IAEA Report on

Strengthening Nuclear Regulatory Effectiveness in the Light of the Accident at the Fukushima Daiichi Nuclear Power Plant

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IAEA REPORT ON STRENGTHENING NUCLEAR REGULATORY EFFECTIVENESS IN THE LIGHT OF THE ACCIDENT AT THE FUKUSHIMA DAIICHI NUCLEAR POWER PLANT

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FOREWORD

by Denis Flory
Deputy Director General
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In response to the accident at the Fukushima Daiichi nuclear power plant, IAEA Member States unanimously adopted the Action Plan on Nuclear Safety. Under this Action Plan, the IAEA Secretariat was asked to organize International Experts Meetings to analyse all relevant technical aspects and learn the lessons from the accident.

Regulatory effectiveness is an area that is represented in many of the main actions of the Action Plan but has not been covered by an International Experts Meeting. However, the IAEA Secretariat organized an International Conference in this area, along with other relevant meetings and activities that brought together leading experts from research, industry, regulatory control and safety assessment. This has made it possible for the experts to share the lessons learned from the accident and identify relevant best practices, and to ensure that both are widely disseminated.

This report on Strengthening Nuclear Regulatory Effectiveness in the Light of the Accident at the Fukushima Daiichi Nuclear Power Plant is part of a series of reports on the lessons learned from the Fukushima Daiichi accident. The report draws on the information provided at the International Conference on Effective Nuclear Regulatory Systems, held in Ottawa, Canada, 8–12 April 2013, as well as on insights from relevant IAEA Secretariat activities carried out since 2011 in this area with the aim of strengthening the effectiveness of nuclear regulatory bodies. It is possible that additional information and analysis related to the accident may become available in the future and will need to be considered.

I am grateful to the participants of the conference and all the other meetings and activities for their valuable input.

I hope that this report will serve as a valuable information tool and reference for governments, regulatory bodies, technical support organizations, nuclear operators, the media and the general public, and that it will contribute to further strengthening the effectiveness of nuclear regulatory bodies.

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1. INTRODUCTION

Following the accident in Japan at TEPCO's Fukushima Daiichi nuclear power plant (the Fukushima Daiichi accident), the IAEA Director General convened the IAEA Ministerial Conference on Nuclear Safety in June 2011 to direct the process of learning and acting upon lessons to strengthen nuclear safety, emergency preparedness and radiation protection of people and the environment worldwide. Subsequently, the Conference adopted a Ministerial Declaration on Nuclear Safety, which committed to, inter alia, "further strengthening the authority, competence and resources of national regulatory authorities" and requested the Director General to prepare a draft Action Plan.[1] The draft Action Plan on Nuclear Safety (the Action Plan) was approved by the Board of Governors at its September 2011 meeting[2]. On 22 September 2011, the IAEA General Conference unanimously endorsed the Action Plan, the purpose of which is to define a programme of work to strengthen the global nuclear safety framework.

The Action Plan includes 12 main actions; one of the actions is focused on communication and information dissemination, and includes six sub-actions, one of which mandates the IAEA Secretariat to "organize international experts meetings to analyse all relevant technical aspects and learn the lessons from the Fukushima Daiichi nuclear power station accident". Given that there has not been a specific International Experts Meeting (IEM) on the subject of strengthening the effectiveness of national regulatory bodies, the report considers the discussions and the outcomes of the conferences and meetings that addressed this subject following the Fukushima Daiichi accident, with the aim of sharing with Member States the most significant lessons learned to date regarding strengthening the effectiveness of national regulatory bodies in the light of the Fukushima Daiichi accident.

The Co-Presidents of the Fukushima Ministerial Conference on Nuclear Safety, held in Fukushima Prefecture, Japan, 15–17 December 2012, highlighted the "utmost importance of establishing and sustaining competent national regulatory authorities with effective independence and adequate human and financial resources." The report by the IAEA Director General to the March 2013 Board of Governors included the Chairpersons' Summaries from the same Conference that described "the imperative of establishing an effective nuclear safety regulatory framework, including an independent (in law, practice

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[1] Declaration by the IAEA Ministerial Conference on Nuclear Safety in Vienna on 20 June 2011, INFCIRC/821, IAEA, Vienna (2011), para. 23.

[2] Draft IAEA Action Plan on Nuclear Safety, Report by the Director General, GOV/2011/59-GC(55)/14, IAEA, Vienna (2011).

and culture) effective expert regulator that is credible, trusted, competent and adequately resourced."

The report is based on insights regarding regulatory effectiveness in the light of the Fukushima Daiichi accident from the International Conference on Effective Nuclear Regulatory Systems, held in Ottawa, Canada, 8–12 April 2013, the Integrated Regulatory Review Service (IRRS) missions conducted since the Fukushima Daiichi accident, the Second Extraordinary Meeting of the Contracting Parties to the Convention on Nuclear Safety, held in August 2012, and results from other international reviews. The latter reviews include those conducted by the CANDU Senior Regulators Group, the European Nuclear Safety Regulators Group (ENSREG)[3], the Forum of the State Nuclear Safety Authorities of the Countries Operating WWER-type Reactors, the Ibero-American Forum of Radiological and Nuclear Regulatory Agencies (FORO), and the International Nuclear Regulators Association (INRA).

This report belongs to a set of IAEA reports summarizing lessons learned from the Fukushima Daiichi accident.

2. BACKGROUND

Following the Fukushima Daiichi accident, the international community addressed, among other things, the issue of the national regulatory frameworks and the national regulatory authorities. In the "Declaration by the IAEA Ministerial Conference on Nuclear Safety in Vienna on 20 June 2011", the Ministers of the IAEA Member States underlined the benefits of strengthened and high quality independent international safety expert assessments through periodic reviews and evaluation missions assessing national regulatory frameworks[4], and expressed commitment "to further strengthening the authority, competence and resources of national regulatory authorities, including through appropriate technical and scientific support and to continuously ensure their effective independence."[5]

The IAEA Action Plan, which was built on this declaration and the conclusions and recommendations of the three working sessions of the Ministerial Conference, addressed the issue of national regulatory bodies in several actions. In particular, the actions to strengthen IAEA peer reviews, in

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[3] All European Union Member States and the European Commission are represented in ENSREG.

[4] Declaration by the IAEA Ministerial Conference on Nuclear Safety in Vienna on 20 June 2011, INFCIRC/821, IAEA, Vienna (2011), para. 12.

[5] Ibid., para. 15.

order to maximize the benefits to Member States, strengthen the effectiveness of national regulatory bodies, review and strengthen IAEA safety standards and improve their implementation, strengthen and maintain capacity building, enhance transparency and effectiveness of communication, and improve dissemination of information.

In response to the above mentioned actions, the IAEA Secretariat initiated the following:

— A module for the IRRS was developed to review regulatory actions in response to the Fukushima Daiichi accident which was used in all IRRS missions[6] after the Fukushima Daiichi accident. The Secretariat conducted an analysis of the conclusions of the application of this module. This analysis suggested that there were no major implications for the regulatory regimes of the reviewed countries.
— Various steps were taken to improve the effectiveness of the IRRS process, including an additional focus on the comprehensive review of national regulations.
— The IAEA Safety Requirements were reviewed in a systematic manner, in the light of the findings of the analysis of the Fukushima Daiichi accident, in order to identify whether modifications were necessary to reflect any of the findings. The Commission on Safety Standards concluded that the current IAEA Safety Requirements have no significant areas of weakness, but certain amendments were proposed to strengthen the requirements and facilitate their implementation.
— As part of the implementation of action related to enhancing transparency and effectiveness of communication, the third in a series of International Conferences on Effective Nuclear Regulatory Systems was held in Ottawa, Canada, 8–12 April 2013, to review and assess ways to further improve the effectiveness of regulatory systems for facilities and activities, taking into account lessons learned in the light of the Fukushima Daiichi accident. This conference provided an opportunity for Member States to discuss important issues related to regulatory effectiveness. Highlights from the conference are documented in the applicable subsequent sections of this report.

Government has an important role in establishing an independent regulatory body and providing it with the necessary human and financial resources for

[6] The following countries hosted IRRS missions after the Fukushima Daiichi accident (in chronological order): the Republic of Korea, Germany (follow-up), Slovenia, Switzerland, Canada (follow-up), Sweden, the United Arab Emirates, Slovakia, Finland, Bulgaria and Poland.

discharging its mandate. Regulatory bodies have an important responsibility in establishing safety standards and the regulatory framework for protecting people and the environment against radiation risks.[7] This framework, including national regulations and guides, may need to be reviewed and, if necessary, revised to keep it current, with due consideration taken of relevant experience gained from events such as the Fukushima Daiichi accident.

Member State regulatory bodies and operating organizations responded to the Fukushima Daiichi accident by reassessing reactor safety, including: (i) assessment of the existing nuclear power plant design and licensing basis; (ii) assessment of the impact of extreme external hazards beyond the design basis; (iii) assessment of the ability to respond to extended station blackout (SBO) and loss of heat sink; (iv) assessment of the provisions for a response to severe accidents; and (v) identification of weak points and areas for improvement.

3. OBJECTIVE AND SCOPE

The objective of this report is to highlight the lessons learned to date from the Fukushima Daiichi accident that are relevant for strengthening the effectiveness of national regulatory bodies. The lessons learned are based on the insights and discussions from the conferences, meetings and results of the reviews mentioned in the introduction to this report. This report aims to bring together the outcomes of these discussions to support and contribute to Member States' efforts to enhance national regulatory effectiveness.

Within its scope, the report provides an overview of the actions taken to date by nuclear regulators worldwide in the aftermath of the Fukushima Daiichi accident. It addresses actions taken by regulators to improve their own technical and organizational arrangements, actions requested by regulators from the licensees, general results and regulatory implications from these actions.

The report is structured in accordance with the three topical areas listed below and reflected in Sections 4, 5 and 6. For each of these topical areas, the main lessons learned from national and international regulatory initiatives are highlighted. The following sections deal respectively with:

— Strengthening the regulatory framework and processes (Section 4);
— Strengthening regulatory oversight for accident prevention (Section 5);

[7] INTERNATIONAL ATOMIC ENERGY AGENCY, Fundamental Safety Principles, IAEA Safety Standards Series No. SF-1, IAEA, Vienna (2006), para. 3.10.

— Strengthening regulatory oversight for accident mitigation (Section 6);
— Conclusions (Section 7).

Each section of the report contains a subsection on lessons learned, followed by a background subsection providing information (e.g. reference to relevant IAEA safety standards, the current situation on specific topics and actions taken by IAEA Members States) based on which the lessons learned were drawn. These two subsections are followed by subsections covering the discussion from the conferences, meetings and results of the reviews mentioned in the introduction to this report.

4. STRENGTHENING THE REGULATORY FRAMEWORK AND PROCESSES

This section presents lessons learned on strengthening the regulatory framework and processes that are based on insights from, and discussions at, the events (listed below) that covered this aspect, and addresses issues related to the regulatory effectiveness of national regulatory bodies, including their independence, authority, oversight and enforcement, competences and transparency. It also deals with international cooperation, peer reviews of regulatory bodies, application of the IAEA safety standards, experience sharing among regulatory bodies and safety culture.

4.1. LESSONS LEARNED

The IRRS plays a key role for enhancing the national regulatory framework and the regulatory capabilities by identifying areas that need to be improved, as well as good practices, to be shared among regulators.

Regulatory bodies should continue their efforts to ensure that the national regulations are in line with the IAEA safety standards.

The circumstances of the Fukushima Daiichi accident highlighted the importance of regulatory body independence and a regulatory safety culture for effective regulatory oversight of the safety of nuclear installations. The ability of regulatory bodies to make independent safety decisions and to ensure their implementation requires competent and sufficient human resources, adequate legal authority (including the right to suspend operation and/or to impose safety improvements on licensees) and adequate financial resources. International cooperation, including exchange of regulatory knowledge and experience among

regulators and peer reviews with transparent and open dialogue, are essential components for strengthening a national regulatory infrastructure.

The national regulatory bodies should determine safety objectives to be achieved by the licensees and ensure implementation of the necessary safety measures. The required safety measures need to be implemented by licensees within stipulated deadlines and subject to regulatory verification. Inadequate regulatory verification may have a negative impact on safety if the licensee does not take the appropriate actions.

Regulatory review and assessment should be expanded to include a systematic reassessment of safety margins (robustness of the nuclear power plant design) for both existing and future nuclear power plants.

Nuclear installations other than nuclear power plants with significant sources of radioactive material should also be subject to a systematic reassessment.

Regulatory bodies should incorporate safety culture into their regulatory processes by developing a safety culture policy, and training senior management and staff in their respective roles and responsibilities in its implementation.

4.2. BACKGROUND

While the operator has the prime responsibility for safety, the regulatory body is responsible for the oversight of the activities of the operator related to safety. These responsibilities are specifically addressed in the IAEA Safety Requirements on the Governmental, Legal and Regulatory Framework for Safety[8]. These Safety Requirements also require that the government ensure that the regulatory body is effectively independent in its safety related decision making and has functional separation from entities having responsibilities or interests that could unduly influence its decision making.

Following the Fukushima Daiichi accident, the process of separation of national regulatory bodies was accelerated in some countries, and their regulatory bodies were repositioned in the governmental structure. Nevertheless, the separation between promotional and supervisory functions has not been completed worldwide. Further clarification of responsibilities between various authorities with regulatory functions and their reporting lines within government is essential to avoid gaps and overlaps that can impact safety. In some cases, the authority of the regulatory bodies may need to be further strengthened. It has

[8] INTERNATIONAL ATOMIC ENERGY AGENCY, Governmental, Legal and Regulatory Framework for Safety, IAEA Safety Standards Series No. GSR Part 1, IAEA, Vienna (2010).

been noted that provision of sufficient funding and strong enforcement powers contribute to the enhancement of the effectiveness of the regulatory body.

After the Fukushima Daiichi accident, a number of Member States reviewed and proposed revisions to their national regulatory documents, taking into account the results of the comprehensive assessments against extreme natural hazards. This includes revising selected requirements and expectations for design basis accidents and design extension conditions to ensure that lessons learned from the Fukushima Daiichi accident are built into the regulatory oversight programme for existing and new nuclear power plants. The efforts of regulatory bodies to update their regulations and guides, taking into consideration IAEA safety standards and best safety practices, are of a continuing nature. Determination of the safety margins for nuclear power plants requires a comprehensive assessment of issues such as defence in depth, extreme external hazards and combinations of events and common cause failures. Specifically, the extended loss of ultimate heat sink and loss of essential power supplies need to be addressed.

The periodic safety review (PSR) process is an effective means used by regulatory bodies to promote continuous safety improvements. The systematic review of relevant experience and up to date scientific knowledge and its implications will further improve the application of PSRs.

4.3. DISCUSSIONS AT THE INTERNATIONAL CONFERENCE ON EFFECTIVE NUCLEAR REGULATORY SYSTEMS

The following are the highlights of the technical presentations, conclusions and recommendations discussed at the conference as they relate to strengthening the regulatory framework:

- Regulatory bodies need to be independent, competent and have strong legislative authority and adequate human and financial resources.
- The high level commitment to peer reviews such as through the Convention on Nuclear Safety and the IRRS, and to transparency of results have to be maintained and enhanced. It is important to ensure that Member States hosting peer reviews commit to a transparent action plan and follow-up missions, in order that they focus on addressing the recommendations from the mission. The results of the peer reviews should be made publicly available.
- Regulatory bodies should seek to adopt, adapt or reference IAEA safety standards in their legal or regulatory framework.

— Sharing regulatory information and best practices among regulatory bodies can be achieved bilaterally, through regional networks, the IAEA or other multilateral arrangements.
— Regulatory bodies should be transparent and open to the public, and provide understandable and fact based information.
— Regulatory bodies can learn from each other from significant operational events and also from less significant events and issues that could contribute to the continuous improvement of the regulatory processes.
— Regulatory bodies should consider safety culture in their regulatory processes by developing a safety culture policy, and training senior management and staff in their respective roles and responsibilities in implementing it.
— Regulatory bodies should engage in ongoing dialogue with licensees to enhance the understanding of safety culture aspects and to seek licensees' commitment to perform self-assessments and independent peer assessments of safety culture on a regular basis.
— Regulatory bodies must increase peer pressure among regulators, especially in the next review meeting of the Contracting Parties to the Convention on Nuclear Safety, to make use of all aspects of the peer review process.

4.4. DISCUSSIONS DURING INTEGRATED REGULATORY REVIEW SERVICE MISSIONS

During the IRRS missions, there were discussions and reviews of actions taken by regulatory bodies in the light of the Fukushima Daiichi accident. The following aspects have been highlighted:

— Conduct of specific research projects to determine whether current approaches for defining the design basis for earthquakes and tsunamis should be updated;
— Additional or updated regulations and guides on accidents affecting several units at the same site are needed;
— Additional or updated regulations and guides for other extreme external natural hazards (e.g. extreme weather conditions) and human-made hazards (e.g. cyber security, airplane crash) are needed;
— Methods for assessment of adequacy of safety margins in connection with external hazards need to be elaborated;
— There should be opportunity to give a more formal regulatory status to probabilistic safety assessment (PSA) and design extension conditions, including severe accidents;

— There can be potential unfavourable interactions among safety systems shared by different nuclear power plant units;
— There is a need to focus all communication by regulatory bodies to the public on matters directly related to risk using simple and understandable language.

4.5. DISCUSSIONS AT THE SECOND EXTRAORDINARY MEETING OF THE CONTRACTING PARTIES TO THE CONVENTION ON NUCLEAR SAFETY

At the meeting, the Contracting Parties encouraged networks of operators, regulatory bodies, international organizations and technical support organizations to cooperate on the lessons learned from the Fukushima Daiichi accident. To further reinforce the peer review process and strengthen national regulatory bodies, the Contracting Parties approved changes to the guidance documents for national reports and for the conduct of review meetings.

Among a number of topics discussed by the Contracting Parties at the meeting was the issue of strengthening the regulatory framework and processes. These discussions addressed the following aspects:

— Review and revision of the legislative framework and undertaking changes to the functions and responsibilities of the regulatory body.
— Reinforcement of international cooperation in the form of regional and bilateral relations, as well as through international organizations: The significance of the different peer reviews, arranged by international organizations, has been recognized and appreciated by the majority of the Contracting Parties. These peer reviews have typically been complemented by a specific module, devoted to the lessons learned from the Fukushima Daiichi accident.
— Reviews and revisions of the legislative framework and changes to the functions and responsibilities of the regulatory body: The nuclear power countries of the European Union as well as Switzerland and Ukraine reported their participation in the stress test process, following the Western European Nuclear Regulators Association (WENRA)/ENSREG specifications. Many other nuclear power countries worldwide have carried out similar stress tests.

— The following aspects were highlighted as being important for the effectiveness of the regulatory body:
  - Adequate legal powers (e.g. enforcement actions such as suspending operation);
  - Ability to make independent decisions;
  - Adequate financial resources;
  - Competent and sufficient human resources;
  - Transparency in communicating regulatory decisions to the public.

Among the issues to be considered, the Contracting Parties agreed that the national reports should cover, inter alia, "[m]easures taken or planned to ensure the effective independence of the regulatory body from undue influence, including, where appropriate, information on the hosting of IRRS missions". Where the regulatory body is constituted of more than one entity, the need to ensure efficient coordination was highlighted by the Contracting Parties.

4.6. DISCUSSIONS DURING OTHER INTERNATIONAL REVIEWS

The following subsections highlight relevant results in the light of the Fukushima Daiichi accident reviews conducted by various groups or organizations of regulatory bodies that were presented in the margins of the Second Extraordinary Meeting of the Contracting Parties to the Convention on Nuclear Safety.

4.6.1. European Nuclear Safety Regulators Group

The European stress test methodology was drafted by WENRA and approved by ENSREG. The peer review[9] of the stress tests by ENSREG demonstrated that the regulatory bodies in Europe played an active role in the process at the national level in reviewing the reassessment of the nuclear power plant safety and specific safety upgrading proposals presented by the licensees. Practically all regulatory bodies modified their regular activities, to a certain extent, in the short and medium term, including specific walk downs or specialized inspections in their standard programmes. In many cases, special assessment programmes were launched at the national level in the light of the

[9] EUROPEAN NUCLEAR SAFETY REGULATORS GROUP STRESS TEST PEER REVIEW BOARD, Peer Review Report: Stress Tests Performed on European Nuclear Power Plants, v12i—2012 04 25, ENSREG (2012).

Fukushima Daiichi accident. Long term changes will result from the final assessment of the accident and the lessons learned from it.

The peer review of the stress tests reconfirmed the importance of the role of regulators in establishing safety requirements and overseeing compliance. Although the ENSREG peer review report does not explicitly deal with the regulatory framework and processes, it is clear that strengthening the regulatory bodies is a high priority task. Harmonization of the approach to the stress test reviews through the relevant regulatory organizations (WENRA, ENSREG) and verification by the peer reviews are considered important factors for enhancing the effectiveness and public trust in regulatory decisions.

4.6.2. Forum of the State Nuclear Safety Authorities of the Countries Operating WWER-type Reactors[10]

Water cooled, water moderated power reactor (WWER) regulators identified a need to reinforce current regulations to extend the design basis considering severe accident management (SAM) provisions.

The analysis provided insights to further strengthen the safety of old WWER plants and for extending the scope of issues to be addressed in new designs.

4.6.3. Ibero-American Forum of Radiological and Nuclear Regulatory Agencies[11]

The phenomena analysed by the FORO in the stress test process go far beyond the current nuclear power plant design basis. Nevertheless, for verification of the fulfilment of the current design basis and licensing basis, a complementary reassessment of nuclear power plant safety was considered necessary.

Non-compliance with the design basis and licensing basis was not identified and no weaknesses or critical situations, such as 'cliff edge' effects[12], were found, which would have required urgent action. However, as a result of the reassessment, many potential improvements were identified.

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[10] Armenia, Bulgaria, China, the Czech Republic, Finland, Hungary, India, the Islamic Republic of Iran, the Russian Federation, Slovakia and Ukraine.

[11] Argentina, Brazil, Chile, Cuba, Mexico, Peru, Spain and Uruguay.

[12] In a nuclear power plant, a 'cliff edge' effect is an instance of severely abnormal plant behaviour caused by an abrupt transition from one plant status to another following a small deviation in a plant parameter and, thus, a sudden large variation in plant conditions in response to a small variation in an input.

4.6.4. International Nuclear Regulators Association[13]

INRA indicated that PSRs are a significant contributor to maintaining and enhancing the safety of nuclear power plants, and to re-evaluating natural hazards on a periodic basis.

Different methodologies were used by INRA countries, but similar conclusions were reached. It was noted by INRA that nuclear power plants in INRA countries remain safe to operate. There is a need for an increased international focus to address major safety lapses.

5. STRENGTHENING REGULATORY OVERSIGHT FOR ACCIDENT PREVENTION

Regulatory oversight of accident prevention measures has traditionally been focused, inter alia, on the review of the application of defence in depth and the robustness of redundant and diverse means to provide protection against operational occurrences, accidents and external hazards that can challenge nuclear power plant safety. Regulatory oversight also includes the review of training of nuclear power plant personnel, maintenance and operational requirements.

Given the importance of an alternating current (AC) power supply to the realization of the fundamental safety functions of reactivity control, heat removal, and confinement, accident scenarios involving loss of on-site and off-site electrical power are also included in the regulatory reviews. As the long term loss of on-site and off-site power was a fundamental element in the Fukushima Daiichi accident, this section addresses issues related to re-examining the robustness of nuclear power plants against extreme external hazards and long term loss of essential nuclear power plant safety features.

[13] Canada, France, Germany, Japan, the Republic of Korea, Spain, Sweden, the United Kingdom and the United States of America.

5.1. STRENGTHENING ROBUSTNESS AGAINST EXTREME EXTERNAL HAZARDS

5.1.1. Lessons learned

The safety assessments carried out by licensees and regulatory bodies worldwide following the Fukushima Daiichi accident showed the need for:

— A comprehensive consideration of external hazards in the design basis of the installation, including consideration of the relevant combination of events and uncertainties associated with the determination of the hazard severity;
— A periodic assessment of the severity of the external hazard design basis, taking into account up to date scientific knowledge;
— Evaluation of safety margins beyond the design basis (in particular, in the case of extreme external hazards), including scenarios leading to core damage and major releases of radioactivity to the environment;
— Clarification and harmonization of the methodologies used for the evaluation of external and internal hazards beyond the design basis, including the objectives and criteria.

The regulatory oversight of accident prevention can be strengthened by requiring that safety improvements be considered through the use of deterministic and probabilistic approaches, such as seismic and tsunami PSAs, that are consistent with the IAEA safety standards and international best practices. Seismic and flood protection walk downs are required to identify observable nuclear power plant specific vulnerabilities. Precautionary safety measures should be taken to protect against multiple failures, even for extremely unlikely accidents with severe consequences. Regulatory reviews and inspections should ensure that licensees have properly considered the lessons learned.

Stricter consideration of uncertainties associated with site characterization and in the siting and design of new nuclear power plants is needed.

5.1.2. Background

Following the Fukushima Daiichi accident, regulatory bodies took actions to require verification of the robustness of nuclear power plants against extreme external hazards. Licensees were required to re-evaluate the seismic and flooding hazards against national requirements and criteria, using assessment methods such as those established in the IAEA safety standards. These re-evaluations were used to update the design basis and establish the robustness of structures,

systems and components (SSCs) important to safety, and provide protection against any newly identified hazards.

Evaluation of the safety margins beyond the licensing basis (in particular, in the case of extreme external hazards) was prompted by analysis of the Fukushima Daiichi accident. In addition to drawing up systematic procedures of evaluation of defence in depth, sufficiently detailed methods of evaluation of the level of damage to SSCs under design extension conditions are also required. The evaluation of such a scope of damage was not a usual part of the safety analysis in the original licensing of the nuclear power plants and, in many cases, it was necessary to use simplified engineering estimates. For the anticipated future analyses, it may be necessary to develop, harmonize and apply methods of assessment of damage to equipment.

5.1.3. Discussions at the International Conference on Effective Nuclear Regulatory Systems

The following are the highlights of the technical presentations, conclusions and recommendations discussed at the conference as they relate to strengthening robustness against extreme natural hazards:

— External hazards should be periodically re-evaluated for all nuclear power plant sites;
— PSRs of installations need to consider the vulnerabilities to external hazards;
— Regulatory bodies need to request licensees to perform external event safety margin assessment, including issues such as in-plant flood protection.

5.1.4. Discussions during Integrated Regulatory Review Service missions

During the IRRS missions that have taken place since the Fukushima Daiichi accident, there were discussions and reviews of actions taken by regulatory bodies, including the following aspects:

— The use of state of the art data by the licensee (as required by the regulatory body) for the determination of the probabilities of seismic loads at specific sites that might lead to a higher level of design earthquakes;
— Protection of buildings against the intrusion of water and flooding resistance in the case of a flood higher than the original design basis;
— Accessibility of the nuclear power plant site in the case of longer term flooding;

— Re-verification of safety margins in the case of external hazards such as blast waves, toxic gases and an airplane crash.

The short term safety improvements required by the regulatory bodies should be followed by more general long term actions aimed at updating the entire review and assessment process. This includes determination of external hazards and associated loads, specification of acceptance criteria and methodologies for demonstration of compliance with the criteria, including both deterministic and probabilistic methods of safety assessment.

Relevant specific actions to be considered in the future for strengthening regulatory oversight for accident prevention include:

— Enhancement of methods for determination of nuclear power plant site specific extreme external hazards;
— Reconsideration of the existing nuclear power plant design basis regarding extreme external natural hazards, taking into account the possibility of extreme events which are beyond the design basis;
— Review of whether the nuclear power plant protection against the impact of extreme hazards is adequate with sufficient margins, taking into account the uncertainties in associated loads using fragility analysis, structural mechanics, review of fault sequences that could occur following extreme events, thermohydraulic analysis and assessment of robustness of the design for maintaining safety functions;
— Combined use of deterministic and probabilistic approaches for safety assessment of extreme natural hazards, with a significantly enhanced scope of the PSA approach.

Regulatory bodies requested licensees to take into account greater protection against external events during site selection. The nuclear power plant design is to take into account revised regulatory requirements for protection against loads caused by extreme external hazards and measures for coping with design basis accidents and design extension conditions.

5.1.5. Discussions at the Second Extraordinary Meeting of the Contracting Parties to the Convention on Nuclear Safety

Among the topics discussed by the Contracting Parties at the Meeting, was the issue of strengthening regulatory oversight for accident prevention. The discussions addressed the following aspects:

— Re-evaluation of the hazards posed by external events, such as earthquakes, floods and extreme weather conditions, for each nuclear power plant site through a targeted reassessment of safety.
— Specific safety improvements based on the reassessment of external events, including protection against flooding and extreme weather protection.
— Upgrading safety systems or installing additional equipment and instrumentation to enhance the ability of each nuclear power plant to withstand an unexpected natural event without access to the electrical power grid for an extended period of time, including for an external event affecting multiple units.
— Reassessment of compliance with the licensing basis concerning external events and performing studies beyond the current licensing basis.
— Safety margin assessments based on periodic re-evaluation of the licensing basis for external and internal events.
— Periodic reassessment of external hazards and their influence on the licensing basis, using state of the art data and methods. Deterministic methods form the basis for hazard assessment, and probabilistic methods, including PSA, are useful to supplement the deterministic methods.
— Assessments of safety margins form the basis for safety improvements by enhancing current design or adding diverse means to fulfil safety functions.
— Updated technical studies to provide new data and methods for future assessments, such as the influence of climate change on historical meteorological data.
— Risk considerations for multi-unit nuclear power plant sites, taking into account the effects of units on each other and the potential effects of other nearby industry.

5.1.6. Discussions during other international reviews

The following subsections highlight relevant results of the Fukushima Daiichi accident reviews conducted by various groups or organizations of regulatory bodies that were presented in the margins of the Second Extraordinary Meeting of the Contracting Parties to the Convention on Nuclear Safety.

5.1.6.1. CANDU Senior Regulators Group[14]

After the Fukushima Daiichi accident, nuclear power plants in the States belonging to the Group were reassessed by seismic margin assessment or PSA based seismic margin assessment to ensure adequate safety margins for low frequency seismic events. Margins have been enhanced for low frequency seismic events. Some seismic upgrades have been performed or planned. Higher seismic requirements considered for new nuclear power plants are typically 1 in 10 000 years for the design basis.

All nuclear power plants are improving relevant defence measures against tsunamis (e.g. raised barriers, additional pump out capability, strengthened sea defence).

Additional fire defence measures have been identified and are being installed.

5.1.6.2. European Nuclear Safety Regulators Group

A variety of regulatory approaches were utilized by European Union national regulators to assess nuclear power plant protection against external events. Most European Union national regulators adopted a prescriptive approach, in which regulations specified details of how safety cases were to be produced and detailing hazard parameters. Other countries adopted a high level, goal setting approach, in which more discretion was left to the operator, provided that they justified the approach adopted. Among the main conclusions of the ENSREG peer review was the recommendation that national regulatory bodies consider the following:

— Driving all nuclear power plant reviews/back-fitting with respect to external hazard safety cases to 10^{-4} per annum, and considering 0.1g as a minimum peak ground acceleration;
— Incrementally increasing flood levels in order to determine potential improvements;
— Strengthening the PSR process by encouraging a more consistent approach to the determination of margins for external events, including external event PSAs (including seismic) and regular reviews of the design and beyond design hazards;
— Developing European guidance on natural hazard assessments, including earthquakes, flooding and extreme weather conditions, as well as

[14] Argentina, Canada, China, India, the Republic of Korea, Pakistan and Romania.

corresponding guidance on the assessment of margins beyond the design basis;
— Clarifying the requirements for the approach to the secondary effects of seismic events, such as flooding or fire arising as a result of the event, in future assessments;
— Using the protected volume approach as an effective method of flood protection for identified spaces;
— Developing standards for plant walk downs with regard to earthquakes, flooding and extreme weather to provide a more systematic search for deficiencies and correct them, such as the appropriate storage of temporary and mobile equipment and tools used to mitigate design extension conditions;
— A 'hardened core' of safety systems as a possible means of protection against extreme external hazards;
— Ensuring storage and availability of mobile equipment to perform necessary safety functions following a significant external event;
— Enhancing the external hazards robustness of on-site emergency centres;
— Installing seismic monitoring systems and development of associated procedures and training;
— Implementing advanced weather alert systems, including appropriate communications and operating procedures.

5.1.6.3. Forum of the State Nuclear Safety Authorities of the Countries Operating WWER-type Reactors

Stress tests, which were conducted by all WWER-operating countries, did not reveal any significant external hazards or their combinations that were not considered in the initial design and/or in the safety assessment reports or periodic safety reports.

5.1.6.4. Ibero-American Forum of Radiological and Nuclear Regulatory Agencies

All FORO countries adopted assessment approaches based on seismic margins, and have quantified or are in the process of quantifying the robustness of each nuclear power plant to cope with beyond design basis accidents.

The assessments are strongly affected by geographical differences at the nuclear power plant sites. All countries have demonstrated that their nuclear power plants have suitable safety margins.

The analysis and assessments of nuclear power plant safety demonstrated a suitable margin to fulfil the safety functions in case of an occurrence of

beyond design basis accident situations. No immediate corrective actions were determined to be necessary. Conceivable 'cliff edge' effects were postulated, and the corresponding improvements or modifications to cope with them were identified and proposed. In some cases, additional studies will be carried out to further confirm these assessments.

5.1.6.5. International Nuclear Regulators Association

INRA indicated that the regulatory review of safety re-evaluations of nuclear power plants for beyond design basis will be completed, taking into account multi-unit events and extreme natural hazards of low frequency and high impact.

5.2. STRENGTHENING ESSENTIAL NUCLEAR POWER PLANT SAFETY FEATURES

5.2.1. Lessons learned

Ensuring adequate protection of the power supply against infrequent and severe external hazards is an important lesson from the Fukushima Daiichi accident. Regulatory bodies should require licensees to demonstrate that, in the case of total loss of power, additional diverse power sources, such as mobile diesel generators or bunkered power supply sources, are available to be connected until off-site electrical power is restored. Additional means of increasing the reliability of electrical power supply should take into account the possibility of major destruction of the infrastructure surrounding the nuclear power plant. In addition, provision for long term fuel reserves for the additional power sources should be considered. The unavailability of electricity supply should also be taken into account in the implementation of emergency measures.

Ensuring the availability of cooling water and an ultimate heat sink is essential. Regulatory bodies should require licensees to demonstrate that alternative sources of water or alternative means of core cooling are available in the case of severe external hazards. The scope of assessment should include failures potentially affecting multiple redundant safety system trains or even multiple units on the same site (due to common cause failures), SBO and long lasting loss of the ultimate heat sink.

Regulatory bodies should ensure that extreme accident scenarios analysed consider potential events that could lead to a loss of the structural integrity of buildings and uncontrollable radioactive releases.

5.2.2. Background

The Fukushima Daiichi accident demonstrated that extreme accident scenarios associated with major site disruption caused by external events can result in extended complete loss of electrical power from all on-site and off-site power sources.

The complete loss of electrical power can also lead to sequential losses of safety systems, instrumentation and other essential safety features, and the ultimate heat sink. This situation may further challenge the structural integrity of buildings.

To enhance accident prevention, high reliability and robustness of electrical power sources/cooling systems is needed to ensure the long term ability to cool the reactor core and the spent fuel pools for extreme accident scenarios.

5.2.3. Discussions at the International Conference on Effective Nuclear Regulatory Systems

The following are the highlights of the technical presentations, conclusions and recommendations discussed at the conference as they relate to strengthening essential nuclear power plant safety features:

— Regulatory bodies should require the provision of backup external power, alternative internal power sources, and mobile power and water supplies;
— Regulatory bodies should require that the safety of spent fuel pools be reviewed with regard to defence in depth and to reduce the risk of a serious accident as much as possible.

5.2.4. Discussions during Integrated Regulatory Review Service missions

During the IRRS missions, there were discussions and reviews of actions taken by regulatory bodies in the light of the Fukushima Daiichi accident, including the following aspects:

— Continued investigations, taking into account all external, low probability natural events, with special consideration given to those events that could affect multiple reactor units;
— Actions for ensuring the capability of installed equipment and associated procedures to mitigate design extension conditions, including long term SBO and loss of ultimate heat sink;

— Actions for ensuring the ability of units to continuously cool the core following a loss of off-site power, the extension of battery discharge time and ensuring long term fuel supply to emergency generators;
— Use of optional system configurations to ensure safety functions when the design configuration is challenged, considering the recovery time necessary to avoid severe core damage and the associated logistical requirements;
— Implementation of an alternative ultimate heat sink;
— Increasing the robustness of the spent fuel pool cooling;
— Considering other long term spent fuel storage options.

5.2.5. Discussions at the Second Extraordinary Meeting of the Contracting Parties to the Convention on Nuclear Safety

The Contracting Parties noted that regulatory bodies should ensure that appropriate safety improvements are identified and implemented. The discussions included highlighting the activities and actions that have been or are being taken by various Contracting Parties. Examples of these activities and actions include:

— Enhancement of the robustness of the electrical supplies by means of reinforcing off-site power robustness in cooperation with the organization in charge of the national grid;
— Enhancement of the robustness of the AC emergency electrical power supply through protection upgrades and increasing the on-site fuel resources for emergency diesel generators;
— Diversification of the power supply for the emergency core cooling system and the emergency feed water system, and increasing the capacity of the direct current (DC) electrical power supply through protection upgrades and enhancement of battery discharge time;
— Enhancement of the robustness of cooling systems by means of upgrades for protecting the ultimate heat sink;
— Creation of alternative heat sinks according to site specificities, diversification of cooling systems, analysis of diverse provisions for primary and secondary feed and bleed;
— Reinforcement of the robustness of instrumentation and control (I&C) systems for reliable information on the reactor and spent fuel during design extension conditions, including identification of key I&C parameters, such as pressure, temperature and water level, and ensuring their robustness in design extension conditions;
— Upgrade of on-site communication means;

— Installing additional equipment and instrumentation in spent fuel pools to ensure that cooling can be maintained or restored in all circumstances, or performing additional technical evaluations to determine whether additional equipment and instrumentation are needed.

5.2.6. Discussions during other international reviews

The following subsections highlight the relevant results in the light of the Fukushima Daiichi accident reviews conducted by various groups or organizations of regulatory bodies that were presented in the margins of the Second Extraordinary Meeting of the Contracting Parties to the Convention on Nuclear Safety.

5.2.6.1. CANDU Senior Regulators Group

In view of the existing CANDU safety features and for strengthening response to severe accident scenarios, the Group recognizes that:

— Existing passive heat sinks have a large inventory of water and can provide many hours of passive cooling with no reactivity or structural concerns with rapid cooldown and depressurization.
— Additional make-up water sources are being implemented by installing accessible connection points to steam generators, the calandria vessel and calandria vault, and by deploying portable pumps, both on-site and off-site.
— Existing electrical systems have good diversity and redundancy. Additional power sources include providing mobile diesel generators stationed on-site or off-site, with accessible connection points and an adequate fuel supply.
— Additional battery capacity or charging capability may be limited to specific purposes, such as accident management related I&C. Portable charging generators may also be provided.
— Existing spent fuel pools are safe. Spent fuel pools are robust and fuel heat-up is slow. There are no criticality issues. Additional safety features include accessible pool make-up connections and better instrumentation for monitoring water level.
— All Canada deuterium–uranium/pressurized heavy water reactors are installing or evaluating passive hydrogen recombiners to supplement existing hydrogen igniters.
— Hydrogen concentration monitoring is under consideration or the means to monitor are already installed.

— Filtered containment venting is in place and is adequate for design basis accidents, and additional filtered systems are being considered or have already been installed.

5.2.6.2. European Nuclear Safety Regulators Group

The assessments of nuclear power plants undertaken during the 'stress tests' identified areas for improvement, in particular by adding flexible mobile systems and arranging for connections, sources of power, water, etc. It is recommended that regulatory bodies consider requiring the following:

— Enhanced on-site and off-site AC power supplies, a robust grid connection, and additional independent and dedicated power sources;
— Availability of a variety of mobile sources of power and coolant stored in safe and secured locations with prepared quick connections, procedures on how to connect and use, and staff training for deployment of such equipment;
— Improved battery discharge time, use of mobile battery chargers or mobile DC power sources to allow extended use of instrumentation and operation of controls;
— Alternative means of cooling, including alternate heat sinks such as steam generator gravity feeding, or using other sources of water including supply from stored condenser cooling water, alternate tanks or wells on the site, or water sources in the vicinity to enable core cooling and prevention of fuel degradation;
— Operational or preparatory actions such as improved inspections and training programmes, verification of access to essential equipment, and ensuring the supply of fuel and lubrication oil;
— Enhanced instrumentation and monitoring capabilities following the loss of power supply;
— Enhanced robustness of plant systems by improving separation and independence, enhanced capacities of ventilation systems, habitability of control rooms and robustness of the spent fuel pools;
— Use of the bunkered or 'hardened' systems for ensuring an additional level of protection to cope with a variety of initiators, including those external events beyond the design basis;
— Improvements in preparedness for the events that could affect multiple units by providing additional equipment and trained staff to deal with events affecting all the units on one site.

5.2.6.3. Forum of the State Nuclear Safety Authorities of the Countries Operating WWER-type Reactors

The following are actions identified by the Forum to be implemented by the licensees:

— Enhanced backup to the original power supply systems has to be provided for safety functions at operating WWERs. Upgrades for the AC power to safety functions includes adding mobile power sources — small portable diesel generators and powerful mobile diesel generator stations have already been implemented in some plants — and improving the reliability of the fixed on-site power supply.
— Further upgrades to deal with an SBO and/or loss of heat sink include enhancing the capability to provide steam generator make-up from alternative and/or mobile sources.

5.2.6.4. Ibero-American Forum of Radiological and Nuclear Regulatory Agencies

The FORO indicated that:

— Loss of on-site and off-site power was considered along with the loss of capability to connect to the normal and ultimate heat sinks, and a combination of the two were analysed. All countries included assessments of the available margins and 'cliff edge' effects.
— The time required for the recovery of safety functions or the lapsed time until unavoidable damage to the fuel in the reactor core or in the spent fuel pools was estimated. The assessments assumed that the loss of safety functions would last for an extended time period, and that the plant site would remain isolated and would not receive external support for at least 24 h.

6. STRENGTHENING REGULATORY OVERSIGHT FOR ACCIDENT MITIGATION

Regulatory oversight for accident mitigation aims at ensuring that the operating organization has established an accident management programme that covers the preparatory measures and guidelines that are necessary for dealing with design extension conditions, including organizational arrangements for

accident management, and communication networks and training necessary for the implementation of the programme.

Regulatory oversight includes ensuring that the operating organization has implemented and maintains adequate preparedness and response arrangements for nuclear and radiological emergencies. The scope of the review of the emergency preparedness and response arrangements by the regulatory body includes the infrastructure, organizations, plans, equipment, programmes, training and exercises in place for: maintaining protection and safety during an emergency; mitigating the consequences of accidents; protecting site personnel; coordinating with local and national authorities for protecting the public and the environment; coordinating with other response organizations; and keeping the public informed in a timely manner.

The conditions of the Fukushima Daiichi accident revealed the need to strengthen regulatory oversight for accident mitigation. This section deals with issues related to strengthening regulatory oversight of the licensees' SAM programme, emergency preparedness and response, and post-accident management.

6.1. STRENGTHENING SEVERE ACCIDENT MANAGEMENT

6.1.1. Lessons learned

The Fukushima Daiichi accident has shown that preventive measures can be compromised for certain accidental sequences (although for very unlikely conditions) and may eventually lead to melting the core, damaging the safety barriers and dispersal of radioactive materials from the containment, thus posing a risk to the nuclear power plant surroundings.

Regulatory bodies should require licensees to address the mitigation of severe accidents in a more comprehensive manner. Prolonged emergencies associated with extreme site conditions should be considered, particularly those involving SBO scenarios. Comprehensive analysis of design extension conditions, both deterministic and probabilistic, followed by implementation of the necessary measures, development of severe accident management guidelines (SAMGs), and the availability of staff and associated training should be required and reviewed by the regulatory body. SAM measures should be periodically re-evaluated to reflect state of the art knowledge.

The arrangements for SAM for single-unit and multi-unit nuclear power plant sites should be considered, including hydrogen management, post-accident monitoring and the safety of spent fuel storage.

Regulatory bodies should specify a schedule for implementation of improvements to protect containment integrity and to strengthen accident management. Regulatory bodies should verify that the licensees are prepared to take prompt and necessary on-site mitigating actions during an emergency situation to avoid delays that could jeopardize an effective response, even if those actions are beyond existing accident management provisions.

6.1.2. Background

The status of the legislative and regulatory basis for SAMGs varies among countries. Some countries already have relevant legislation in place, while others are at different stages of preparation for new legislation. The expedited implementation of SAM measures was identified as an area of concern.

WENRA, through its Reference Levels, recommends the implementation of measures to protect containment integrity for existing nuclear power plants, mainly by preventing high pressure core melt scenarios, through the installation of hydrogen control mechanisms and preventing containment overpressurization or degradation by molten corium. The effectiveness of filtered venting as a countermeasure against containment overpressurization is the subject of further discussions among regulators and operators as a design specific issue.

The hardware and procedural provisions for coping with design extension conditions have not been fully implemented in all nuclear power plants. Regulatory bodies can be a driving force in accelerating the implementation of the necessary measures.

Mitigating the consequences of extended accident conditions, particularly those related to external events, requires providing multiple means of power and water supply to support key safety functions. This may require upgrading the availability and capability of the installed nuclear power plant equipment, additional equipment located on-site or nearby as well as additional equipment located remotely. The reliability of this equipment, and the capability to deliver it to the necessary point of need should take into account the potential for major disruption in the local civil infrastructure and plant surroundings.

6.1.3. Discussions at the International Conference on Effective Nuclear Regulatory Systems

The following are the highlights of the technical presentations, conclusions and recommendations discussed at the conference as they relate to strengthening SAM:

— Regulatory bodies need to consider the necessity of additional regulatory requirements for SAMGs, taking into account the effect of external events;
— Regulatory bodies should require that licensees perform an external event safety margin assessment, covering such items as spent fuel pool monitoring, hydrogen monitoring, and control and habitability of the emergency control centre.

6.1.4. Discussions during Integrated Regulatory Review Service missions

During the IRRS missions, there were discussions and reviews of actions taken by regulatory bodies in the light of the Fukushima Daiichi accident, including the following aspects:

— Further development of the accident management programmes applicable under external hazard conditions;
— Securing additional protective equipment in preparation for a prolonged emergency;
— Securing countermeasures for protecting maintenance workers;
— Reinforcing education and training for severe accidents;
— Reinforcing radiological emergency exercises;
— Improvements to be introduced to the SAMGs;
— Incorporation of PSA results into the safety analysis report;
— Establishing a backup control room.

6.1.5. Discussions at the Second Extraordinary Meeting of the Contracting Parties to the Convention on Nuclear Safety

Among a number of topics discussed by the Contracting Parties at the meeting, was the issue of strengthening regulatory oversight for SAM. The discussions addressed the following aspects:

— Developing PSAs to identify additional accident management measures or changes in radiation protection measures for workers on the site that might be needed to perform necessary activities in the event of a severe accident.
— Performing or planning an evaluation of the guidance that is to be used by the operator to manage emergency situations resulting from severe accidents caused by extreme natural phenomena at nuclear power plants, including for low power and shutdown states. These documents include emergency operating procedures to prevent core damage, SAMGs to prevent containment failure, and extensive damage mitigation guidelines to

address accidents that result in fires or explosions that affect a large portion of a nuclear power plant.
— Completing ongoing studies and analyses with regard to the effectiveness of the SAM measures, including organizational aspects and consideration of PSA.
— Developing or updating the SAMGs, in particular for plant shutdown states and accidents taking place in the spent fuel pools.
— Updating rules and regulations with regard to accident management considering risks insights.
— Improvement of the availability of systems and components by protecting existing equipment against external hazards and/or installing new hardware dedicated to coping with severe accident scenarios.
— Improvement or installation of connection points for additional water or electricity supplies.
— Improvement of existing instrumentation or installing new instrumentation, monitoring and communication equipment.
— Analysing measures for hydrogen management and containment venting.
— Reassessment of whether on-site and off-site emergency control rooms, either existing or under construction, consider habitability and accessibility under extreme situations.
— Enhancement of the robustness of containment systems, including implementation of passive systems (e.g. autocatalytic hydrogen recombiners) and modification of the containment design (provisions for filtered venting, provisions to implement containment sealing and to avoid core damage with high pressure scenarios).

6.1.6. Discussions during other international reviews

The following subsections highlight the relevant results in the light of the Fukushima Daiichi accident reviews conducted by various groups or organizations of regulatory bodies and presented in the margins of the Second Extraordinary Meeting of the Contracting Parties to the Convention on Nuclear Safety.

6.1.6.1. CANDU Senior Regulators Group

The CANDU Senior Regulators Group indicated that:

— Enhancements are being developed for the SAMGs to address the credible worst case scenario, including for multi-unit nuclear power plant sites. In some countries, implementation is already under way.

— Improving the robustness of equipment and instrumentation under severe accident conditions, including hardening key I&C and, if necessary, additional instrumentation to support SAM.

6.1.6.2. European Nuclear Safety Regulators Group

The stress tests and their peer reviews provided impetus to accelerate SAM improvements by highlighting the strengths and weaknesses of the different national approaches. Based on the lessons learned, the following recommendations were offered for consideration by regulators:

— PSR should continue to be maintained as a powerful regulatory instrument for the continuous enhancement of defence in depth in general, and the provisions of SAM in particular.
— In response to their previous commitments, regulators should incorporate the WENRA Reference Levels related to SAM into their national legal frameworks, and ensure their implementation as soon as possible.
— Effective implementation of SAM requires that adequate hardware provisions be in place to perform the selected strategies.
— The hardware provisions for maintaining containment integrity should, in particular, include depressurization of the reactor coolant system, prevention of damaging hydrogen explosions and means of addressing long term containment overpressurization, such as filtered venting.
— SAM should take into account all nuclear power plant states, such as full power, low power and shutdown, and include accidents initiated in the spent fuel pools.
— Effective management of severe accidents requires the improvement of communication systems, both internal and external, including the transfer of severe accident related nuclear power plant parameters and radiological data to all emergency and technical support centres and regulatory premises.
— An on-site emergency centre protected against severe natural hazards and radioactive releases, allowing operators to stay on-site to manage a severe accident, is an important component of SAM.
— The availability of the rescue teams and adequate equipment to be quickly brought on-site in order to provide additional support to local operators in the case of a severe situation should be considered.
— A review of SAM hardware provisions should be performed, focusing on the availability and appropriate operation of nuclear power plant equipment in the relevant circumstances, taking account of accident initiating events, in particular extreme external hazards and a potentially harsh working environment.

— The enhancement of SAM provisions should take account of the need to work with a severely damaged infrastructure, in which the usual means of communication and access are disabled, of plant-level, corporate-level and national-level aspects, and of long-duration accidents affecting multiple units at the same time on individual and nearby sites as appropriate.
— The SAMGs should be comprehensively validated, taking due account of the potential long duration of the accident, the degraded nuclear power plant and the surrounding conditions. Pre-planned SAM actions should be designed to function effectively and robustly for suitably lengthy periods following the initiating event. In most cases, durations of at least several days should be assumed for planning and assessment purposes.
— Training and exercises aimed at checking the adequacy of SAM procedures and organizational measures should include testing of extended aspects such as the need for corporate and national level coordinated arrangements and long-duration events.
— Radiation protection of operators and all other staff involved in the SAM and emergency arrangements should be assessed and then ensured by adequate monitoring, guaranteed habitability of the facilities (hardened on-site emergency response facility with radiation protection) needed for accident control, and suitable availability of protective equipment and training.
— Although PSA is an essential tool for screening and prioritizing improvements and for assessing the completeness of SAM implementation, low numerical risk estimates should not be used as the basis for excluding scenarios from consideration of SAM, especially if the consequences are severe.
— When developing SAM action plans, conceptual solutions for post-accident fixing of contamination and the treatment of potentially large volumes of contaminated water should be addressed.

6.1.6.3. Ibero-American Forum of Radiological and Nuclear Regulatory Agencies

Severe accident prevention and mitigation aspects were considered, including situations affecting the core and spent fuel storage pools. All countries of the FORO are implementing the necessary actions considering organizational and technical aspects as well as those regarding procedures, guidelines and suitable training plans.

The equipment needed to maintain containment integrity under severe accident conditions characterized by hydrogen accumulation or overpressurization

was identified, e.g. passive autocatalytic recombiners and containment venting, to which filtration capacity may be eventually incorporated.

The regulatory bodies recognize the importance of tracking and eventually adopting ongoing international developments related to accidents initiated during plant shutdown conditions or those implying risk to the spent fuel stored in pools.

6.1.6.4. International Nuclear Regulators Association

INRA indicated that:

- Enhancement of stationary power supply and mobile backup power sources are needed in the case of SBO;
- There is a need to evaluate the installation of passive hydrogen recombiners and hydrogen igniters, and to consider filtered venting for all reactor containment designs;
- Improved instrumentation is required to ensure accurate monitoring of spent fuel pool conditions;
- The highest priority needs to be given to actions and measures to ensure cooling of the reactors during all types of external event;
- Operators have to acquire off-site resources located at nearby nuclear power plants and to provide adequate training to response forces.

6.2. STRENGTHENING EMERGENCY PREPAREDNESS AND RESPONSE, AND POST-ACCIDENT MANAGEMENT

6.2.1. Lessons learned

As the Fukushima Daiichi accident showed, emergency response needs to be planned with a wide picture of complex disaster scenarios, including those of low probability and combined with naturally occurring events affecting multiple units and the local infrastructure.

The extent of the consequences of the accident brought greater awareness of the difficulties inherent in managing the emergency response and long term recovery. There is a need for re-examining the approach, limits and criteria for long term recovery actions and return to normal phases.

The Fukushima Daiichi accident also highlighted the need for the regulatory body to provide for timely, objective, accurate and understandable dissemination of information to both the general public and the international community.

The regulatory body should review its internal processes and procedures to ensure its ability to effectively implement the assigned responsibilities during and after a complex emergency.

6.2.2. Background

The Fukushima Daiichi accident confirmed that the decision making process in managing a severe accident has a strong impact on the effectiveness of the emergency response. The need to respond to an accident affecting multiple units and spent fuel pools simultaneously and under extreme working conditions proved challenging. Severe accidents caused by external events imposed additional difficulties related to communication that affected the emergency response, as well as the ability of emergency workers to contact their families affected by the external event. Full characterization of the radiological conditions in the wide area around the nuclear power plant is a challenge during a complex accident and in the long term.

Although the role and responsibility of the regulatory body in off-site emergency preparedness and response varies from country to country depending on national legislation, it always plays an important role. The regulatory body's role includes:

— Performing its regulatory function over the emergency arrangements of the licensees and its coordination with off-site emergency arrangements;
— Providing independent technical advice to other governmental and public authorities;
— Providing consistent information to the general public and the international community.

In the light of the Fukushima Daiichi accident, regulatory bodies need to pay attention to several aspects when reviewing on-site emergency arrangements established by the licensee, including:

— The potential severe damage caused by the accident initiator to the site infrastructure and its surroundings, the effect of an accident on multiple units operating at the site, the breakdown of internal and external communication, and the command and control system.
— The operability and habitability of emergency response facilities for managing the on-site emergency response and providing technical support to the control room operating personnel under a range of hazardous conditions including those not considered in the design basis.

— Emergency arrangements, including those for obtaining off-site support and sufficiency of available human and technical resources.
— Ability to provide relevant information to off-site authorities that can be used as a basis for an effective response.
— Scope and frequency of emergency training and exercises based on realistic scenarios. These exercises require the involvement of the relevant stakeholders.
— Instrumentation and radiation monitoring capability in the event of a prolonged loss of electrical power.
— Roles and responsibilities between utility headquarters and the nuclear power plant during the emergency response.
— The identification and forecasting of radioactive releases.

Information provided to the public in an emergency needs to be clear, accurate, consistent, coordinated, timely and authoritative. It is also important that the information be put in perspective in terms of the associated health hazards. The credibility and authority of the regulatory body in this situation is essential.

A more comprehensive discussion regarding emergency preparedness and response is contained in the IAEA Report on Preparedness and Response for a Nuclear or Radiological Emergency in the Light of the Accident at the Fukushima Daiichi Nuclear Power Plant, which is part of the series of IEM reports being published by the IAEA.

6.2.3. Discussions at the International Conference on Effective Nuclear Regulatory Systems

The following are the highlights of the technical presentations, conclusions and recommendations discussed at the conference as they relate to strengthening emergency preparedness and response, and post-accident management:

— Regulatory bodies should facilitate implementation of the IAEA safety standards in emergency preparedness and response to contribute to international harmonization of national policies for emergency management;
— Regulatory bodies should facilitate the preparation and conduct of national exercises, with exercise scenarios to address emergency management at all levels, from the national government to the local authorities;
— Regulatory bodies should consider peer review of the results by an independent appraisal mission (emergency preparedness review) and report results in a transparent manner;

— Regulatory bodies should ensure development of a national communication plan for nuclear and radiological emergencies that is consistent with a national emergency response plan, and is regularly tested and exercised.

6.2.4. Discussions during Integrated Regulatory Review Service missions

During the IRRS missions, there were discussions and reviews of actions taken by regulatory bodies in the light of the Fukushima Daiichi accident, including the following aspects:

— Amending the emergency plan to include a combined emergency of both a large scale natural disaster and a nuclear accident;
— Amending the procedure for providing information to the public, putting health risks into perspective, in the event of a radiation emergency;
— Securing additional protective equipment in preparation for prolonged emergency;
— Allocation of responsibilities between relevant central and local organizations;
— Reinforcing the performance of emergency alarm systems and providing instructions to the public within emergency planning zones;
— Frequency and scope of national emergency exercises;
— Tools and methods for identification and forecast of the release of radioactive materials from a nuclear accident and its effects;
— Evaluating protective measures for residents who live beyond the emergency planning zone.

6.2.5. Discussions at the Second Extraordinary Meeting of the Contracting Parties to the Convention on Nuclear Safety

Among a number of topics discussed by the Contracting Parties at the meeting, was the issue of strengthening regulatory oversight for emergency preparedness and response, and post-accident management. The discussions addressed the following aspects:

— Reviewing and updating national, regional, provincial, municipal and local emergency plans, and conducting exercises to encourage greater coordination among the different organizations;
— Improving radiation monitoring and communications capabilities, and enhancing public communications, such as via dedicated public web sites;
— Upgrading regional, off-site and on-site emergency response centres;

— Updating emergency plans considering scenarios of multiple units on a site, multiple sites and initiating event impacts in more than one country;
— Ability to deal with persons residing abroad from their home country;
— Increasing the scope of drill and exercise programmes to reflect multiple and simultaneous problems affecting external infrastructure, including use of mobile resources (e.g. power, water, compressed air);
— Diversification and redundancy in radiation monitoring and communication systems;
— Difficulties in trans-border processing of goods and services such as container transport;
— Re-examination of the approach/philosophy and associated limits and criteria governing the 'remediation' phase including clarification of criteria for returning to the evacuated area and criteria for returning from an emergency to a normal state;
— Development of plans for recovery and return to normal phases.

6.2.6. Discussions during other international reviews

The following subsections highlight the relevant results in the light of the Fukushima Daiichi accident reviews conducted by various groups or organizations of regulatory bodies and presented in the margins of the Second Extraordinary Meeting of the Contracting Parties to the Convention on Nuclear Safety.

6.2.6.1. European Nuclear Safety Regulators Group

ENSREG indicated that on-site and off-site emergency arrangements are considered important and complementary components of SAM. While on-site arrangements were addressed by the 'stress tests', off-site arrangements remain an issue for potential further consideration. European 'stress tests' did not include off-site emergency preparedness and response, nor post-accident management.

6.2.6.2. Ibero-American Forum of Radiological and Nuclear Regulatory Agencies

The FORO indicated that:

— Different topics were included in the assessments: management and control, decision making, personnel availability (including multi-units plants), site accessibility, fuel damage mitigation, radioactive emission reduction, revision of procedures, communication (internal and external), emergency

lighting, radiological protection (for workers), personnel training and equipment availability.
— The improvements include modifications to the applicable procedures; equipment to be used in emergencies; system modifications; and availability of new facilities and equipment.

6.2.6.3. International Nuclear Regulators Association

INRA indicated that there is a need to reinforce the capability to assess the dose resulting from a severe accident scenario involving several nuclear power plants.

7. CONCLUSIONS

This report summarizes the lessons learned in the area of regulatory effectiveness drawn from the evolving understanding of the Fukushima Daiichi accident and taking into consideration insights gained from the International Conference on Effective Regulatory Systems, held in Ottawa, Canada, 8–12 April 2013, IRRS missions conducted after the accident, the Second Extraordinary Meeting of the Contracting Parties to the Convention on Nuclear Safety, held in August 2012, and results from other national and international reviews, in particular the 'stress tests' organized by ENSREG and countries operating or building nuclear power plants. More information may become available in the future which could lead to additional lessons learned in the area of regulatory effectiveness.

The lessons learned for various areas covered in this report have been summarized as the following conclusions on Strengthening Nuclear Regulatory Effectiveness in the Light of the Accident at the Fukushima Daiichi Nuclear Power Plant:

(1) Although improvements in safety rely primarily on the actions of operators, regulatory oversight will be a driving force. In particular, regulatory bodies should promote continuous safety improvement processes. Regulatory independence, competence, a strong legislative authority and adequate resources are crucial to this process and are to be sustained by governments.
(2) The IRRS plays a key role in supporting the enhancement of the national regulatory framework and regulatory capabilities by identifying areas

that need to be improved, as well as good practices to be shared among regulators.

(3) The establishment of an enduring safety culture remains essential and regulatory bodies should take the necessary actions in this direction. Constant vigilance is paramount to ensuring safety. There is no room for complacency or anything less than a total commitment to safety.

(4) The high level commitment of Member States to peer reviews through, for example, the full participation in the Convention on Nuclear Safety and the hosting of IRRS missions, have to be maintained and enhanced. Countries should pursue and further develop initiatives for sharing information at the international level, including the transparency of results of peer reviews. There should be a frank and open dialogue.

(5) The analyses and actions undertaken by regulators and operators demonstrate an effort to learn from the Fukushima Daiichi accident. These analyses reconfirmed the value of the general approach to safety as reflected in the IAEA safety standards and have identified measures to further strengthen this approach. A more comprehensive regulatory framework in line with the IAEA safety standards, including national regulations, should be encouraged.

(6) The implementation of improvements in the light of the Fukushima Daiichi accident should not detract operators and regulators from the day to day work of ensuring that existing safety requirements are met.

(7) Regulatory bodies should foster an environment that encourages licensees to invest in improvements beyond national requirements. Precautionary safety measures should be taken to protect against multiple failures, even for extremely unlikely accidents with severe consequences.

(8) Regulatory bodies should enhance communication, transparency and sharing of regulatory knowledge and experience among themselves and with interested parties such as industry and the public.

(9) Regulatory bodies should ensure that external hazards, including low probability events with severe consequences, are more comprehensively assessed and that the robustness of the installations, including spent fuel pools, is ensured. This assessment should be periodic and include extreme events, relevant combinations of hazards and uncertainties, as well as evaluation of the associated safety margins.

(10) Regulatory bodies should require the licensees to ensure the high reliability and robustness of electrical power sources/cooling systems, as well as identify and resolve vulnerabilities associated with complex accident scenarios generated by extended complete loss of electrical power from all on-site and off-site power sources.

(11) Regulatory bodies should ensure that adequate SAM provisions and necessary measures are in place, taking into account severely damaged infrastructures caused by extreme external hazards and long-duration accidents affecting multiple units.

(12) Regulatory bodies should require at the site level and encourage at the national level emergency planning with consideration of complex disaster scenarios including those of low probability and combined with naturally occurring events affecting multiple units and the local infrastructure. There is also a need for establishing policy elements in advance for long term remediation and recovery actions.

(13) Regulatory bodies should encourage development of a national communication plan for nuclear and radiological emergencies that is consistent with a national emergency response plan, and is regularly tested and exercised.

Annex A

PRESIDENT'S SUMMARY[1] OF THE INTERNATIONAL CONFERENCE ON EFFECTIVE NUCLEAR REGULATORY SYSTEMS, 8–12 APRIL 2013, OTTAWA, CANADA

T. Varjoranta
President of the Conference

Director General,
Radiation and Nuclear Safety Authority,
Helsinki, Finland

The third International Conference on Effective Nuclear Regulatory Systems, organized in connection with the implementation of the IAEA Action Plan on Nuclear Safety and hosted by the Government of Canada through the Canadian Nuclear Safety Commission, was held in Ottawa, Canada, from 8 to 12 April 2013. The purpose of the conference was to review and assess how experience has been transformed into regulatory improvements since the previous regulatory conference, held in 2009 in Cape Town, South Africa, and since the accident at the Fukushima Daiichi nuclear power plant. The IAEA Action Plan on Nuclear Safety, and national action plans mirroring the IAEA plan, formed an important framework for the conference.

The large number of participants was one indication of regulators' firm commitment to addressing and improving nuclear safety. Substantial efforts and resources have been invested to gain an understanding of what happened, and why, in the Fukushima Daiichi accident. 'Stress tests' having a variety of scopes have been carried out at all nuclear power plants around the world. Key technical areas important to strengthening reactor and spent fuel safety have been addressed. A considerable amount of good professional analysis and work has been done, is under way or is planned.

Learning and sharing lessons is an ongoing process. The conference identified the following six action items as needing to be addressed, implemented and followed up on.

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[1] The opinions expressed in this summary — and any recommendations made — are those of the President of the Conference and do not necessarily represent the views of the IAEA, its Member States or other cooperating organizations.

Action item 1

Peer reviews must include national action plans and follow-up missions to complete the process. Regulators must increase peer pressure on Member States, especially in the next Review Meeting of the Convention on Nuclear Safety, to make use of all aspects of the peer review process. In particular, if Integrated Regulatory Review Service (IRRS) missions have been conducted, the results and the mission report should be made public, as should information on whether a follow-up mission has been agreed upon. The implementation status of IRRS missions (missions planned and carried out, reports published, national action plans published and status of follow-up missions) should be included in the Secretariat's reports to the Board of Governors on the implementation of the IAEA Action Plan on Nuclear Safety.

Action item 2

The main theme of the conference was 'transforming experience into regulatory improvements'.

It was noted that regulatory bodies do not have a systematic way of collecting, analysing and sharing regulatory experience.

Both the regulatory bodies and the operators utilize — to varying degrees — operating experience from nuclear power plants to improve nuclear facility safety on an ongoing basis. Additionally, regulatory bodies perform detailed assessments of regulatory requirements, systems and processes following significant operational events such as those at Three Mile Island, Chernobyl and Fukushima. However, they do not routinely assess less significant events and issues, which would contribute towards continuously improving the regulatory process.

Therefore, the need for a regulatory operating experience programme that is directed towards improving regulations as well as regulatory systems and processes should be evaluated. Guidance needs to be developed on reporting — for example, on the threshold of reportable issues and events. This is an area where the IAEA's help is needed for evaluating and establishing such a system.

WASTE MANAGEMENT AND SPENT FUEL SAFETY

Action item 3

An accident involving spent fuel in pools could have far-reaching consequences. The safety of spent fuel in pools should be reviewed regarding obvious weaknesses in defence in depth and possible new mechanisms to eliminate, as far as possible, the possibility of a serious accident.

EMERGENCY MANAGEMENT

Action item 4

Emphasizing the importance of communication, coordination and consistency in national and international responses to emergencies, regulatory bodies should implement the relevant IAEA safety standards, especially requirements on the development and implementation of predefined generic and operational criteria (such as abnormal facility conditions, observables on the scene and operational intervention levels). Regulators should ensure that national communication plans are developed, tested, implemented and improved well before any accident occurs.

The conference noted that potential long term, off-site consequences have to be taken into account. Since the possibility of a severe accident cannot be ruled out, it is of the utmost importance to be prepared and to establish adequate response strategies (protection of the population; management of contaminated land, goods and food products). The need to promote harmonization of response measures at the regional level was emphasized.

Regulatory bodies should also facilitate the preparation and conduct of national exercises (national ‘stress tests’ of emergency management), utilizing harmonized scenarios developed by the IAEA and engaging stakeholders at all levels. Regulators should report results in a transparent manner.

EMERGING PROGRAMMES

Action item 5

Introducing nuclear power involves a wide range of long term infrastructure issues, including establishment of an effective regulatory system, as well as responsibilities that go beyond national borders. One important example is the

back end of the fuel cycle. The regulatory body must be involved early in the process of long term spent fuel management and establish a safe end point for the spent fuel and/or high level radioactive waste (for example, a repository).

For a successful programme, building and maintaining national and international trust is a must. Since this trust depends, to a large extent, on the effectiveness of the regulatory body, governments must ensure that regulators have proper resources early on. Regulatory bodies should make use of the IAEA peer review process as early as possible, report the results openly and undertake the needed follow-up actions. Countries embarking on a nuclear power programme should join international conventions and report their progress and challenges in a transparent manner. The president's reports of meetings of the Contracting Parties to these conventions should highlight those countries that do not submit reports.

The regulatory body of a vendor country has a responsibility towards the regulatory body of an embarking country, in particular in developing and transferring needed technical skills. As the regulatory body of the vendor country has already made the assessment of the design of the nuclear power plant and technology being sold, it has to lead assistance efforts.

HUMAN AND ORGANIZATIONAL FACTORS, SAFETY AND SECURITY CULTURE

Action item 6

The projected growth in nuclear power combined with the retirement of experts from current programmes will require a growing workforce with the appropriate skills. Many countries face significant challenges in dealing with the expected need for experts. A more consistent, international effort is still needed, in which further IAEA actions would be appreciated by regulatory bodies.

Regulators must promote safety and security culture as a blame free, but accountable, culture. On the one hand, regulators must ensure the creation and maintenance of a reporting environment where staff can speak up when they have identified a risk or made a mistake. It should be a culture that rewards reporting and places a high value on open communication — where risks are openly discussed between managers and staff. It should also be a culture hungry for knowledge.

On the other hand, there must be a well established system of accountability. A blame free culture must recognize that we as humans are fallible. The concept should be one of shared accountability, where good system design and the good behavioural choices of staff together produce good results.

Regulators should report openly and regularly on progress in developing their safety and security culture.

CONCLUSIONS OF THE CONFERENCE

(1) Nuclear safety is better today than it was a year ago. Since the previous conference in Cape Town, and since the Fukushima Daiichi accident, experience in several areas has already been transformed into regulatory improvements. However, gaining experience and understanding it, and learning and sharing lessons are ongoing processes. While much has been done, much remains to be done and will take years.

(2) This President's Summary provides measurable action items aimed at continuing the transformation of experience into regulatory improvements within the framework of the IAEA Action Plan on Nuclear Safety. Regulators are committed to implementing these actions and to following up on progress made.

(3) In view of the value of this regulatory forum, the IAEA is requested to organize another regulatory conference to review the progress made as a result of the findings of this meeting, as well as to discuss and assess possible new regulatory issues.

Annex B

CONTENTS OF THE ATTACHED CD-ROM

RELATED DOCUMENTS

Integrated Regulatory Review Service (IRRS) Guidelines for the Preparation and Conduct of IRRS Missions
IAEA Services Series No. 23
International Atomic Energy Agency (IAEA)

Main Conclusions of the Second Extraordinary Meeting of the Contracting Parties to the Convention on Nuclear Safety: Press Release Statement

Final Summary Report of the Second Extraordinary Meeting of the Contracting Parties to the Convention on Nuclear Safety

INTERNATIONAL CONFERENCE ON EFFECTIVE NUCLEAR REGULATORY SYSTEMS: TRANSFORMING EXPERIENCE INTO REGULATORY IMPROVEMENTS, 8–12 APRIL 2013, OTTAWA, CANADA

PROGRAMME

Programme of the International Conference on Effective Nuclear Regulatory Systems: Transforming Experience into Regulatory Improvements

PRESENTATIONS

Opening Plenary

The IAEA Action Plan on Nuclear Safety — Regulatory Aspects
D. Flory
Deputy Director General and Head of the Department of Nuclear Safety and Security, International Atomic Energy Agency (IAEA)

Session 1

Steps to Improve Nuclear Safety Regulation in the Russian Federation: From Fukushima to the Future
V. Bezzubtsev
Federal Environmental, Industrial and Nuclear Supervision Service, RUSSIAN FEDERATION

Nuclear Safety Regulatory Actions of China after Fukushima Nuclear Accident
W. Hou
National Nuclear Safety Administration, CHINA

Immediate Actions and Safety Review in Germany
H. Klonk and K. Weidenbrück
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, GERMANY

Lessons from Fukushima — Response and Changes to Regulatory Framework and System
K. Oshima
Nuclear Regulation Authority, JAPAN

Regulatory Response and Changes to Regulatory Framework Arising from the Lessons Learned from the Fukushima Accident
P. Jamet
French Nuclear Safety Authority (ASN), FRANCE

Regulatory Actions and Follow-up Measures against Fukushima Accident in Korea
S.H. Song
Korea Institute of Nuclear Safety, REPUBLIC OF KOREA

INSAG Perspective on the International Experts' Meetings to Support the IAEA Action Plan
R. Meserve
Carnegie Institution for Science, USA, and Chairman of the International Nuclear Safety Group (INSAG)

Session 2

Licensing of the Spent Fuel Disposal Facility in Finland
R. Paltemaa, T. Varjoranta and J. Heinonen
Radiation and Nuclear Safety Authority, FINLAND

Role of the Regulatory Authority in Developing the Radioactive Waste Management System and Interim Storage Facility in Sudan from 1996 to 2012
O.E.A. Osman
Sudanese Nuclear and Radiological Regulatory Authority, SUDAN

Regulatory Challenges in the Licensing of a Spent Nuclear Fuel Repository in Sweden
J. Anderberg
Swedish Radiation Safety Authority, SWEDEN

Canadian Nuclear Safety Commission (CNSC) Early Role in the Adaptive Phase Management Project
D. Howard
Canadian Nuclear Safety Commission, CANADA

WENRA: Harmonisation of Safety Requirements by Self-commitment, Mutual Benchmarking and Control
H. Wanner
Western European Nuclear Regulators Association (WENRA)

EU Technical Assistance for Nuclear Safety through the Instrument for Nuclear Safety Cooperation
Y. Stockmann, B. Batandjieva-Metcalf, M. Hulsmans,
H. Pauwels, K. Robin and P. Daures
European Commission, Joint Research Centre (EC/JRC)

Panel Presentation

Highlights From the Work of the NEA on Impacts of the Fukushima Accident
J. Reig
Nuclear Safety Division, OECD/NEA

Session 3

IAEA Safety Standards and Guidelines for Preparedness and Response to Nuclear and Radiological Emergencies
E. Buglova
Incident and Emergency Centre, International Atomic Energy Agency (IAEA)

Radiation Protection Issues: Challenges for Communication, Coordination and Consistency in the Response to Emergencies
A. González
Nuclear Regulatory Authority (ARN), ARGENTINA

Emergency Communication: Keys for an Effective Communication
R. Velasco
Nuclear Safety Council (CSN), SPAIN

A New Emergency Response Scheme Based on Lessons Learned from the Fukushima Daiichi NPP Accident
T. Homma
Japan Atomic Energy Agency, JAPAN

The French CODIRPA Approach — Policy Elements for Post-accident Management in the Event of a Nuclear Accident
J.C. Niel
French Nuclear Safety Authority (ASN), FRANCE

Challenges in Integrating Local Authorities and First Responders in National Emergency Management Programs
M. Purdy
Margaret Purdy Consulting Inc., CANADA

Session 4

Strengthening the Regulatory Infrastructure in Countries Embarking in Nuclear Power Programmes
A. Nicic
International Atomic Energy Agency (IAEA)

An IAEA Perspective on the Current Radiation Safety Status of Member States That Have Expressed Interest in Embarking in a Nuclear Power Programme
A. Al-Khatibeh
International Atomic Energy Agency (IAEA)

RCF Support in Development of the Vietnam Nuclear Regulator
Le Chi Dung
Vietnam Agency for Radiation and Nuclear Safety, VIETNAM

Establishing the Independent, Effective Regulatory Authority in the United Arab Emirates
I. Grant
Federal Authority for Nuclear Regulation, UNITED ARAB EMIRATES

Interfaces of Nuclear Safety, Security and Safeguards in Malaysia
R. Adnan and M. Kostor
Department of the Atomic Energy Licensing Board, MALAYSIA

Early Integration of Nuclear Safety and Security and Safeguards
A. Simo
National Radiation Protection Agency of Cameroon, CAMEROON, and Chairman, Forum of Nuclear Regulatory Bodies in Africa (FNRBA)

Nuclear Security Infrastructure for a Nuclear Power Programme: Emerging Countries
R. Evans
International Atomic Energy Agency (IAEA)

Panel Presentation

Regulatory Cooperation Forum
R. Gibbs
International Atomic Energy Agency (IAEA)

Session 5

Human and Organizational Factors, Safety and Security Culture
Y.W. Park
Korea Institute of Nuclear Safety, REPUBLIC OF KOREA

Regulation of Human and Organizational Factors in Canada: Recent experiences with a Safety Culture Discussion Paper
K. Heppell-Masys
Canadian Nuclear Safety Commission, CANADA

Human and Organizational Factors (HOF) in Nuclear Safety — ASN's Point of View and Oversights
T. Houdré
French Nuclear Safety Authority (ASN), FRANCE

Safety and Security Culture within the Regulatory Body
M.A. Habib
Pakistan Nuclear Regulatory Authority, PAKISTAN

Nuclear Safety Culture: The US NRC Experience
B. Borchardt
US Nuclear Regulatory Commission, USA

Why Regulators Must Set Professional Competency Standards for Nuclear Security Management
R. Howsley and M. Beaudette
World Institute for Nuclear Security (WINS) and Canadian Nuclear Safety Commission, CANADA

Regulatory Oversight of the Licensee — The Finnish Experience
P. Tiippana
Radiation and Nuclear Safety Authority, FINLAND

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Crossroads: Where People, Technology and Organizations Meet
J. Lyons
International Atomic Energy Agency (IAEA)

Safety Culture and Emergency Response
J. Maddox
Institute of Nuclear Power Operations (INPO)

SECOND EXTRAORDINARY MEETING OF THE CONTRACTING PARTIES TO THE CONVENTION ON NUCLEAR SAFETY, 27–31 AUGUST 2012, VIENNA, AUSTRIA

PRESENTATIONS

Commonalities of Post Fukushima Dai-ichi Safety Reviews: Contribution of the International Nuclear Regulators Association — INRA
A. Lacoste
International Nuclear Regulators Association (INRA)

Assessment of the Stress Tests Performed to the NPPs Belonging to the FORO Member Countries.
C. Martinez Ten and V. Gonzalez
Ibero-American Forum of Radiological and Nuclear Regulatory Agencies (FORO)

European Stress Tests Part 2: WENRA and Follow-up
H. Wanner
Western European Nuclear Regulators Association (WENRA)

WANO Members' Mobilization to Reinforce Nuclear Safety Worldwide
L. Stricker
World Association of Nuclear Operators (WANO)

The European Stress Tests, Peer Review and Follow-up Actions of ENSREG and WENRA
P. Jamet
European Nuclear Safety Regulators Group (ENSREG)

Implementation of Lessons Learned from Fukushima Accident in CANDU Technology
R. Jammal
CANDU Senior Regulators Group

Perspectives on the Further Safety Enhancement of the NPPs with WWER Reactors in Response to Fukushima Daiichi Accident
S. Sholomitsky
Forum of the State Nuclear Safety Authorities of the Countries Operating WWER-type Reactors

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