safety reviews as defined in Article 8c(b).

PRÉSENTATION

DEMONSTRATION OF NUCLEAR SAFETY

- **A deterministic approach enlightened by a probabilistic vision**
- **All events that can affect nuclear safety shall be identified**: single initiating events, internal and external hazards and plausible combinations of initiating events
- Events shall be "**excluded**" or "**studied**" in the demonstration of nuclear safety
- **Design reference conditions and hazards:** it comprises single initiating events, grouped and classified in design-basis categories, and design-basis hazards.
- **Design extension conditions and hazards:** multiple failures or more severe events
- **Hazards resulting from malicious acts**
- **Use of PSAs** to orient or consolidate design choices (redundancy, diversification…)
- **Principles for developing analysis methods** (qualification of calculation tools, uncertainties…)

PRÉSENTATION 8

GENERAL RECOMMENDATIONS FOR THE DESIGN (1/2)

- Sufficient **independence** between levels of defence in depth shall be granted by the architecture of the reactor safety functions
- **Shared safety systems** between units must be limited and justified; independent systems for a reactor and a spent fuel pool must be favored
- The installation shall be able to operate **autonomously** in accidental conditions for a sufficient period, typically 72h
- A safety classification shall be defined to guarantee that safety related systems are designed, manufactured and monitored in operation with a quality standard commensurate with their role in nuclear safety
- The systems necessary for the control of the design-basis condition categories 2 to 4 (DBC-2 to 4) shall be designed in compliance with the single failure criterion
- Safety related systems shall undergo qualification with the aim of guaranteeing their capability to meet their requirements for the conditions in which they are necessary

PRÉSENTATION 9

GENERAL RECOMMENDATIONS FOR THE DESIGN (2/2)

- **Application of fail-safe principle insofar as this does not induce excessive complexity**
- **Human and organisational aspects shall be taken into account in the design of the socio-technical system**
- Consideration of **constraints inherent to the construction or manufacturing** of the installation, in order to ensure the feasibility and reliability of these operations, including the associated **inspections**
- Constraints for **maintenance, in-service monitoring** and relative to **ageing** of components and systems shall be considered in the design
- **Radiation protection** shall be taken into account in the design
- Final shutdown, decommissioning and the targeted physical state of the installation after decommissioning shall be taken into account at the design stage

PRESENTATION 10

SPECIFIC RECOMMENDATIONS FOR THE DESIGN OF BARRIERS

Specific recommendations for the design of ...

- **the core**: fuel assembly and core design margins for DBC, DEC-A, earthquakes...
- **the main primary and secondary systems:** measures to guarantee the integrity of the main primary and main secondary systems (quality of design, verification, periodic inspections...), protection against overpressures, **break preclusion** (see next slide)...
- **the third barrier:**
  - the 3rd barrier shall be designed so as to limit releases during the short- and long-term phases of the accidents considered in the demonstration of nuclear safety
  - the number of penetrations shall be limited
  - regarding the opening of the access hatch, whatever the case, its closure shall be possible within a time frame that allows the objectives to be achieved
  - the outer part of penetrations to be located into peripheral buildings with adequate containment capacities

PRESENTATION 11

SPECIFIC RECOMMENDATIONS FOR THE DESIGN OF BARRIERS

In addition to the application of the **break-preclusion principle** to **large components of the main primary and secondary systems** (because no reasonable measure to limit the consequences of their rupture could be defined), the Guide n°22 allows the application of this principle for **the main coolant pipes** and the **main steam pipes**

The principle of the **"break-preclusion" for piping consists in not addressing the consequences of the piping break** as the break is considered **extremely unlikely with a high degree of confidence**, which necessitates :

- stringent provisions in the design, manufacturing and in-service monitoring: similar measures as for large components above-mentioned are to be applied
- demonstrating that the choice is reasonable considering the advantages and drawbacks in terms of safety and radiation protection

If break preclusion is adopted, **double-ended guillotine breaks** (of the main coolant pipes or of the main steam pipes) are still considered with appropriate assumptions for some systems, structures or components design (safety injection system, reactor containment, qualification profiles of devices…)

As the use of this assumption is a decisive choice, its use and its conditions of application will have to be examined at an **early stage of the design**

PRESENTATION 12

RECOMMENDATIONS SPECIFIC TO CERTAIN SAFETY FUNCTIONS

The guide contains some recommendations specific to :

- **The control of nuclear chain reactions in the core** (efficiency and diversification of reactor shutdown means, neutronic stability of the core, instrumentation…)
- **The removal of residual heat produced by the radioactive substances and nuclear reactions** (systems for removing residual power, injecting water into the core, depressurizing the primary system in accident situations, removing heat from the reactor containment)
- **Containment of radioactive substances** (static systems supplemented, if necessary, by dynamic ones, avoid direct leaks into the environment, isolation of systems connected to the main primary system, detection means, ventilations…)

PRESENTATION 13

OTHER SPECIFIC DESIGN RECOMMENDATIONS

Examples of such specific design recommendations (1/2):

- Regarding the systems removing the heat to and from the **heat sink**, measures shall be taken to prevent risks of heat sink failure associated with external hazards (such as distancing, diversification, constitution of an emergency reserve…) depending on the site

- Regarding the **electrical power supply**, the installation shall comprise a normal power supply system and an emergency power supply system and the risk of common cause failure of electrical components shall be reduced

- Regarding **the volumetric and chemical control of the primary coolant**, one or more systems shall allow the physical-chemical characteristics of the primary coolant to be controlled (to limit corrosion of fuel and primary system, to control radioactivity in the primary system…)

- Regarding **fuel handling and storage**, the systems shall allow identification of each fuel assembly inserted or removed from the RPV, prevent any damage to the fuel, prevent any drop of a fuel assembly …

PRÉSENTATION 14

OTHER SPECIFIC DESIGN RECOMMENDATIONS

Examples of such specific design recommendations (2/2):

- Regarding the **control room**, the main control room shall permit operational control of the installation in normal operation and in incident and accident situations, including accidents with core meltdown.

- The guide addresses **digital I&C** (diversified digital I&C is accepted in France)

- Regarding **emergency management**, several recommendations regarding habitability and accessibility of the emergency situation management premises are addressed in the guide.

- …

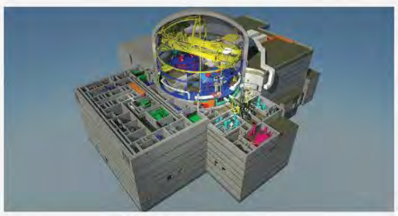
PRÉSENTATION 15

CONCLUSION

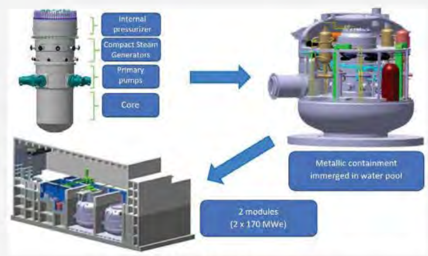
The first application of the guide is the **EPR2 project**

By principles, recommendations of the guide can be applied to **LW-SMRs** even though adapted recommendations may be necessary

There are several SMRs projects in France currently, among which NUWARD is the most mature LW-SMRs project



EPR2 model



NUWARD project

PRESENTATION

16

asn

D.3 Japan

Country Presentation
Japan
Session 2

March 15, 2023

International Regulatory Advisory Committee Meeting

ICHIMURA Tomoya, Dr.
Deputy Secretary-General for Technical Affairs
Nuclear Regulation Authority(NRA), Japan

SEKIMURA, Naoto, Dr.
Vice President, The University of Tokyo
Professor, Department of Nuclear Engineering and Management
Chairperson, Nuclear Reactor Safety Examination Committee, NRA Japan

Contents

- **Development/Construction of Next-generation Advanced Reactors (Announcement by Government of Japan)**
- **Advisory Committee Structure and Topics discussed at RSEC and NFSEC**
- **Nuclear Regulatory Human Resource Development Project**
- **A Model of a Robust National Nuclear System**

Disclaimer:
The opinions/views expressed in this presentation and on the following slides are solely those of the presenter and not necessarily those of the organization.

1

Development/Construction of Next-generation Advanced Reactors (1)

Policy announced by Japanese Government

(Policy for development and construction)

- Make efforts on development and construction of next-generation advanced reactors on the premise of regional understanding to realize the value of nuclear power and maintain and strengthen technology and human resources

  →First, target rebuilding of reactors that have been decided to be decommissioned based on the progress of back-end issues

  →Other development and construction will be considered based on future situations, such as the status of restarts and progress in securing understanding

(Improvement in business environment)

- Promoting investment in next-generation advanced reactors to realize the value of nuclear power

  →Policy support for demonstration reactor development

  →Consideration and materialization of institutional measures that contribute to income stabilization, etc.

Development/Construction of Next-generation Advanced Reactors (2)

(Establishment of R&D system)

Policy announced by Japanese Government

- Gathering public and private resources to develop an effective development system

  →Clarification and sharing of prospects, support on a project basis, establishing a "control tower function," etc.

  →Promotion of self-driven R&D of next-generation advanced reactors through strategic collaboration with the United States, UK, France, etc.

  →Formulation of strategies for fusion, fostering related industries, and promoting research and development

(Development of basic infrastructure and cultivation of human resource)

- R&D of next-generation advanced reactors and construction of foundations for human resource development for that purpose

  →Acceleration of necessary support for basic R&D and infrastructure development

- Promoting production and R&D of radioisotopes for medical use, etc.

  →Manufacturing by JPR-3 and JOYO

  →Supporting technical development for production using research reactors and accelerators

Development and construction of next-generation advanced reactors (3)

Policy announced by Japanese Government

- **Promote developing and constructing next-generation advanced** reactors that incorporate new safety mechanisms **on the basic premise of ensuring safety.**
- The first target is to **rebuild the decommissioned reactors into next-generation advanced reactors on the premise of securing the understanding of the local community**.
  Proceed with specifics while considering the progress of back-end issues such as the completion of the Rokkasho Reprocessing Plant. Other development and construction will be considered based on the restart status in each region, progress in securing local understanding, and other factors.

(1) Improvement in business environment

- **Project-based support for** demonstration reactors, based on the magnitude of the initial short-term cost.
- **Promote study and implementation of the electricity market system** to address medium- and long-term revenue predictability, etc.

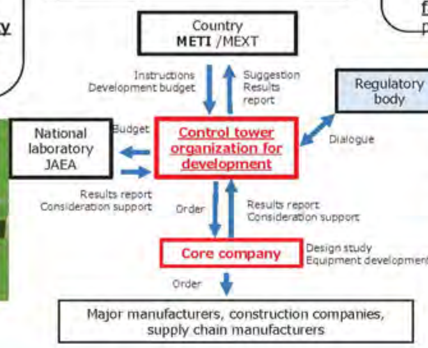
(2) Establishment of R&D system

- Promote development readiness based on **reflections on past development** and **overseas case studies.**

(3) Fundamental R&D and Development of basic infrastructure

- Development of basic infrastructures such as **research reactors** and **fuel manufacturing facilities** for future development is promoted.

Advanced light water reactor SRZ-1200 (Mitsubishi Heavy Industries)

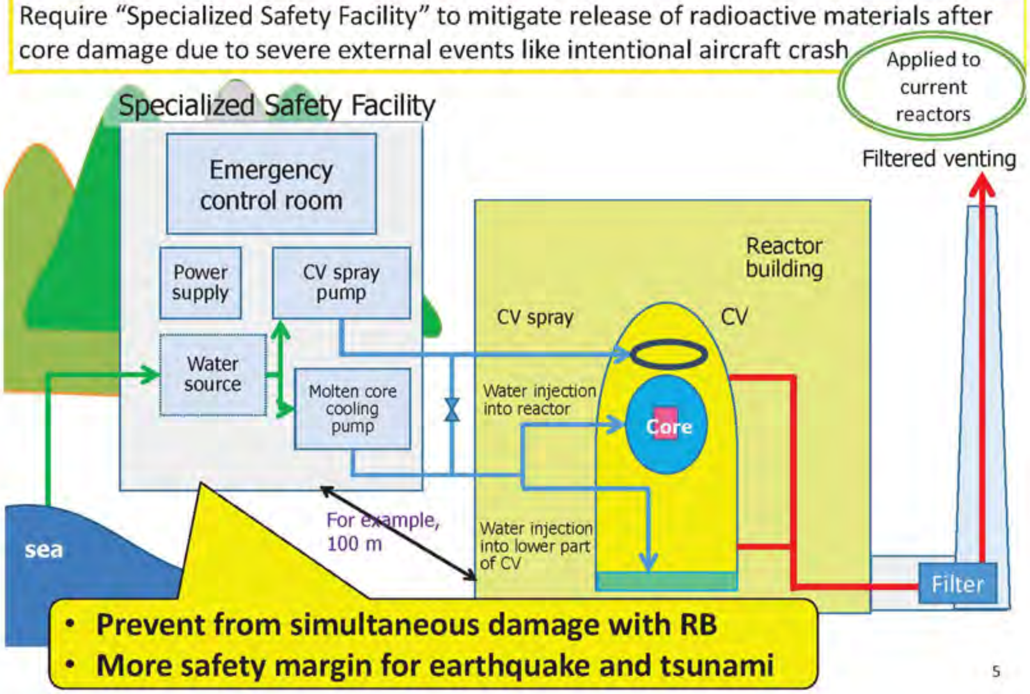


High Temperature Engineering Test Reactor (HTTR)

Experimental Fast Reactor Joyo

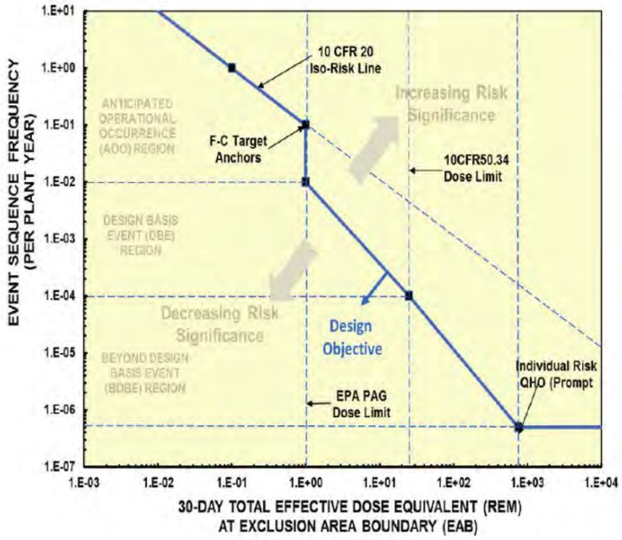
Additional Measures against Severe External Events

Require "Specialized Safety Facility" to mitigate release of radioactive materials after core damage due to severe external events like intentional aircraft crash



5

Risk-informed and Performance-based Approach considering Severe External Events



NEI 18-04, Rev. 1
Aug. 2019

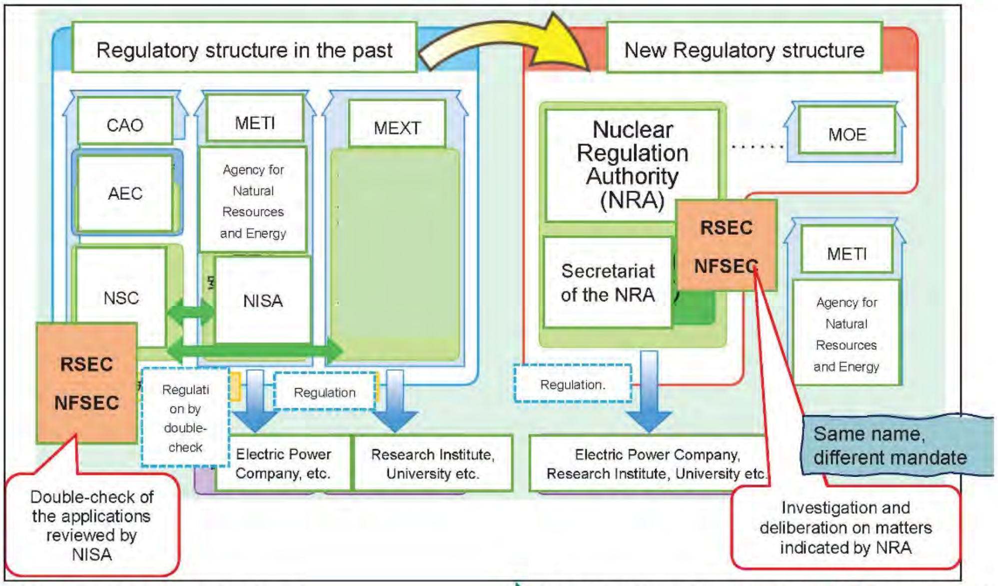
Frequency - Consequence (F-C) Target and Licensing Basis Events

Overview of Advisory Committee Structure

NSC: Nuclear Safety Commission
NISA: Nuclear and Industrial Safety Agency

7

Overview of Advisory Committee Structure



Examination of applications → *Examination of applications NOT conducted*

8

Methods for Accomplishing Mission

Decided and by NRA on Feb. 5, 2014

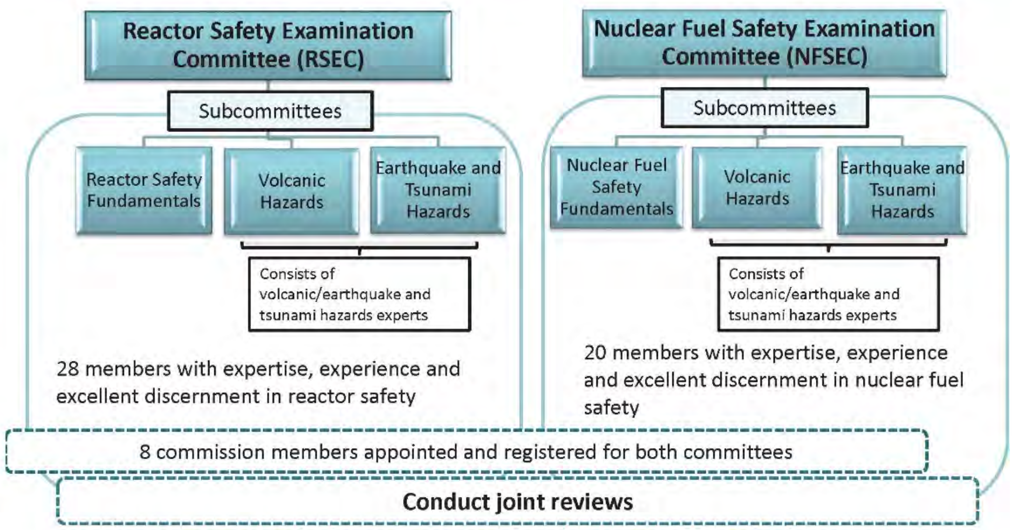
- RSEC and NFSEC
  - ✓ conduct investigation and deliberation on matters related to reactor safety and nuclear fuel safety when indicated by NRA,
  - ✓ do not act as a substitute for decision making of NRA, and
  - ✓ provide advisory information to NRA for its own decision making.

Operational Policy decided by the Committees on May 12, 2014

- Committee meetings are open to the public and minutes of meetings and materials used in these meetings are publicly disclosed, in principle.
- Deliberation status is reported to NRA.

9

Overview of Advisory Committee Structure



Challenges

- ✓ **Human resource development (academia)**
- ✓ **Gender balance**

10

Topics under Review and Challenges (1/2)

Decided and revised by NRA on Sept. 30, 2020

8 topics for review and discussion in the RSEC and NFSEC

(1) To conduct investigations and deliberations on the necessity of responses based on the collection and analysis of information on accidents and troubles that have occurred in Japan and overseas, as well as trends in regulations overseas, and provide advice.

(2) To evaluate and advise on the response status of the NRA in response to the conclusions (including conclusions related to transportation) of the IRRS (Integrated Regulatory Review Service of the IAEA) follow-up mission conducted in January 2020.

(3) To conduct investigations and deliberations on the implementation status of the new nuclear regulatory oversight program (ROP-type inspection) enforced in April 2020 by regulatory bodies and operators, and provide advice.

(4) To hear from operators about evaluation report for improving the safety of power reactor, based on the provisions of Article 43-3-29 of the Act on the Regulation of Nuclear Source Materials, Nuclear Fuel Materials and Reactors, and provide advice on how to utilize them.

11

Topics under Review and Challenges (2/2)

Following 4 topics are for subcommittees on Volcanic Hazards and Earthquake and Tsunami Hazards

(5) To conduct investigations and deliberations on the NRA's evaluation of the volcano monitoring results of nuclear power generation operators, and provide advice. *<Instructions only to the RSEC>*

(6) To conduct investigations and deliberations on the NRA's evaluation of the volcano monitoring results of nuclear fuel facility operators, and provide advice. *<Instructions only to the NFSEC>*

(7) To conduct investigations and deliberations on the necessity of regulatory responses and provide advice, based on the results of collection and analysis of information related to earthquakes, tsunamis, and other events, disasters that have occurred in Japan and overseas, knowledge announced by administrative agencies, etc.

(8) To conduct investigations and deliberations on the necessity of regulatory responses and provide advice, based on the results of collection and analysis of information related to volcanic events, such as disasters that have occurred in Japan and overseas, and findings announced by administrative agencies, etc.

12

Specialty of RSEC and NFSEC Members

Reactor Safety Examination Committee (RSEC)

- **Nuclear reactor 8**
- **Radiation 5**
- **Natural disaster (earthquake, tsunami, etc.) 7**
- **Human and organizational factors (human factor, quality assurance, etc.) 1**
- **Safety in non-nuclear industries 5**
- **Other areas related to reactor safety (including nuclear security) 2**

28 RSEC members are from Universities (22), Research Institutes (5) and Other (1).

Nuclear Fuel Safety Examination Committee (NFSEC)

- **Nuclear fuel material 6**
- **Radioactive waste 1**
- **Radiation 3**
- **Natural disaster (earthquake, tsunami, etc.) 6**
- **Human and organizational factors (human factor, quality assurance, etc.) 0**
- **Safety in non-nuclear industries 3**
- **Other areas related to reactor safety (including nuclear security) 1**

20 NFSEC members are from Universities (17), Research Institutes (2) and Other (1).

13

Topics discussed at RSEC and NFSEC

- ✓ **Safety Goals**
- ✓ **IRRS**
- ✓ **Nuclear Oversight Program**
- ✓ **Periodic Safety Assessment of Continuous Improvement**

Safety Goals (1/2)

Related events and activities

- February 2017 (2-1-2017)

  Instructed by NRA to investigate and deliberate on ***the comparative evaluation of the safety goals of NRA and the level of safety to be achieved through compliance with the new regulatory standards (including methods of explaining them to the nation in an easy-to-understand manner)*** , including advice
- February 2017

  Explanation of the instruction
- October 2017

  Memo of discussion on safety goals and new regulatory standards
- January 2018

  Draft summary of opinions for safety goals and new regulatory standards
- March 2018

  Draft answer for the instruction on 2-1-2017

15

Safety Goals (2/2)

- May 2018

  RSEC and NFSEC summarized the following points to which NRA should pay attention and report them to the NRA.

  1. The NRA's safety goals are based on its determination not to cause another severe accident, such as the accident at the Fukushima Daiichi Nuclear Power Station, and on its stance of constantly improving safety without falling into safety myths. Therefore, NRA should also refer to the safety goals when formulating regulatory standards.
  2. It is currently not possible, and should not be done, to directly compare, evaluate and explain the safety goals NRA set out and the level of safety achieved through compliance with regulatory standards using only the probability scale.
  3. The above points should be explained to the public about the safety goals.

16

IRRS (Integrated Regulatory Review Service of the IAEA) (1/2)

Background

- NRA accepted the IAEA IRRS mission from January 11 to 22, 2016 and discussed issues related to regulations and systems for nuclear safety in Japan.
- The IRRS team provided two good practices of recent amendments to the legal framework for nuclear and radiation safety and the framework for government and regulatory body.
- The IRRS team made 13 recommendations and 13 suggestions to the Government of Japan and/or the NRA that improvements are needed or desirable for Japanese framework to be continuously consistent with the IAEA safety standards.

17

IRRS (Integrated Regulatory Review Service of the IAEA) (2/2)

Related events and activities

- March 2016

  Instructed by NRA to evaluate and advise on ***the status of the NRA's efforts for the response to the matters pointed out in the IRRS mission*** conducted in January 2016
- As a follow-up to the issues identified in the IRRS, NRA reported on the status of all 31 issues on 7 themes at a total of 7 meetings with RSEC and NFSEC.
- September 2017

  RSEC and NFSEC summarised the advice on NRA's future efforts for the issues identified in the IRRS.
- January 2020

  The IRRS follow-up mission was conducted.
- June 2020

  Instruction was amended.
- Instructed by NRA to evaluate and advise on ***the status of NRA's response to the conclusions (including conclusions related to transportation) of the follow-up mission of the IRRS*** conducted in January 2020
- Investigation and deliberation are ongoing.

18

Nuclear Oversight Program (1/2)

Background

- New nuclear regulatory inspection system is the ROP-type inspection conducted in the US. In response to the IRRS recommendations and suggestions, NRA revised the inspection system and implemented the ROP-type inspection in 2020.

Related events and activities

- February 2017

  Instructed by NRA to investigate and deliberate on ***specific modalities for monitoring/evaluation and administrative measures, including the use of risk information and the reflection of safety assurance performance, and modalities for the development of regulatory bodies' systems for monitoring/evaluation (human resource development system for inspectors, qualification certification system, etc.), in preparation for the implementation of a new monitoring/evaluation system based on the revision of the inspection system,*** including advice

19

Nuclear Oversight Program (2/2)

- April 2020

  The Nuclear Regulatory Inspection System came into effect.

  Revise the phrase "specific modalities for monitoring/evaluation and administrative measures, including the use of risk information and the reflection of safety assurance performance, and modalities for the development of regulatory bodies' systems for monitoring/evaluation (human resource development system for inspectors, qualification certification system, etc.), in preparation for the implementation of a new monitoring/evaluation system based on the revision of the inspection system" to "***the implementation status of the new nuclear regulatory inspection system.***"
- June 2020

  Instruction was amended.
- Instructed by NRA to study and deliberate on ***the implementation status of the new nuclear regulatory inspection system, which came into effect in April 2020 by regulatory bodies and operators,*** and provide advise
- The NRA reports the inspection results quarterly to the RSEC and NFSEC for their investigation and deliberation.

20

Periodic Safety Assessment of Continuous Improvement

Background

- Pursuant to Article 43-3-29 of the Reactor Regulation Act, the operator is required to conduct its own safety evaluation and notify the NRA of the results of such evaluation in order to improve the safety of the reactor facilities for power generation.

Related events and activities

- June 2020

  Instructed by NRA to ***hear from operators about evaluations for improving the safety of reactor facilities for power generation conducted by the establishers of reactors for power generation under Article 43-3-29 of the Reactor Regulation Act, and provide advice on how to utilize such evaluations***
- RSEC and NFSEC conducted hearing from operators.

  September 2021: Kyushu Electric Power Co., Inc.

  March 2022: Kansai Electric Power Co, Inc.

  December 2022: Shikoku Electric Power Co., Inc.

21

Periodic Safety Assessment of Continuous Improvement

- November 2022

  RSEC and NFSEC chairs held an opinion exchange meeting with NRA.

  The first round of hearing from the operators who submit an evaluation report for improving the safety of reactor facilities for power generation would be finished and the proposal of improvement for the report should be summarized.

- November 2022

  Instruction was amended.

- Instructed by NRA to advise ***how the system should be organized and how its operation should be improved with regard to the evaluation for improving the safety of reactor facilities for power generation conducted by the establishers of reactors for power generation under Article 43-3-29 of the Reactor Regulation Act;*** At first, to report on ***the improvement of the operation of the system based on the framework of the current system***

22

Nuclear Regulatory Human Resource Development Project

【Objective】

To support projects conducted by universities and other institutions in Japan to effectively, efficiently, and strategically develop human resources to lead nuclear regulation.

【Project】

Provide financial support for programs to develop human resources with scientific and technical knowledge necessary to conduct the following three types of work.

1. Work related to nuclear plant regulation, etc. (review and inspection of commercial power reactors, nuclear fuel facilities, radioactive waste-related facilities, etc.) (including scientific and technical expertise related to nuclear safety, security and safeguards)
2. Work related to radiation protection (nuclear disaster countermeasures, radiation control and radiation monitoring)
3. Work related to natural hazards and seismic (review of geotechnical, earthquake, tsunami, volcanic and seismic/tsunami resistant designs)

【Establish educational programs on nuclear regulation at universities, etc.】

Lecture by dispatched NRA official

The maximum subsidy of approximately 30 million yen per year will be provided.

23

Nuclear Regulatory Human Resource Development Project (List of on-going projects, 1/2)

University, etc.	Program
University of Tokyo	Educational program for building a knowledge base for nuclear risk management based on the unique characteristics of Japan
Tokyo City University	Experience-oriented program for continuous human resource development on earthquakes, tsunamis, and volcanoes
University of Tsukuba	Nuclear regulatory human resource development program based on risk and resilience studies with a core of human capacity
Osaka University	Nuclear regulatory human resource development program through co-creation with Society
National Institutes for Quantum Science and Technology	Practical training in radiation protection based on understanding of radiation effects
Osaka University	Osaka University OJE (On the Job Education) Connected nuclear regulatory human resource development (Phase 2)
Tohoku University, School of Engineering	Development of nuclear regulatory human resource with bird's eye view knowledge through collaborative education and research programs

24

Nuclear Regulatory Human Resource Development Project (List of on-going projects, 2/2)

University, etc.	Program
National Institute of Technology, Fukushima College	Development of nuclear regulatory personnel who can contribute to local environmental restoration and environmental safety
Kyushu University	Advanced radiation protection human resource development program with practical problem-solving skills
Nagaoka University of Technology	Building an educational system from technical college to graduate school based on the "Niigata Model"
Tohoku University	Development of an educational system to support radiation health risk science education in medical schools
Tokyo Institute of Technology	Development of regulatory personnel who can look at, practice, and lead the 3Ss of nuclear plants extended over or into physical and cyberspace
Niigata University	Development of advanced nuclear regulatory human resource by integrating nuclear science and disaster science
Hirosaki University	Creation of a sustainable and practical radiation protection human resource development program through industry-government-academia collaboration

25

Nuclear Regulatory Human Resource Development Project (List of completed projects, 1/3)

University, etc.	Program
National Institutes for Quantum Science and Technology	Practical training on radiation protection, health effects and its risk communication
Tohoku University, School of Engineering	Human resource development project that contributes to the improvement of safety in nuclear power business by cultivating an understanding of nuclear regulations
Nagasaki University	Education and research program for establishment of emergency monitoring platform at radiation facilities in universities
Shizuoka University	Inter-university collaboration program for radiation measurement specialist and educator training for radiation safety
Hirosaki University	Comprehensive human resource development program for response to radiation exposure accidents in nuclear disasters
Ibaraki University	Practical human resource development featuring radiation visualization training
Nagoya University	International Standards Proactive Expert Training

26

Nuclear Regulatory Human Resource Development Project (List of completed projects, 2/3)

University, etc.	Program
University of Tokyo	Human Resource Development towards a Proactive Nuclear Regulation
Osaka University	Osaka University OJE (On the Job Education) Model project for connected nuclear regulatory human resource development
Nagaoka University of Technology	Nuclear regulatory human resource development based on the "Niigata model" of system safety and regional cooperation
National Institute of Technology, Fukushima College	Development of nuclear regulatory personnel who can contribute to local environmental restoration and environmental safety
Fukui University of Techonology	GLOCAL nuclear human resource development with compliance awareness
University of Fukui	Nuclear regulatory human resource development through government-academia collaboration (Fukui model)
Tohoku University, School of Medicine	Development of an educational system to support mandatory radiation health risk science education in medical schools

27

Nuclear Regulatory Human Resource Development Project (List of completed projects, 3/3)

University, etc.	Program
Tokyo Institute of Technology	Systematization and practice of education for nuclear safety, security and safeguards
Kyushu University	Enhancement of nuclear energy curriculum at Kyushu University by adding fostering of multidimensional thinking skills and regulation
Tokyo City University	Establishment of a basic education program for nuclear security and safeguards

28

Nuclear Regulatory Human Resource Development Project

Result of the HRD project led to recruitment of new NRA staff

	FY2019	FY2020	FY2021
Participants in the program (persons)	4,744	3,641	1,570
Participants who were interested in companies and government agencies related to nuclear safety or regulation as a place of employment (%)	67	59	59
Participants who participated in the program in the previous year and joined NRA after graduation (persons)	2	4	3

29

Specialty of RSEC and NFSEC Members

Reactor Safety Examination Committee (RSEC)

- **Nuclear reactor 8**
- **Radiation 5**
- **Natural disaster (earthquake, tsunami, etc.) 7**
- **Human and organizational factors (human factor, quality assurance, etc.) 1**
- **Safety in non-nuclear industries 5**
- **Other areas related to reactor safety (including nuclear security) 2**

28 RSEC members are from **Universities** (22), Research Institutes (5) and Other (1).

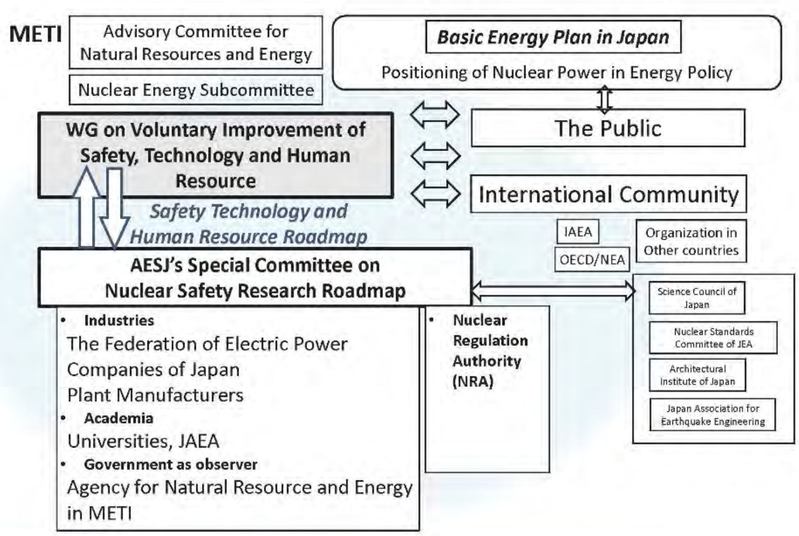
Nuclear Fuel Safety Examination Committee (NFSEC)

- **Nuclear fuel material 6**
- **Radioactive waste 1**
- **Radiation 3**
- **Natural disaster (earthquake, tsunami, etc.) 6**
- **Human and organizational factors (human factor, quality assurance, etc.) 0**
- **Safety in non-nuclear industries 3**
- **Other areas related to reactor safety (including nuclear security) 1**

20 NFSEC members are from **Universities** (17), Research Institutes (2) and Other (1).

30

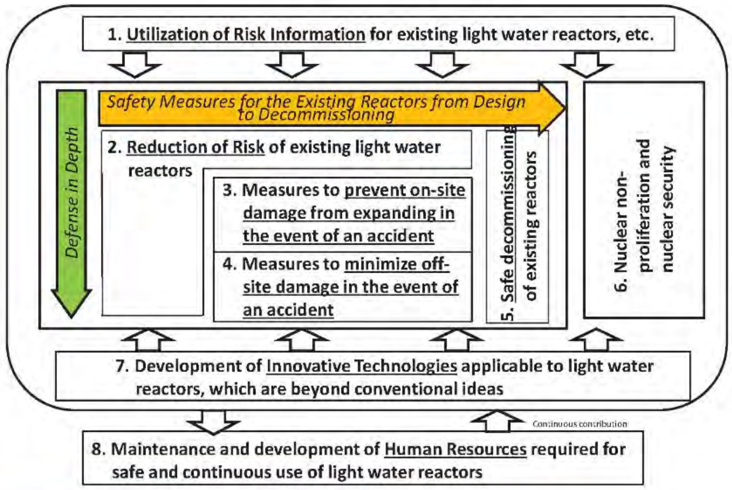
Roadmap for Light Water Reactor Safety Technology and Human Resource



AESJ : Atomic Energy Society of Japan

31

Eight Categories of Challenges provided by the METI WG on Voluntary Improvement of Safety, Technology & Human Resource



32

Human Resource Development towards a Proactive Nuclear Regulation at The University of Tokyo (2014-2018)

東京大学 THE UNIVERSITY OF TOKYO

Objectives

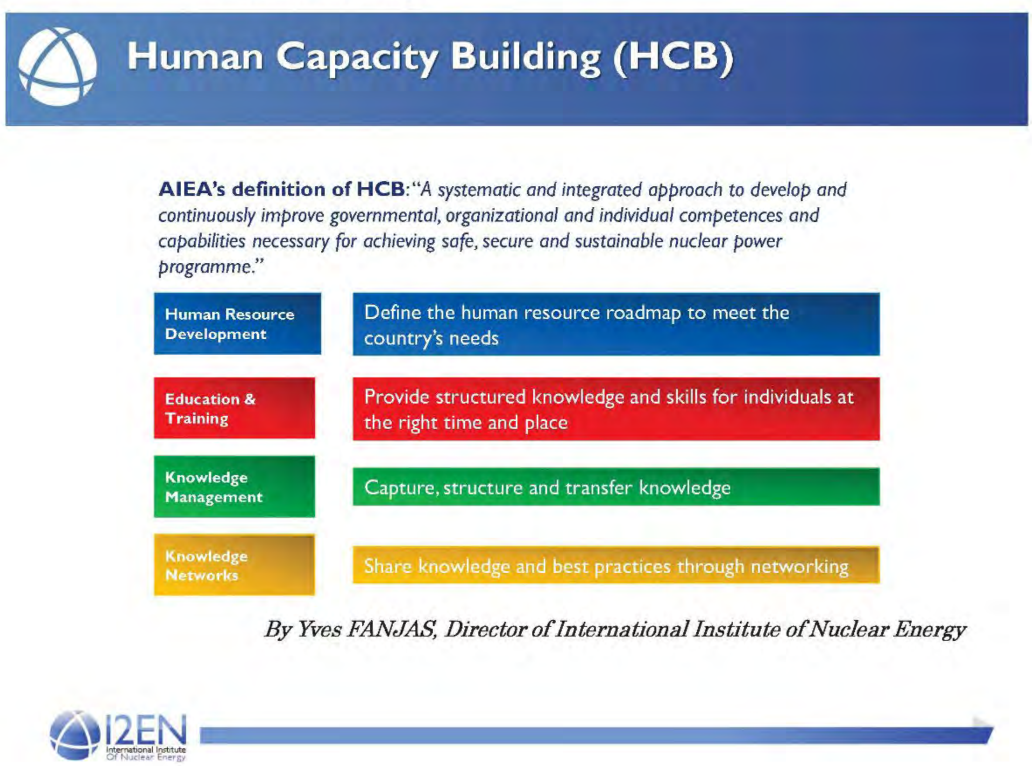
Basic Human Capacity Building project for the Japanese Nuclear Regulatory Authority (NAR) at the University of Tokyo,

- with the **lessons learned from the Fukushima accident** and to create proactive regulation authority,
- with **international perspectives** of nuclear safety and
- with the ability of contribute to international consensus formation of nuclear safety and standards.

Background

Recommendation in the **IRRS mission report to the NRA** in 2016


Human Resource Development
towards a Proactive Nuclear Regulation
at The University of Tokyo (2014-2018)
東京大学
THE UNIVERSITY OF TOKYO
1
Understanding the Fukushima Accident
① Experimental and computational study.
② Study visits to domestic and international nuclear power plants including Fukushima Daiichi NPS.
0
Basic knowledge on nuclear Safety by course study and textbooks
2
Understanding regulatory activities and international standardization activities in US, IAEA and others
③ Lecture and discussion by inviting experts from international and domestic organizations
3
Proactive expert development
④ Project Based Learning (PBL) for IAEA standards etc.
4
Internship programs
⑤ Sending students to international organizations for the internship


Human Capacity Building (HCB)
AIEA's definition of HCB: "A systematic and integrated approach to develop and continuously improve governmental, organizational and individual competences and capabilities necessary for achieving safe, secure and sustainable nuclear power programme."
Human Resource Development
Define the human resource roadmap to meet the country's needs
Education & Training
Provide structured knowledge and skills for individuals at the right time and place
Knowledge Management
Capture, structure and transfer knowledge
Knowledge Networks
Share knowledge and best practices through networking
By Yves FANJAS, Director of International Institute of Nuclear Energy
I2EN
International Institute Of Nuclear Energy

2 - Understanding regulatory activities in

>> Ms. Cynthia Pederson (Branch manager- Region III, US-NRC)

"Regulatory Framework and importance of NRC regional office for effective regulation"

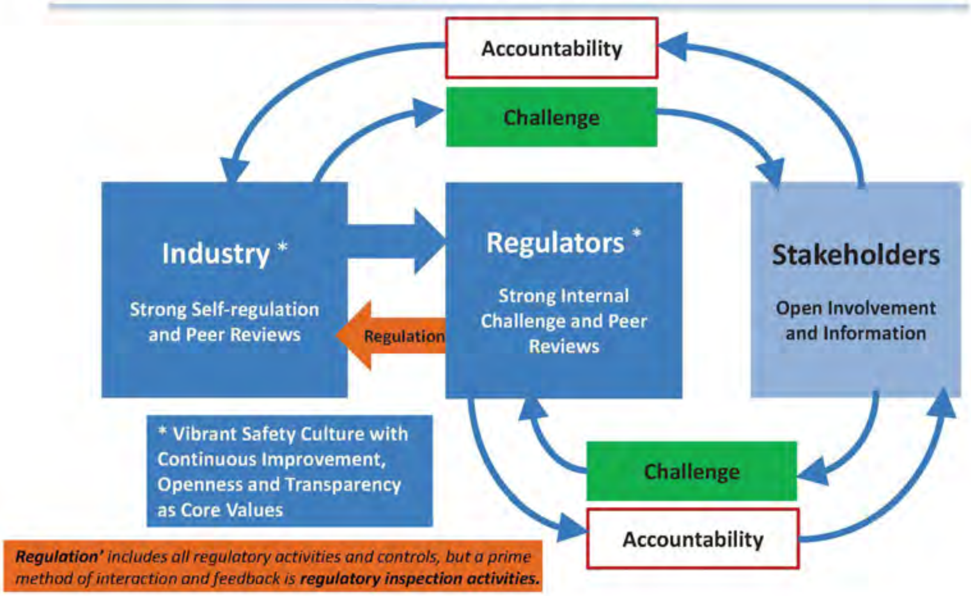
US-NRC International office Mr. Eric Stahl

Questions by students (Examples)

- How do you explain nuclear safety to the public?
- How do you regulate improvement of safe culture and leadership?
- Do you perform the inspection to the manufacturer?
- Are you collaborating with ASME for updated codes?
- Are there the liaison office for the information exchange with new comers?

A Model of a Robust National Nuclear System

INSAG-27 (IAEA, 2017)



Layer 1 : Components of a Strong Nuclear Industry Sub-system

Layer 1.1 Licensee and Operator level	Layer 1.2 Peer Pressure at State/Regional level	Layer 1.3 Peer Pressure/Review at International Industry level	Layer 1.4 Review at International Institutional level
• Suitably qualified and experience staff to ensure safety • Technical, design or operational capability including sub-contractors • Strong management systems multiple checks and balances • Company Nuclear Safety committee with external members • Company board that holds the executive to account • Vibrant safety culture led from the top • Independent nuclear safety assessment review and inspection	• National/Regional Industrial High Level Forums/ Associations (JANSI, ATENA?) • Other Organizations involved in Emergency Preparedness and Response	• WANO missions and Requirements • Bilateral and Multilateral Organization (e.g. BWR Owners Group)	• IAEA OSART missions • IAEA SALTO missions

OSART: Operational Safety Review Team
SALTO: Safety Aspects of Long Term Operation

Nuclear leadership, culture and values

Layer 2 : Components of a Strong Regulatory Sub-system

Layer 2.1 Regulatory Authority	Layer 2.2 Special Outside Technical Advice	Layer 2.3 International Peer Pressure	Layer 2.4 International Peer Reviews
• World class technical /regulatory capability and competencies, including assessment, licensing, inspection, enforcement and influencing • The inherent technical capabilities are sometimes augmented by TSO • Organizational structure with internal standards, assurance, operating experience feedback, policy, strategy, decision reviews, etc. • Regulatory safety culture with openness and transparency as core values • Formal Accountability to internal governing body	• Standing Panel of experts Reactor Safety Examination Committee Fuel Safety Examination Committee • Special Expert Topic Groups on such as; • Natural hazards (Seismic, Tsunami, Volcanic, ...) • Aircraft crash • Probabilistic safety assessment • Human intervention • Digital instrumentation and control	• OECD/NEA committees and WGs (CNRS & CSNI) • IAEA Convention on Nuclear Safety • WENRA reference levels, reviews, groups, stress tests • HERCA • INRA (top regulators) • IAEA Safety Standards Commission and Committee meetings	• IAEA IRRS missions IRRS : Integrated Regulatory Review Service

WENRA : Western European Nuclear Regulators' Association
HERCA : Heads of the European Radiological protection Competent Authorities
INRA : International Nuclear Regulators Association

Nuclear leadership, culture and values

Layer 3 : Components of a Strong Stakeholder Sub-system

Layer 3.1 Public	Layer 3.2 National Government or Parliament	Layer 3.3 Local Government	Layer 3.4 Neighbors, including Local Committees	Layer 3.5 Media	Layer 3.6 NGOs, Special interest groups	Layer 3.7 Internationa l peer reviews

- Nuclear industry and regulatory routine supply of information
- Accountability to public through Government/Parliament
- Routine reports on activities and decisions
- Special reports on matters of interest
- Responsiveness to request for information
- Routine and special meetings

Openness and Transparency, Accountability, Assurance

Nuclear Industry and Regulator Leadership, Culture and Capability

D.4 United Kingdom

Office for Nuclear Regulation

International Regulatory Advisory Committee Meeting – Challenges for New Reactors

Tim Parkes, Head of Safety Regulation, Sizewell C and Advanced Nuclear Technologies

15 March 2023

Contents

- Approach to common acceptance criteria for novel/ advanced reactor technologies
- International collaboration on vendor inspections and commissioning test results for SMRs/ AMRs
- Practical elimination and emergency preparedness

29/03/2023 Footer 2

Approach to Acceptance Criteria for Novel Reactors

- There is much well-established guidance / standards for LWRs
- In many countries regulations are explicitly written with LWR acceptance criteria included
- In the UK the challenge is different due to our goal setting approach
- **Our guidance (SAPs, SyAPs, TAGs) sets high level expectations that apply equally to all nuclear facilities.**
- **They are currently used for regulation of operating PWRs, AGRs, fuel manufacturing and reprocessing facilities, waste storage, decommissioning sites, etc., as well of being the basis for assessment of new reactor designs.**
- **It is the duty holder/ licensee's responsibility to set out in its safety case the standards/ criteria that have been followed, who they are appropriate, and demonstrate how they reduce risks so far as is reasonably practicable.**
- **Generally this does not lead to divergence of regulatory requirements – our expectations of 'relevant good practice' for LWRs is set out in IAEA standards, IEC standards, NUREGs, ASME codes, etc.**

29/03/2023 Footer 3

Approach to Acceptance Criteria for Novel Reactors

- Through 2018/19, we reviewed our regulatory guidance to ascertain suitability for regulation of advanced technologies.
- In general the framework remains robust as it is technology neutral.
- **In line with the UK Government's intention to develop a HTGR demonstrator, we are considering whether some technical areas would benefit from targeted guidance specific to HTGRs.**
- The lack of relevant good practice/ OpEx for advanced technologies presents a challenge. It is noted that sometimes there is a lack of appetite to take this on.
- **At the IAEA NHSI Working Group 2 (International Pre-licensing process), member states have limited the scope of discussions to LWR SMRs.**

29/03/2023 Footer 4

Approach to Acceptance Criteria for Novel Reactors

- We have supported reviews of the applicability of IAEA safety standards to the design of novel advanced reactors (although again we have observed a reluctance amongst Member States to drive this forward at, e.g., NUSSC).
- We note USNRC's publication of Reg Guide 1.232 on developing design criteria for non-light-water reactors.
- We would assess the design and safety case for an advanced reactor on its merits. We would be open to considering criteria developed and agreed in other countries.
- **Under our framework it would be for the vendor to demonstrate to us the appropriateness of the arguments, regardless of the source of the criteria.**

29/03/2023 Footer 5

Approach to Acceptance Criteria for Novel Reactors

- The UK is committed to actively promoting and advancing the drive towards standardisation, although the challenges of achieving full regulatory harmonisation are recognised.
- There are a wide range of technologies/ designs, each with their own criteria. It is not possible for all countries/ regulators to look at all designs
- Collaboration on specific designs that are being taken forward in multiple countries is key to success.
- There will typically be a 'lead' country for FOAK deployment, as progressing in multiple territories concurrently is resource/ cost intensive.

29/03/2023 Footer 6

Approach to Acceptance Criteria for Novel Reactors

- If 'generic' criteria for every single technology type is too difficult, and if design specific criteria will inevitably be developed and agreed in one or two lead countries (with involvement of advisory panels), how do we get collective agreement and sharing of effort?

Vendor Inspections and Commissioning Test Results

- If SMRs are to be a success, many multiples of reactor units will be deployed but it is unlikely they will all be delivered through 'home-grown' supply chains and manufacturing capabilities.
- This is already the case with GW-scale reactors but the issue is likely to expand beyond quality control issues with single components to whole systems. Indeed maybe to whole units and significant amounts of commissioning work.
- Through OECD/NEA MDEP, and subsequently on a bilateral basis, there have been good examples of collaboration of between regulators on vendor inspections (e.g. EPR) and sharing first of kind commissioning results (e.g. AP1000).

Vendor Inspections and Commissioning Test Results

- Some of the more significant expectations for quality requirements and commissioning tests have been informed by advisory committee expectations.
- This area for common approaches and expectations is the next hurdle after common design requirements.
- How is it going to be achieved? Many countries have stepped away from MDEP.
- In the past advisory committees might have taken a key role in deciding what has to be demonstrated. How are these requirements going to be derived, shared, and demonstrated in the context of a goal of common designs across countries?

Emergency Preparedness and Offsite Planning

- A common question asked by SMR vendors considering entering the UK is "what are the requirements/expectations for off-site emergency planning?" There seems to be two main drivers for this:
- **1) a business model approach of deploying SMRs in new areas closer to populations; and**
- **2) an awareness/engagement in US NRC's new approach**
- The challenges in the UK are not quite the same as in other countries:
- **It is the duty of the local government authority to determine the appropriate emergency planning zone, taking into account a number of considerations, including technical information provided by the operator.**
- **ONR does not prescribe the emergency planning zone but ensures the local authority and operator have fulfilled all the duties on them to have a plan in place. It is therefore some time before the regulator needs to reach a view on the size of any zone.**
- **The initial deployment of SMRs in the UK is expected to be on or adjacent to existing nuclear sites which already have long established existing off-site emergency plans. Again, it is likely to be some time before challenging questions need to be answered.**

Emergency Preparedness and Offsite Planning

- It is not satisfactory answer to tell vendors that we cannot comment on the emergency planning zones for many years, and to not have a view on what is being submitted in other countries.
- When a design undergoes assessment we will engage on the IAEA/ WENRA/ Vienna Declaration requirement that large or early releases are practically eliminated by design.
- If through a combination of deterministic and probabilistic means it can be shown that large or early releases beyond the site boundary fence are practically eliminated, potentially leveraging demonstrations performed in other countries to new methods for emergency zones, there is a potential to reach a consensus on what a design does and does not achieve, even with differing emergency preparedness requirements.

29/03/2023 Footer 11

Emergency Preparedness and Offsite Planning

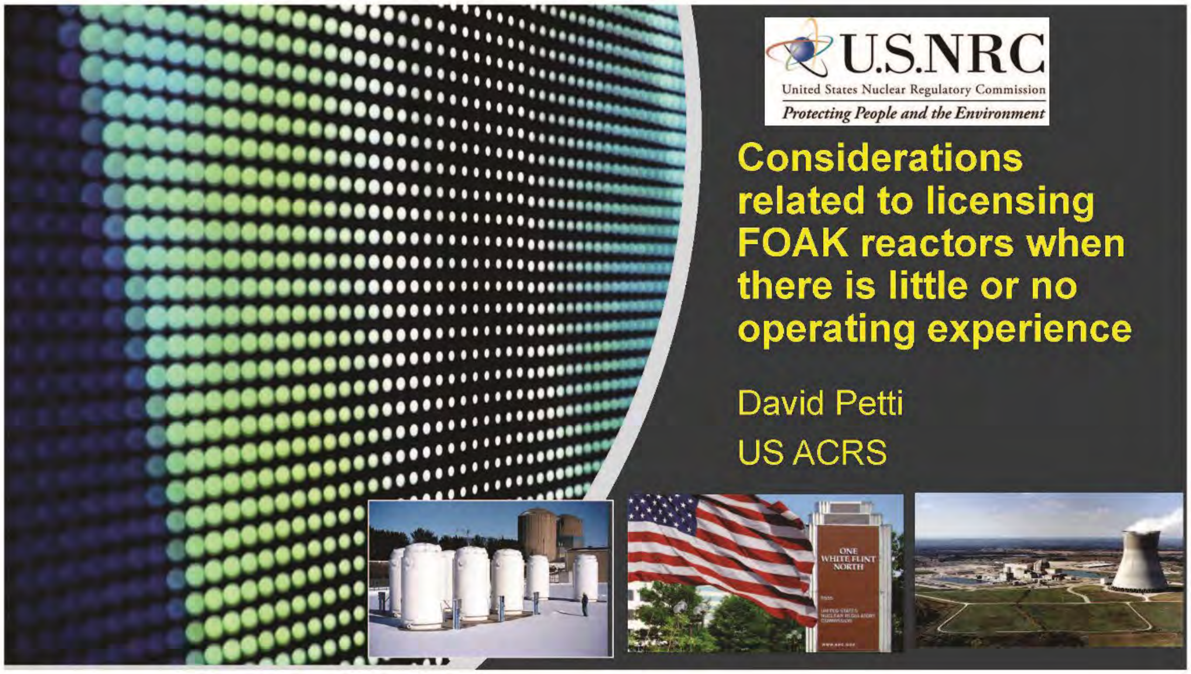
- What is not acceptable is a vendor declaring large or early release have been practically eliminated, and therefore no analysis of potential severe accidents is needed or the need for off-site emergency planning can simply be disregarded. Practical elimination is something that must be demonstrated.
- In conclusion – hopefully discussions and demonstrations in the context of the widely accepted concept of practical elimination allows multiple countries to form a view on what a design can achieve, even with differing emergency preparedness requirements

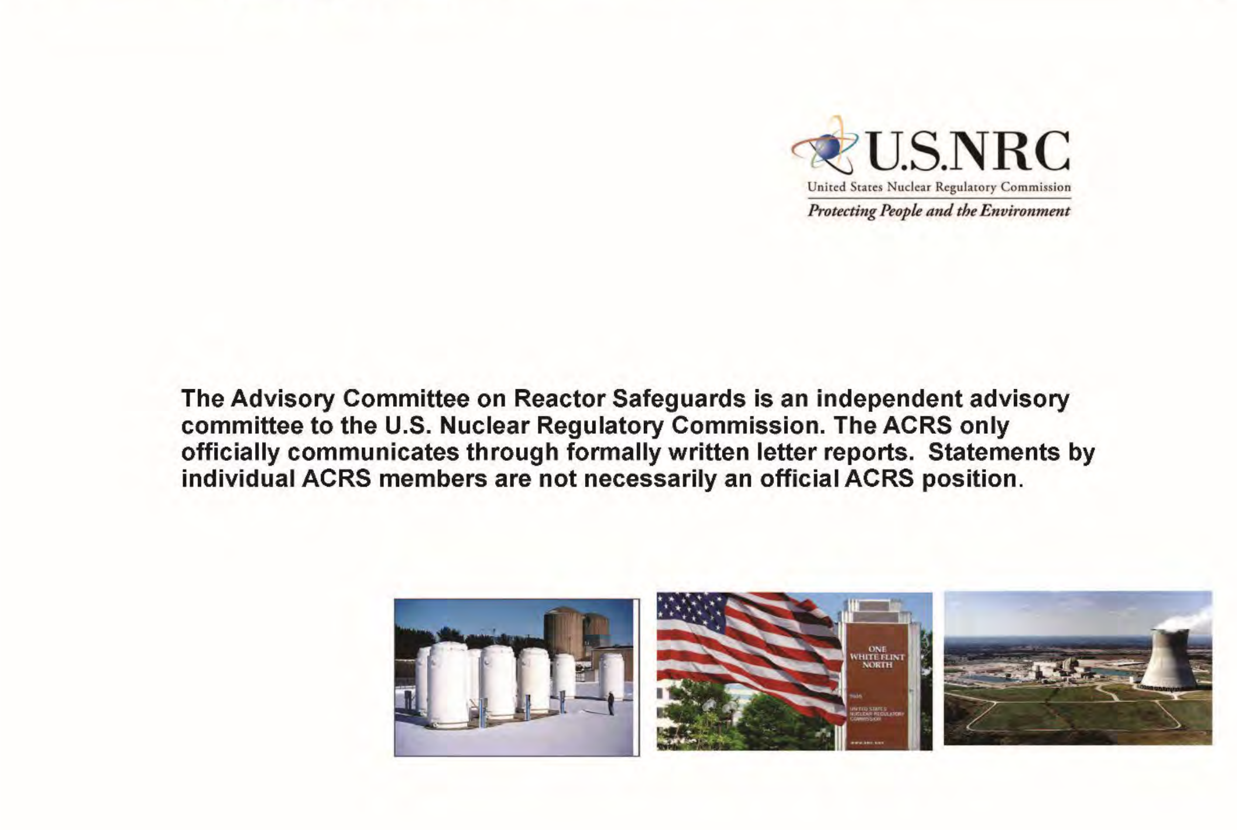
29/03/2023 Footer 12

Discussion

D.5 United States

D.5.1 Licensing of FOAK Reactors





Key Items in Licensing Assessment

Safety Functions

- Safety Functions
  - Identify a logically complete set of independent (if possible) safety functions
- Confirm integrated safety system operation/performance
  - Confirmatory analysis using independent computer codes
  - Scaled testing of safety systems: passive heat removal as an example
  - Demonstration safety testing of reactor as a condition of license

Uncertainty

- How to compensate for uncertainty and lack of operating experience
  - Evidence of large operational and safety margins
  - Lessons learned from operation of reactors using similar technology (if applicable)
  - Defense in depth

Safety Analysis

- Robust (systematic, thorough, and creative) initiating event and event sequence selection process
- Anticipated source term for advanced reactors

Identify a logically complete set of independent (if possible) safety functions

Critical Safety Functions

- What critical safety functions are necessary to prevent release of fission products in the system?
  - The primary safety function is limiting the release of radioactive materials from the facility
  - It must be maintained during routine operation and for licensing basis events over the life of the plant.

Additional Safety Functions

- Additional safety functions supporting the retention of radioactive materials during routine operation and licensing basis events include controlling:
  - heat generation
  - heat removal
  - chemical interactions

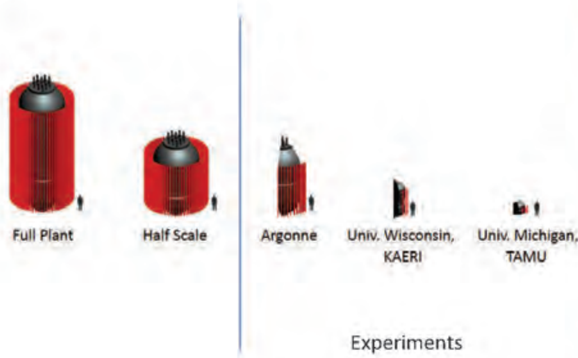
Confirmatory Analysis

Independence
- Using independent computer codes to see if similar behavior is predicted

Complexity
- Used when complex temporal or spatial behavior is expected and/or strongly coupled physics/thermal/fuel interactions

Validation
- Some validation is expected but will probably not be as extensive as LWR computer tools

Scaled Testing of Safety Systems: Passive Heat Removal as an example



Multiple Scales
- Testing at multiple physical scales per NRC T/H testing guidance

Examples
- Example: HTGR heat removal experiments (UW-Madison, TAMU, and ANL)

Code Calculations
- Codes must be able to calculate results of scaled testing to give confidence in performance of actual system

Integral safety testing in the actual reactor to reduce uncertainties

EBR-II

AVR

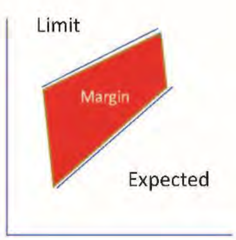
Historical
- Historical testing in advanced reactors: US EBR-II (LMR), German AVR pebble bed (HTGR), Japanese HTTR prismatic (HTGR), Chinese HTR-10 pebble bed (HTGR)

Transients
- Loss of flow, loss of heat sink, and transients without scram to demonstrate overall negative reactivity coefficient, instrumentation to provide temperatures and flow rates for computer code validation

Leveraging
- Some designs can leverage the historical testing if their design is similar to the historical reactor, while others may need testing of the actual reactor once it is built

License Condition
- Such testing may be imposed as a condition in the license

Increased margins and defense-in-depth to compensate for lack of operating experience



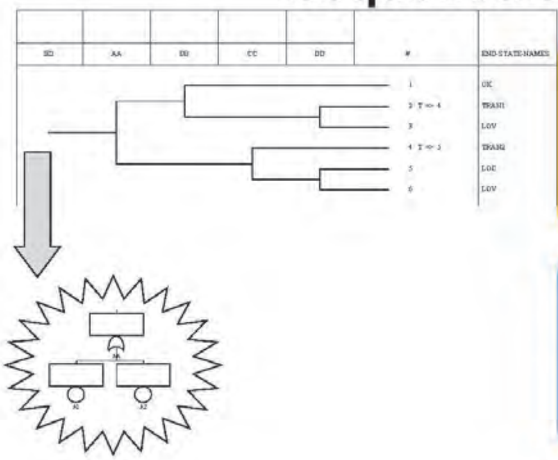
Normal Operation
- Limits vs peak predicted conditions (normal operation)
  - Fuel temperature (time at temperature)
  - Burnup and fast fluence/radiation damage
  - Power density
  - Material temperatures

Accidents
- Safety analysis calculations to establish margin
  - Peak temperatures vs experimental database or code allowable
  - Accident doses vs dose limits

Lessons Learned
- Lessons learned from previous operations
  - For HTGR and sodium systems mainly, less for salt and lead systems
  - Consider both nuclear and non-nuclear experience; human and computer interface issues

Defense in Depth
- Defense in depth to compensate for uncertainties
  - Greater focus on accident prevention than mitigation

The need for a robust (systematic, thorough, and creative) initiating event and event sequence selection process



Goal

- Clean Sheet of Paper
- No preconceived set or list of events
- Goal is development of a spectrum of events from anticipated operational events to very unlikely events

Approaches

- Use of risk and safety engineering approaches
- Use both inductive and deductive risk approaches
  - FFMEA, FMEA, MLD, HAZOP, etc.

Source Term for Advanced Reactors

Functional Containment

- Smaller fission product inventories given proposed smaller reactor sizes
- Functional Containment: use of multiple independent barriers to limit fission product release

Mutual Compatibility

- Mutual compatibility between fuel, coolant and moderator
  - HTGR – TRISO fuel/graphite moderator/helium coolant
  - LMR – metallic fuel/metallic clad/ sodium coolant

Inherent Characteristics

- Inherent robustness of fuel forms
  - Inherent retentiveness of fission products in TRISO fuel and graphite
  - Inherent retentiveness of fission products in molten salts

Result

- Less likely to lead to events with serious off-site consequences
  - Doses may be low enough to technically preclude the need for off-site evacuation planning

Summary

Inherent Characteristics	○ Advanced reactors' inherent safety characteristics result in a greater emphasis on accident prevention than accident mitigation
Compensating Measures	○ The lack of operating experience is compensated by greater reliance on inherent and passive safety features, large safety margins, and defense in depth in the design, supported by scaled testing and integral safety demonstration

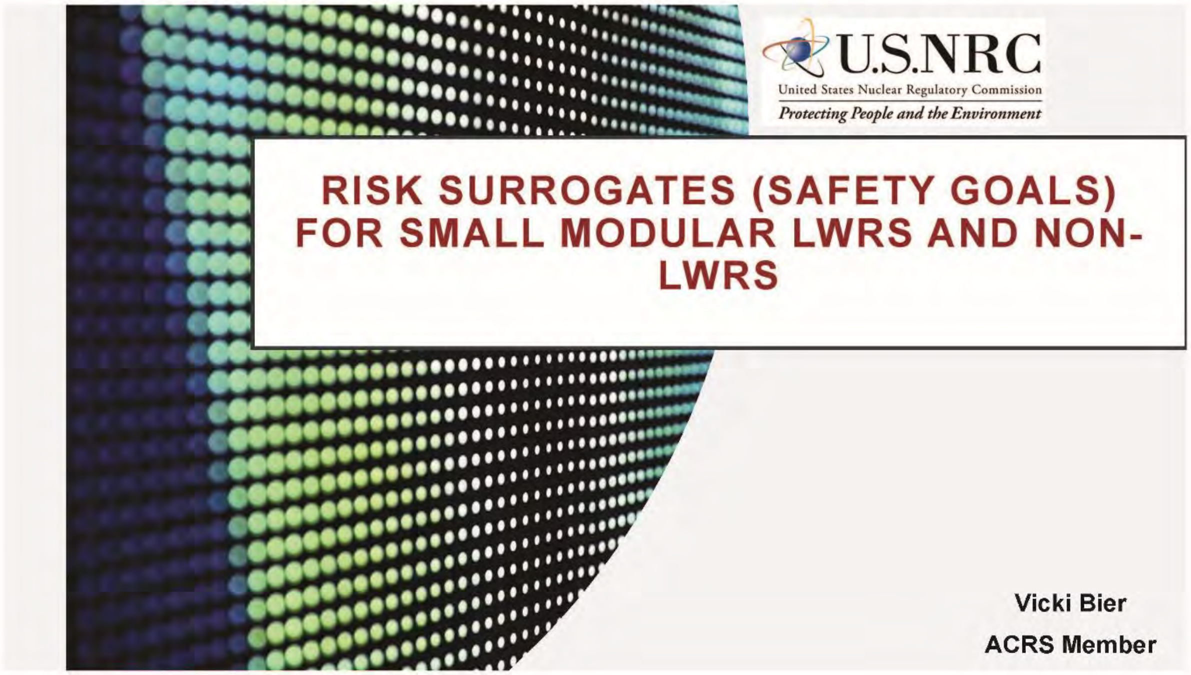
ACRS, 2022a	Advisory Committee on Reactor Safeguards, Report from Joy L. Rempe, ACRS Chairman, to Christopher T. Hanson, NRC Chair, Subject: Final Letter on Draft 10 CFR PART 53 Rulemaking Language, November 22, 2022. (https://www.nrc.gov/docs/ML2231/ML22319A104.pdf)
ACRS, 2022b	Advisory Committee on Reactor Safeguards, Report from Joy L. Rempe, ACRS Chairman, to Christopher T. Hanson, NRC Chairman, Subject: Fourth Interim Letter on 10 CFR PART 53 Rulemaking Language, August 2, 2022. (https://www.nrc.gov/docs/ML2219/ML22196A292.pdf)
ACRS, 2022c	Advisory Committee on Reactor Safeguards, Report from Joy L. Rempe, ACRS Chairman, to Christopher T. Hanson, NRC Chairman, Subject: Integration of Source Term Activities in Support of Advanced Reactor Initiatives, April 4, 2022. (https://www.nrc.gov/docs/ML2206/ML22069A083.pdf)
ACRS, 2022d	Advisory Committee on Reactor Safeguards, Report from Joy L. Rempe, ACRS Chairman, to Christopher T. Hanson, NRC Chairman, Subject: Preliminary Proposed Rule Language and Guidance to Align Licensing Processes and Lessons Learned from Recent Reactor Licensing Activities, March 23, 2022. (https://www.nrc.gov/docs/ML2206/ML22069A269.pdf)

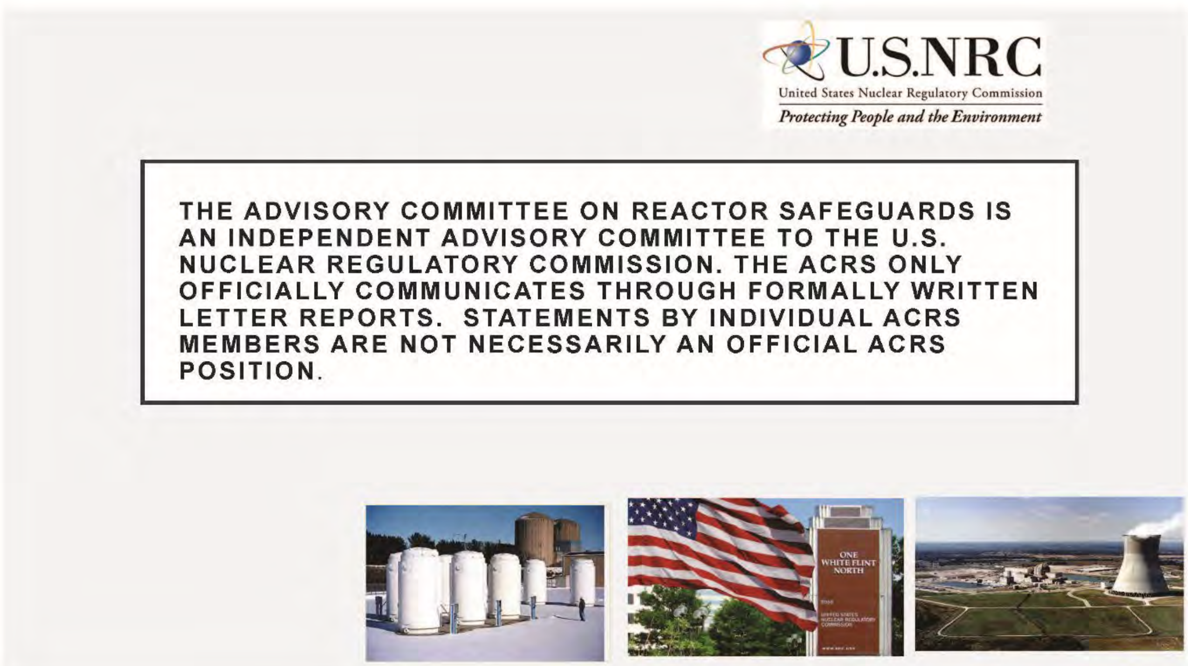
ACRS, 2022e	Advisory Committee on Reactor Safeguards, Report from Joy L. Rempe, ACRS Chairman, to Christopher T. Hanson, NRC Chairman, Subject: Preliminary Rule Language For 10 CFR PART 53, SUBPART F, "Requirements for Operations," Interim Report, February 17, 2022. (https://www.nrc.gov/docs/ML2204/ML22040A361.pdf)
ACRS, 2020a	Advisory Committee on Reactor Safeguards, Report from Matthew W. Sunseri, ACRS Chairman, to Kristine L. Svinicki, NRC Chairman, Subject:10 CFR PART 53 Licensing and Regulation of Advanced Nuclear Reactors, October 21, 2020. (https://www.nrc.gov/docs/ML2029/ML20295A647.pdf)
ACRS, 2020b	Advisory Committee on Reactor Safeguards, Report from Matthew W. Sunseri, ACRS Chairman, to Kristine L. Svinicki, NRC Chairman, Subject: Observations and Lessons-Learned from ACRS Licensing Reviews Relevant to Future Advanced Reactor Applications, October 02, 2020. (https://www.nrc.gov/docs/ML2026/ML20267A655.pdf)
ACRS, 2018	Advisory Committee on Reactor Safeguards, Report from Michael L. Corradini, ACRS Chairman, to Kristine L. Svinicki, NRC Chairman, Subject: Draft SECY Paper, "Functional Containment Performance Criteria for Non-Light Water Reactor Designs," May 10, 2018. (https://www.nrc.gov/docs/ML1810/ML18108A404.pdf)

Acronyms

- ANL – Argonne National Laboratory
- AVR - A***rbeitsgemeinschaft Versuchsreaktor*** **reactor (German)**
- EBR – experimental breeder reactor
- FFMEA - **Functional Failure Mode & Effect Analysis**
- FMEA – Failure Mode & Effect Analysis
- FOAK – First of a Kind
- HAZOP – hazard and operability study
- HGTR – high temperature gas reactor
- KAERI – Korean Atomic Energy Research Institute
- LMR – liquid metal reactor
- LWR – light water reactor
- MLD – master logic diagram
- TAMU – Texas A&M University
- T/H – thermal hydraulic
- TRISO – tristructural isotropic
- UW – University of Wisconsin

D.5.2 Risk Surrotates (Safety Goals) for SMRS and Microreactors





Background

- This was motivated by the ACRS review of draft language for Part 53:
  - **Risk Informed, Technology-Inclusive Regulatory Framework for Advanced Reactors**
- The ACRS subsequently decided to establish a working group to revisit the current NRC safety goals, and explore possible changes:
  - Considering their applicability to industry plans for small modular light-water reactors (LWRs) and non-LWRs

History of Safety Goals

1980 — ACRS developed a draft proposed set of safety goals (NUREG-0739)

1986 — NRC adopted a formal Policy Statement on safety goals

- **Two qualitative safety goals**:
  - No individual should bear a significant additional health risk;
  - Societal risks no greater than the risks of generating electricity by competing technologies [primarily coal plants] and should not be a significant addition to other societal risks
- **Two quantitative objectives** used to gauge achievement of the safety goals:
  - Prompt-fatality risks no more than 0.1% of the comparable risks from other types of accidents
  - Latent cancer-fatality risks no more than 0.1% of cancer risks from other causes
- **Large radioactive release** should occur less often than 10^{-6} per year:
  - A general performance guideline that was proposed for further staff examination

1989 — "Subsidiary objectives"

- Core-damage frequency (CDF) no greater than 10^{-4}
- Conditional containment-failure probability less than 0.1 (for evolutionary designs)

1998 — Large early-release frequency (LERF) no greater than 10^{-5}

Safety Goals Applied to New Reactor Designs

Smaller reactor sizes and source terms:
- Historically, "significant additional risk" was defined as an 0.1% increase
- This may be more than is justified for extremely small facilities

CDF may not be well defined for some reactor designs

Possible reliance on bounding analysis:
- There may not be PRAs from which to compute CDF or health risks

Changes in competing technologies:
- "Competing technologies" in U.S. will no longer be **base-load coal:**

Natural gas	38%
Coal	22%
Renewable	20%
Nuclear	19%

Planned Activities and Outcomes

- Collecting historical information on development/application of safety goals
- Reviewing international efforts on advanced reactors and/or safety goals
- Identifying relevant departures from past historical circumstances
  - Changes in background or comparison risks
  - Changes in baseload power, etc.

- **Planned outcome**
  - White paper discussing issues involved in applying safety goals to advanced reactors
- **Possible additional outcome**
  - Proposed recommendations regarding application of safety goals to small modular LWRs or microreactors, and/or non-LWRs