

**PRESIDENT’S REPORT FOR THE INTERNATIONAL CONFERENCE
ON A DECADE OF PROGRESS AFTER FUKUSHIMA DAIICHI:
BUILDING ON LESSONS LEARNED TO FURTHER STRENGTHEN
NUCLEAR SAFETY
8-12 NOVEMBER 2021**

EXECUTIVE SUMMARY

This report provides a summary of this important, timely and seminal conference hosted by the IAEA in cooperation with:

- The Food and Agriculture Organization of the United Nations (FAO) International Labour Organization (ILO);
- The Organisation for Economic Co-operation and Development/ Nuclear Energy Agency (OECD/NEA);
- The Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO);
- The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR);
- World Health Organization (WHO); and
- The World Meteorological Organization (WMO).

This report provides the background to the conference, its objectives, its structure, the conclusions and findings of the various sessions, and most importantly the President’s “Call for Action” that was the principal output of the Conference.

It was suggested that a mechanism needed to be put in place to ensure that the Actions identified were taken forward and addressed adequately. The President in his closing remarks proposed that one possible way to address this would be via a suitable side event each year at the IAEA General Conference. Providing the President’s “Call for Action” to other fora, such as the meeting of the parties to the Convention of Nuclear Safety and IAEA review committees could also assist in its delivery.

The President’s Call for Action

During the conference international experts recalled lessons learned, experiences shared, results, and achievements from actions undertaken by national, regional, and international communities following the Fukushima Daiichi nuclear power plant accident. Furthermore, they tried to identify initiatives for further strengthening nuclear safety in the context of the wider use of nuclear power to help combat climate change.

An important outcome of the conference was, based on lessons learned from the Fukushima Daiichi nuclear power plant accident and recognizing the global trends, a proposal of priorities for stakeholders regarding safe operation of nuclear power for the next decades. This specific outcome is the “President’s Call for Action”.

Nuclear power remains an important element of the global electricity production. Therefore, the overarching goal is: ***Safe nuclear power for all as part of the solution to climate change.***

The aim of the “President’s Call for Action” is to highlight that safe **nuclear power exists in a broader context** and that now is the time to plan for the next 10 years. Apart from technical matters, human, organizational and societal matters are equally important; and, the matters of public trust, climate

change, and the involvement of future generations, must form a large part of any global development and success.

The President's Call for Action falls into four areas:

- 1) Enhance Openness
- 2) Embed Lessons from Fukushima Daiichi nuclear power plant accident
- 3) Better Prepare for the Wider Use of Nuclear Power
- 4) Transfer of Knowledge for the Future

To Enhance Openness:

- Summarize all the experience and work in response to the accident, as a foundation for the demonstration of the international institutions working together, as well as lessons learned globally and improvements made over the last ten years; and, as a basis for more effective working together in the future.
- Enable better understanding of the balance of radiological and non-radiological impacts through enhanced guidance on the justification and optimization of protective actions for decision makers. The guidance needs to be open and understandable to all stakeholders, including the public.
- Review the present system of radiation protection with regard to the inference of risks at low doses and the use of dose criteria when there are different balances to be made, to help facilitate better public understanding of the basis for decision making.
- Extend practical guidance in support of decision making on balancing risks associated with ionizing radiation versus other risks or benefits/detriments in policy, design, operations, decommissioning and waste management, providing examples for different circumstances.
- Promote and use relevant research findings on risk perception and human behaviour to develop further communication tools and guidance to help earn the trust of the public and stakeholders in the context of a global strategy.
- To foster the above-mentioned research and considering human behaviour in relation to radiation risks in communication tools and advice, so that policymakers and the public can make effective decisions during and after an accident.
- Reach out to the younger generations especially leveraging such tools as the internet and social media for clear and concise communications that simplify technical concepts through analogies and illustrations to generate interest, understanding and earn trust.

To Embed Lessons from Fukushima Daiichi nuclear power plant accident:

- Encourage Member States to timely implement any remaining safety improvements at existing nuclear power plants resulting from lessons from the Fukushima Daiichi nuclear power plant accident.
- Member States, vendors, licensees, regulators to ensure that new reactor technologies take into account lessons from the Fukushima Daiichi nuclear power plant accident by taking into consideration the IAEA safety standards.
- Relevant organizations to undertake a review to determine whether a more comprehensive view of public health consequences from an accident requires changes to guidelines for decision-makers on protective actions following an accident. Criteria for the emergency phase and for the actions in the recovery phase need to be considered.

- Provide for the implementation of the UNSCEAR report on attribution of health effects and inference of risks by developing best practices and guidance for their application in radiation and nuclear safety, to provide better understanding on radiation effects and to avoid misconceptions among those responsible for making decisions on protective measures and members of the public.
- The IAEA Member States and relevant organisations to develop and promote strategies and share experiences of applying a systemic approach to safety related decisions, considering organizations, people, and technology, and their interactions to build robust safety systems.

To Better Prepare for the Wider Use of Nuclear Power:

- The IAEA to undertake a review and propose enhancements, as necessary, of the global system for nuclear safety (national frameworks, technical support capabilities, international cooperation), taking into account the potential for wider use of nuclear power in the future.
- Member States that are considering embarking on or expanding their capability in nuclear power should review their existing systems for nuclear safety.
- Develop strategies and build cooperation networks among reactor designers and operators to strengthen design and operational safety for preventing severe accidents and mitigating their consequences to avoid unacceptable radioactive releases, taking into account methods to determine how safe is safe enough using techniques such as cost-benefit analysis.
- Relevant international organizations to continue and bring to a conclusion the work on unified/harmonized standards and guidelines for levels of radionuclides in commodities (food and others) that are based on risk.
- Member States to include generic planning for recovery and arrangements for recovery after an accident, and establish the division of responsibilities between different parties in an emergency in the consultation process preceding the authorization of new facilities.
- The IAEA, NEA and Member States to elaborate the concept of “Culture for Safety” taking into consideration national factors.
- Member States to consider a national approach for the implementation of a robust culture for safety at all levels from staff to policy makers.
- Develop further guidance on promoting and implementing leadership approaches to guard against complacency, continuously seeking innovation and improving nuclear safety.
- Member States to ensure emergency management systems are established under an “all hazards” model, optimizing resources and integrating various functions, to enable a holistic approach to responding to different hazards at the same time.

To Transfer Knowledge for the Future:

- The IAEA to enhance facilitation of the implementation of knowledge transfer strategies to countries embarking on nuclear power programmes.
- The IAEA to consolidate the international experience of recovery from accidents and review their impact in order to take better based decisions on emergency planning and recovery.
- Ensure the systematic application of knowledge management to the decommissioning and recovery from the Fukushima Daiichi nuclear power accident to facilitate decommissioning of redundant nuclear sites and be better prepared to respond to and recover from any potential nuclear accident.

- The IAEA and Member States to increase capacity and facilitate capability building to ensure the availability of regulatory and technical competence for the safety of new nuclear facilities.
- The IAEA to establish a sustainable and open forum for sharing and promoting best practices in the remediation and decommissioning of nuclear facilities.
- The IAEA and Member States to promote and facilitate the scientific understanding of ionizing radiation and the peaceful use of nuclear energy in general education programmes for the youth of tomorrow to inform future generations and encourage them to pursue careers in the sector.

INTRODUCTION

Background

The IAEA's Incident and Emergency Centre received information from the International Seismic Safety Centre at approximately 08:15 CET the morning of 11 March 2011 concerning an earthquake of magnitude 9 near the east coast of Honshu, Japan. A massive tsunami ensued that inundated coastal areas of the east coast of Japan. Tragically, nearly 20,000 people lost their lives or went missing.

The earthquake and tsunami impacted on several nuclear power plant sites in the area, principally at the Fukushima Daiichi site that lost essentially all off-site and on-site power, leading to station blackout and loss of ultimate heat sink. Despite the intensive efforts of the operators over the next few days there were substantial releases of radioactive materials off-site from the combined impact of hydrogen explosions and core meltdowns. At its peak, approximately 165,000 residents in Fukushima Prefecture were evacuated due to the nuclear accident. Although the estimates of dose are such that future radiation-associated health effects are unlikely to be discernible, about 3,500 deaths have been attributed to the impact of the evacuation.

Japan succeeded in getting the damaged reactors under control, and over the last ten years has been undertaking immense efforts to make the Fukushima Daiichi site safer, decommission it, and decontaminate and restore the surrounding area.

The international community and organizations have sought to help the Japanese in their efforts, learn lessons and improve nuclear safety globally. This has been greatly helped by the openness and the transparency of Japan and the collaborative efforts of all involved.

As a significant part of these global efforts the IAEA has sent multiple official missions to Japan, starting with an international expert Fact Finding mission in May/June 2011, and held many international meetings and conferences. The Fact-Finding mission fed into an IAEA Action Plan, which was endorsed by Member States in September 2011 that defined a programme of work to strengthen the global nuclear safety framework in response to the accident. The plan outlined actions to strengthen safety in 12 areas: safety assessment of nuclear power plants; IAEA peer reviews; emergency preparedness and response; national regulatory bodies; operating organizations; IAEA safety standards; the international legal framework; Member States planning to embark on a nuclear power programme; capacity building; protection of people and the environment from ionizing radiation; communication and information dissemination; and research and development.

The Action Plan and other reviews stimulated Member States to introduce measures to enhance nuclear safety, including those taken in response to the results of “Stress Test” assessments of nuclear power plants' vulnerability to extreme external events.

The IAEA's work under the Action Plan included strengthening relevant safety standards and peer review services and enhancing efforts to assist Member States in building capacity for safety. The Agency also held nine meetings of international experts that analysed technical aspects of the accident so that lessons could be learned. In addition, the IAEA conducted 15 international expert missions to

Japan and published the reports.

Work to implement the Action Plan went on to form part of the Fukushima Daiichi Accident Report by the Director General and its five accompanying Technical Volumes. These reports, released at the 2015 IAEA General Conference, addressed the accident's causes and consequences and aimed to provide a comprehensive understanding of what happened and why. Five working groups with approximately 180 experts from 42 Member States and several international bodies collaborated on the report.

In addition to the Action Plan, a lot of work has been conducted worldwide to strengthen nuclear safety. Many parties across the globe demonstrated their commitment to enhance nuclear safety. Through initiatives such as the Action Plan, the European Stress Tests, the adoption of the Vienna Declaration on Nuclear Safety in accordance with the objectives of the Convention on Nuclear Safety, as well as the multitude of national and regional initiatives, many safety improvements have been developed and implemented.

Given all these initiatives and the increasing concerns about how to address the global climate change crisis, now is the time, some 10 years after the Fukushima Daiichi nuclear power plant accident, to demonstrate to the world that lessons have been learned, built on international cooperation, that provide a robust foundation for the wider use of safe nuclear power while seeking practical ways to enhance nuclear safety even further. Then safe nuclear power can fulfil its potential to assist the world in successfully addressing the global climate change crisis.

Objectives

The conference focused on two main objectives:

- Looking back on the lessons learned, experiences shared, results, and achievements from actions undertaken by national, regional, and international communities following the accident;
- Identifying ways for further strengthening nuclear safety as part of the answer to maximizing the beneficial peaceful use of nuclear energy.

The Conference gathered internationally recognized high-level experts in safety and other leaders to discuss initiatives taken in the aftermath of the accident, and initiatives for further strengthening nuclear safety, together with other aspects relevant to achieving the overall goal of helping to address the climate change crisis. Vital to this goal was the development of a President's action plan based on the conference.

Programme Structure

To achieve these objectives the conference was based on a different structure to that normally used for such events. It was developed using technical sessions augmented by dynamic narrative panels and consisted of three main parts, after an Opening Session and Keynote Speakers that set the context for the Conference. The three main parts were:

- Part I - International Perspective;
- Part II - Learning Lessons;
- Part III - Path Forward.

Part I provided insights from various international organizations from their work in response to the accident, reflecting on their work, thinking about the future and demonstrating the global safety of nuclear energy and its robustness through its international institutions and systems.

Part II involved high-level policy and technical sessions on the overall themes central to the Conference, and covered topics such as:

- Ensuring the safe generation of nuclear power;
- Emergency preparedness and response;
- Radiation safety;
- Post-accident recovery;
- International cooperation;
- Leadership and management for safety;
- Communication and trust building;
- International legal instruments for safety;
- Facing new challenges;
- Safety for nuclear power development.

Each technical session consisted of an opening of the session by the Chairperson(s), presentations by each panellist, and questions by participants and answers by the panellists. Again, this part was aimed at demonstrating the improvements made in nuclear safety but from a more technical and themed approach.

Part III, The Path Forward, sought to identify actions to further enhance nuclear and radiation safety, considering crosscutting strategic considerations and global challenges. It consisted mainly of dynamic panel discussions among leaders and experts from a variety of different perspectives.

The last panel of this part discussed the insights offered by speakers during the week, and conclusions and recommendations from the earlier sessions to identify and propose future actions that would be most beneficial in maintaining momentum.

In a closing session the President of the Conference presented the summary and conclusions of the conference, including visions and strategies for the future, and most importantly called for action.

In addition to these main parts of the Conference, there were three special sessions covering topical subjects, viz:

- Nuclear safeguards at Fukushima Daiichi site;
- Safety related aspects of ALPS treated waters after the accident; and vital to the future;
- Youth and the nuclear industry.

Appendix A provides a copy of the programme of the Conference.

OPENING SESSION

Opening Remarks

R.M. Grossi welcomed participants, noting that nuclear safety always comes first, and nuclear energy must form part of the mix to combat climate change. This conference was one way to demonstrate that as a global community we have taken stock, learned the lessons of Fukushima Daiichi nuclear power plant accident and applied them. However, we are also looking forward, continuously improving and learning, never complacent, innovating and adapting to meet the challenges of the future. We need to communicate all of this clearly and with transparency so that governments and the public can trust that nuclear energy is safe and make informed decisions about its use in a de-carbonized world.

T. Hikihara expressed sincere appreciation for the conference and noted the substantial improvements in nuclear safety over the past 10 years. He briefly explained Japan's efforts to date and their plans going forward, including sweeping reforms so that the Fukushima Daiichi nuclear power plant accident will never happen again.

These include:

- Ongoing decommissioning of the Fukushima Daiichi site;
- Sharing information with other States and CNS signatories;
- Actions for environmental recovery of the area;
- Continuing efforts to enhance Japan's nuclear safety;
- Working with the IAEA and cooperating with the international community, including training at Fukushima Daiichi site for newcomer countries.

M. Weightman welcomed participants to the conference and gave an overview of the programme. He expressed his hope that by demonstrating that the nuclear industry has learned the lessons from the Fukushima Daiichi nuclear power plant accident, has made real progress over the last ten years and is continuously improving nuclear safety, with more plans for the future, we can show that safe nuclear power can be an important part of the solution to the climate change crisis, providing clean energy for all.

G. Caruso noted that over 700 people were attending the conference whether virtually or in person. He emphasized the importance of open and transparent discussion and the need to hear the views of all participants. The message of the conference is that nuclear safety has a role to play at all levels and nuclear energy is of vital importance to the future.

Keynotes

L. Evrard noted that international cooperation is essential, as nuclear safety is a national responsibility, but accidents affect us all globally. We need to learn in a holistic manner over many dimensions, as demonstrated by the conference programme. Cumulative experience is invaluable and experiences from more mature nuclear countries can be lessons to newcomers. She outlined the IAEA's support for Member States and reiterated that we must continuously identify ways to further improve nuclear safety. This conference would assist in that regard, shaping IAEA activities for the next decade.

H. Yamana gave an overview from his experience on how to avoid nuclear accidents, grounded in the status of Fukushima Daiichi nuclear power plant post-accident. He noted six areas where lessons were learned:

- Institutional issues, such as safety culture and regulatory independence;
- Technological issues, with defence in depth and diversity of safety systems being key elements;
- Evacuation considerations and the need to pay more attention to its psychological and social effects;
- Accident management and Emergency Preparedness and Response, with staff capability and collaboration with government key to dealing with an emergency;
- Social and environmental recovery, including compensation for survivors and damage; and the challenge of restoring a contaminated environment;
- Decommissioning of the site with emphasis on the importance of stakeholder involvement in the final solution to decommissioning, and the consideration of the serious reputational damage caused by the accident – the impacts are global and regaining the public's trust is a huge challenge.

He encouraged participants to work together to establish better and safer systems for nuclear safety moving forward with the lessons learned from Fukushima Daiichi nuclear power plant accident.

PART I – INTERNATIONAL ORGANIZATION PERSPECTIVE

Session A – Contribution of International Organizations to Global Safety

Speakers in this session noted the activities of their various organizations after the Fukushima Daiichi nuclear power plant accident, with several cross-cutting themes/lessons becoming evident:

W. Magwood of OECD/NEA noted that:

- The NEA issued a report shortly after the accident that stated that nuclear power plants are safe, but they need to be made more resilient to very extreme threats.
- Safety culture is key to success. The NEA reported five years ago on changes implemented globally; training, equipment and procedures have all changed in nuclear power plants.
- The removal of the damaged core at Fukushima Daiichi nuclear power plant is a huge challenge and the international community must help.
- Important lessons learned included:
 - The ability to recover is as important as avoidance;
 - Safety culture is as important as technical expertise;
 - Improving regulatory authority, recognizing the health aspects, and seizing the opportunity for economic development are important in recovering from a nuclear accident.
- Public and stakeholder engagement is crucial. Nuclear power is essential to the future, to the environment, the economy and civilization, however nuclear power cannot play a strong role if the public does not believe it is safe. Advanced technologies can help such as SMRs, but the public must be part of the discussion.

I. Engkvist of WANO noted that:

- While operators are responsible for safety, regulators, governments and organizations contribute to safety and all need to work together.
- All aspects of operating NPPs have been strengthened in the past 10 years. Institutions have been strengthened and operators are humbler and wiser, leading to even safer nuclear power plants.
- There are programmes and processes in place to identify operational weaknesses to maximize safety.
- Leadership is key and efforts are being made in this area as well.
- WANO recognizes the value of nuclear energy as a reliable, safe and economically viable source of power. The business and political pressures, geographic challenges for global cooperation and collaboration are unique to this industry but we can be safe and productive in the future.

G. Caruso gave the IAEA perspective on the accident, with an overview of the actions taken at the time and over the past 10 years, including:

- Development and implementation of the IAEA Action Plan on Nuclear Safety;
- Numerous international meetings and documents on analysis and lessons learned from the accident, concurrent with IAEA support to Member States to enhance nuclear safety in peer reviews and advisory missions;
- The review of the IAEA safety standards to incorporate findings from the Fukushima Daiichi nuclear power plant accident.

Going forward, the IAEA has also been requested to oversee the discharge of ALPS treated water into the sea and continues to provide support to Fukushima Prefecture.

G. Hirth of UNSCEAR presented information on the UNSCEAR 2020 report¹ on Fukushima. She noted that overall, the findings of the UNSCEAR 2020 Report are generally consistent with those in the 2013 Report but there is now more information available to support the Committee's conclusions, which are:

- The accident led to no adverse documented public health effects that were directly attributable to radiation exposure from the accident;
- Future cancer rates that could be inferred from radiation exposure from this accident are unlikely to be discernible;
- Increased incidence of thyroid cancer observed in children in Japan was judged to be the result of extensive ultra-sensitive screening.

Lessons learned included:

- The importance of gathering quality measurement data taken as soon as possible during and after an accident;
- The need to understand the base rate of cancer and to follow up with estimates due to radiation effects;
- The need to continue high quality research and base information on science.

G. Graham of CTBTO presented an overview of key achievements in the CTBTO radionuclide monitoring technology over the last decade, in terms of additional station certification and novel software tools for data analysis and dissemination, including:

- In March 2012, the CTBTO became a member of the Inter-Agency Committee on Radiological and Nuclear Emergencies (IACRNE). Further civil applications for disaster risk reduction have been proposed.
- According to the Joint Radiation Emergency Management Plan, the critical response tasks of the CTBTO during an emergency phase is to provide real-time particulate and noble gas monitoring data including confirmation of no detection.

He noted the unique capability of ICP to help in looking at the consequences of nuclear accidents, and that the accident changed the way analysis is done.

C. Blackburn and G. Dercon of the Joint FAO/IAEA Centre of Nuclear Technologies in Food and Agriculture gave a presentation of activities in their area from the lessons learned covering:

- Improved international standards and guidance for radionuclides in food and agriculture;
- Targeted technical aids for use by agricultural departments in general;
- Coordinated international research activities to improve and extend remedial options for agricultural land in less well studied agricultural domains.

J. Pintado Nunes of ILO outlined some of the ILO's work on occupational safety and health (OSH) and radiation protection since the Fukushima Daiichi nuclear power plant accident including:

- The declaration of OSH as fundamental to decent work in the ILO Centenary Declaration 2019, with a resolution requesting study of the options for it to be incorporated as a possible fifth category of ILO Principles and Fundamental Rights at Work.
- The ILO's Global Call to Action for human-centered recovery from Covid-19.

¹ <https://www.unscear.org/unscear/en/fukushima.html>

- The ILO’s international legal framework including Convention 115, 1960 concerning all activities where workers may be exposed to ionizing radiation, with 50 ratifications, and Recommendation 114, that specifically concerns the protection of workers against ionizing radiation. Member States must report periodically on their adherence to the Conventions.
- Observations on Convention 115 in 2015 noted the need for Emergency Preparedness and Response plans that optimized protection strategies with reference levels in emergencies within or preferably below the range of 20–100 mSv, with measures taken to ensure emergency workers are not subject to more than 50 mSv.
- Development and promotion of a training package for IAEA Safety Guide GSG-7 on Occupational Radiation Protection.
- International cooperation in the work of several platforms with the IAEA, OECD/NEA, Inter-Agency Committees and UNSCEAR on occupational radiation protection.

L.P. Riishojgaard presented on the capacity of the WMO to assist in nuclear accidents, noting that:

- They have specialized stations for monitoring radioactive emissions in the atmosphere to respond to nuclear emergencies.
- They now cover all environmental data, including climate, hydrology, oceans, etc.
- In October 2021 they updated their policies and vehicles to finance data sharing, particularly with developing countries.
- The objective is uniform coverage both surface and satellite with a global data processing and forecasting system for a global modelling network that makes products and services available to countries and organizations such as the IAEA.

M. Neira of the WHO stated that:

- The Fukushima Daiichi nuclear power plant accident transformed the local, national and global response to nuclear accidents.
- International health regulations for managing health emergencies require coordination and cooperation, so that roles are complementary, and duplication is avoided.
- Non-radiological aspects can have terrible effects, with the social fabric destroyed and people deprived of privacy and access to health care. The mental health and psychosocial and health determinants should be taken into account in preventative measures, as they can last for decades.
- There is a need to invest in environmental and ecological protection and planning for the future.

PART II – LEARNING LESSONS

Findings from the Fukushima Daiichi nuclear power plant accident have shown that a drive towards continuous safety improvement leaves no place for complacency. Technical, organizational, and regulatory measures taken to enhance safety further reduce the likelihood of occurrence of accidents with significant radioactive releases. On the other hand, the assumption is that such an accident might still occur, the nuclear industry and regulatory bodies need to be prepared for the unexpected.

Session B – Ensuring the Safety of Nuclear Installations

The Fukushima Daiichi nuclear power plant accident emphasized the importance of continuously challenging the existing assumptions regarding nuclear safety to prevent future accidents. Countries reviewed and reinforced, as necessary, the capability of nuclear installations to withstand or control possible accidents originating from extreme conditions and/or extreme external events to minimize risk. The IAEA and the Member States reviewed and revised their safety frameworks, including updates to

the IAEA safety standards, to enhance nuclear safety at the national level and worldwide.

During the session, speakers summarized the lessons and associated actions from the accident and highlighted the different approaches and decisions that were taken to enhance nuclear safety and face emerging challenges.

The opening to this session consisted of a series of speakers followed by a high-level discussion of measures to ensure safety. It was followed by a specialist panel discussion on minimizing the possibility of serious off-site releases.

K. Watanabe looked back at 10 years of change and improvements in Japan in light of the lessons learned from the Fukushima Daiichi nuclear power plant accident, including:

- Reform of the regulatory system, both the regulator and the regulations;
- Establishment of the NRA as an independent body, with the separation of regulation and promotion;
- New regulations on severe accidents that add more measures against severe external events with enhanced safety margins for tsunamis and earthquakes;
- An environment that encourages responsibility, open and frank discussion, a questioning and learning attitude and continuous improvement.

He noted that no one died from exposure to radiation, but many thousands remain evacuated and work to decommission and decontaminate is still ongoing.

F. Aparkin provided an overview of the Russian developments for nuclear power covering:

- NPP safety assessments in light of the lessons learned from the accident at the Fukushima Daiichi nuclear power plant;
- Building a strengthened safety concept for nuclear power plants with new generation VVER reactors, taking into account national experience and lessons learned from the accident at the Fukushima Daiichi nuclear power plant;
- Building a safety concept for prospective nuclear power plants using the examples of land-based nuclear power plants and floating nuclear power units, taking into account national experience and lessons learned from the accident at the Fukushima Daiichi nuclear power plant; and
- The review and update of the safety standards in the light of the developments in nuclear energy.

P. Tippa reported on changes at STUK in the area of safety culture as a result of the Fukushima Daiichi nuclear power plant accident. STUK developed a safety culture assessment programme in response to Japan's acknowledgement of the influence of culture on the disaster. He noted the following findings:

- Organizational culture has an effect on nuclear safety. We need to pay attention to the effect of various levels of culture, including national culture, on safety culture.
- Survey results revealed that the Finnish system generally supports a good, healthy, safety culture. However, they did find that the same cultural attributes, on their own or in their composition can have both positive and negative impacts on safety. STUK is incorporating these findings into its operations.
- Regulatory oversight culture has an impact on the operators' safety culture.
- Societal expectations change; they can focus on confirming compliance with regulations or on client driven safety performance.

A. Pelle offered a review of changes made at EDF as a result of the accident, noting that they do not define reactor life. Previously they had 10-year inspections with a compliance review. After the Fukushima Daiichi nuclear power plant accident, they implemented the following measures to increase the robustness of nuclear power plants:

- Safety improvements for station blackout and external hazards, constructing new equipment on each reactor and making major improvements to crisis organization and training;
- The creation of the Nuclear Rapid Action Force (known by the French acronym FARN), a response task force with the objective to access all sites within 12 hours and be operational within 24 hours;
- Increased site autonomy to three days with changes to primary circuit supply, reactor buildings, fuel buildings, spent fuel pools and mitigation of core meltdown in severe accidents;
- Improved core meltdown prevention.

There has been a paradigm shift from preparing for specific hazards to preparing for all hazards after the Fukushima Daiichi nuclear power plant accident, with accompanying changes in safety culture, operations and regulatory oversight. The Q&A discussion highlighted the following:

- The need for a strong safety culture to maintain public trust in decision making;
- The need to employ a systemic institutional approach in every decision to ensure safety at different lifetime stages of nuclear power plants;
- The need to consider the issue of “how safe is safe enough?” and accident preparedness vs. prevention.

Panel 1 – Minimizing the Possibility of Serious Off-Site Radioactive Releases

Findings from the Fukushima Daiichi nuclear power plant accident have shown that a drive towards continuous safety improvement leaves no place for complacency. Technical, organizational and regulatory measures taken to enhance safety further reduce the likelihood of occurrence of accidents with serious radioactive releases. On the other hand, as such an accident might still occur, the nuclear industry and regulatory bodies need to be prepared for the unexpected.

The panel discussed measures that can be taken to ensure that serious accidents are very unlikely and to highlight actions to ensure that serious off-site radioactive releases will be avoided or minimized, in line with the principles of the Vienna Declaration. This included specific examples from different countries explaining the ‘why’ as well as the ‘what.’ The most significant changes noted were:

- An updated approach to safety analysis and hazard assessment programmes;
- Examining “black swan”² events and giving operators the resources to deal with them;
- Changing the regulatory mindset, realizing that a lot of what used to be impossible is possible and imagining new situations;
- Recognizing the need to be open minded and reviewing safety culture and leadership through this lens.

The panel also investigated the potential and limitations of advanced reactor technologies to practically eliminate the risk of off-site releases. They discussed the innovative passive systems in SMRs, the designs of new reactors that consider the issues with current reactors, the need to engage with the public in a two-way dialogue and communicate clearly what is safe and what is not safe. Panellists discussed the importance of leadership for developing cultures for safety and where a questioning attitude contributes to safety and where strict implementation and following instructions is a prerequisite for the safe operation of nuclear installations. A questioning attitude and continual review are necessary to prevent further accidents, however it is important to avoid endless analysis that results in no progress.

² A “black swan” event can be considered to be a potentially very severe event that is beyond normal expectations and difficult to predict.

A strong regulator that can consider a multitude of perspectives in decision making and maintain public trust is key.

Session C – Preparing and Responding to a Potential Nuclear Emergency

An integrated and coordinated emergency management system for preparedness and response for a nuclear emergency has to be in place at the national level for effective action. The Fukushima Daiichi nuclear power plant accident has shown that these arrangements have to cover, among other things the case of responding simultaneously to a nuclear emergency and a natural disaster. In this session experiences were shared on various aspects of managing emergency response, including protecting emergency workers and helpers and justifying protective actions.

Findings included the following:

- In a nuclear emergency, protective actions have to be justified and implemented in an effective and timely manner, doing more good than harm.
- A comprehensive approach to planning and decision making has to be followed to ensure balance between potential radiological consequences, non-radiological consequences, and health hazards, with special consideration to sensitive population groups, such as children, pregnant women and those in nursing homes and chronic care facilities.
- Communicating with and educating the public is vital in the preparedness phase.
- International exercises like ConvEx-3 are important to test and build capacity at the international level.
- Capabilities should be integrated into a plan for all hazards.
- IAEA safety requirements and generic criteria address the termination of a nuclear emergency and the subsequent transition to an existing exposure situation; however, the Fukushima Daiichi nuclear power plant accident highlighted that further guidance was needed.
- The Emergency Preparedness and Response Standards Committee (EPReSC) was formed as a direct result of the Fukushima Daiichi nuclear power plant accident. It developed a road map for the future, driven by Member States’ needs, a gap analysis and mapping, including protective strategies for planned, emergency and existing stages. Governments have suggested that this guidance should be elevated to safety standard status in order to be more fully utilized.
- Emergency preparedness is more than just the plan: practice is key. Therefore, workers need to be designated in advance and given instructions and duties before an emergency. They need to participate in practice sessions that simulate real world conditions.

A specialist panel discussed how to ensure emergency arrangements are robust, in light of the lessons learned.

Panel 2 - Preparing and Responding to a Potential Nuclear Emergency – Robust Preparedness Arrangements

To be robust, preparedness arrangements need to be able to respond to an emergency at a nuclear power plant that might occur simultaneously with a natural disaster. The response to a nuclear emergency involves many national organizations, as well as international organizations and, therefore, has to be coordinated and effective. This panel discussed the importance of infrastructural elements for emergency preparedness and response, including: regulatory requirements; clearly defined roles and responsibilities; pre-established plans and procedures; tools, equipment and facilities; training, drills and exercises; and a management system.

Conclusions included:

- Effective communication, talking with and the inclusion of stakeholders including NGOs and the public, is needed in the preparedness phase.
- Simulation exercises should be done with people who will participate in the emergency response, including local public safety officials and government representatives, as behaviours and risk perception change when in an actual emergency.
- A multidisciplinary approach to preparedness is necessary.
- It is crucial to build trust and engagement prior to an emergency.
- We must communicate the benefits and safety of nuclear power to help the world address climate change and de-carbonized energy, including the value of SMRs and advanced reactors and their need for less extensive emergency planning arrangements and less constrictive siting criteria.
- The media is the most direct route to the public; however, an authoritative source is necessary given the dissemination of misleading or incorrect information in the democratization of information. The IAEA is one of the best sources for nuclear safety information.

Session D – Protecting People Against Radiation Exposure

An important lesson from the Fukushima Daiichi nuclear power plant accident is the difficulty non-specialists have in understanding the international system of radiation safety, including the principles and criteria for radiation protection. It is important to communicate the rationale behind the judgement as to whether and how radiation doses to the public should be averted, and to make clear that justification of protective measures and actions is based not solely on radiation science but on consideration of the overall benefits and detriments to society and the individual. Furthermore, guidance on monitoring doses to the public in the aftermath of an accident can be limited and this potential lack of information might create public anxiety. The public is particularly concerned about the protection of children and pregnant women after a nuclear accident. This session discussed such challenges, and successful approaches for protecting the public against radiation exposure while ensuring timely and effective communication to the public.

A high-level discussion covered some of the main issues in this area followed by a panel discussion addressing the particular aspect of the risk of low dose radiation exposure.

Session speakers noted the following:

- It has been shown that there would be no discernible health effects from radiation from the Fukushima Daiichi nuclear power plant accident over time, however, the public remain concerned. Care needs to be practiced in attributing health effects to radiation when there are none observed, or they can only be inferred.
- There were significant non-radiological (psycho-social) impacts which need to be recognized. However, there is no one-size-fits-all approach to deal with the mental well-being and psychosocial impacts of an emergency.
- Potential non-radiological consequences need to be taken into consideration when implementing protective actions.
- It is important to take an all-hazards approach, considering both radiological and non-radiological consequences and the emotional dimension of risk perception, and practical tools need to be developed and made available to decision makers.
- The scientific community needs effective communication methods to convey scientific facts and evidence in a way that can be easily understood and trusted by the public, particularly as there are other sources exposing the public to misleading information.

Panel 3 - Protecting People Against Radiation Exposure – Attributing Health Effects to Ionizing Radiation Exposure and Inferring Risks

In the aftermath of the Fukushima Daiichi nuclear power plant accident, the radiation risk estimates used for radiation protection purposes were misinterpreted by the media and members of the public. While such estimates are intended for inferring risks based on assumptions, they were used to project absolute numbers of radiation-induced cancers following low-dose radiation exposure resulting from the accident. This resulted in disproportionate perceptions of risks by members of the public and might have contributed to increasing public anxiety with its associated health detriments.

The limitations of epidemiological studies for attributing radiation effects following low level radiation exposures need to be discussed and clearly explained. One aspect covered by this panel was the validity of the linear no-threshold theory in the light of the current understanding of radiation-induced health effects.

The panellists agreed that:

- The linear no-threshold approach is a practical and simple model for radiation protection purposes; however, it remains an unproven model for the interpretation of the radiation effects at low doses, and great care must be taken in trying to apply it to low doses for which an increase in cancer risk is deemed not proven. Indeed, the statistical power of epidemiological studies is too low at such doses to support firm conclusions and where radiation biology studies provide insufficient evidence for either LNT or other general dose-response models.
- What is needed is a distinction between the attribution of effects and the inference of risks.
- Epidemiological studies alone cannot elucidate health effects of radiation at low doses.

They discussed the question of whether accurate estimates of the effect of low doses of radiation are necessary, since the risk of health effects can be negligible and with the uncertainties in estimating these effects, incorrect interpretation can have a detrimental impact on decision making. In terms of public communication, it is important to answer the questions asked in an easily understandable way, enabling the public to make risk-informed decisions.

Session E – Recovering from a Nuclear Emergency

The nuclear industry exists in a broader context; therefore, recovering from a nuclear emergency is a complex social/political/economic/technical/scientific process. It requires coordination among a wide range of stakeholders and consideration of many aspects. This session covered several related topics including: the role of technology and innovation; the involvement of the public in decisions on remediation efforts; and the identification of challenges that can inform future planning.

In this session, speakers shared their experiences from the perspective of international organizations, government authorities, and local and regional leaders involved in the recovery operations from the Fukushima Daiichi nuclear power plant accident. Points made included:

- Planning for recovery is part of assuring overall safety and emergency preparedness over the entire lifetime of a facility.
- Fukushima Daiichi nuclear power plant is now at the beginning of the decommissioning phase, 10 years after the accident, with a roadmap expected to take 30–40 years. This is in parallel with ongoing off-site reconstruction.
- There are challenges in water management, fuel and fuel debris removal and waste management.
- The end state for the site and area is not yet decided and requires the involvement of local stakeholders to reach an agreed outcome.

- There are a wide variety of health issues associated with people in contaminated areas, including those evacuated. The Fukushima Health Management Survey after the accident showed psychological distress and an increase in lifestyle diseases, due not to radiation but to the effects of evacuation and reduced accessibility to health care. Stigmatization from the media also led to negative health impacts.
- As decontamination efforts continue, there is a need for further international cooperation to clarify and harmonize criteria for radioactivity in commodities and consumer goods.

Panel 4 – International Cooperation

The Fukushima Daiichi nuclear power plant accident emphasized the importance of international cooperation in safety related areas, including safe operation, emergency preparedness and response and regulatory effectiveness, and of incorporating lessons from the accident into national programmes to build capacity for more resilient systems.

Institutional networks for safety, such as regional networks, knowledge networks and regulatory forums, provide a platform for information exchange and help to optimize resources, compare processes, procedures and policies, identify good practices, identify and address existing gaps and needs.

The panellists shared different perspectives on how international cooperation contributes to establishing an international framework and global commitment for nuclear safety, and what more could be done. Findings included:

- International, regional and bilateral cooperation is vital for establishing mechanisms for provision of assistance and it is important to avoid duplication of efforts.
- Cooperation mechanisms established and agreed in case of emergency need to be in place for strengthening nuclear safety worldwide.
- International legal instruments and IAEA safety standards evolved after both the Chernobyl and Fukushima Daiichi nuclear power plant accidents to reflect findings and streamline the direction for international cooperation.
- The IAEA plays a vital role in facilitating the independent and transparent exchange of experience, where all parties benefit. Cooperation in such areas as post-accident recovery, leadership, safety culture and capacity building has been a focus.
- In nuclear safety, technical cooperation should be utilized for both developed and developing countries.
- International cooperation is needed and will be instrumental in avoiding the politicizing of nuclear safety.

Special Topical Events

These events covered some issues that are of particular topical interest, either to understanding the lessons learned or what needs to be addressed to ensure lessons are learned and actions are taken into the future.

Panel 5 – Youth and the Nuclear Industry

The IAEA invited students and early career professionals up to 30 years of age to submit essays on selected topics related to the themes of the conference. The aim of the essay competition was to promote creative and innovative thinking and highlight the critical role that the next generation will play in

sustaining and ensuring a safe future for the peaceful uses of nuclear technology in areas such as nuclear power, food and agriculture, water management, and human health. The essay competition attracted 250 submissions from 60 countries. Finalists were selected through a blind evaluation process and attended the Conference and participated in this special youth panel.

Discussions covered several topics including:

- The future of power generation, including the need for the timely implementation of safety standards to ensure that future generations remain safe in the long run, and that maintaining safety stays as the highest priority.
- Recognizing that nuclear power is even safer, the inclusion of youth in the nuclear industry and their innovative ideas in decision-making will help drive it forward further;
- The importance of speaking the public’s language, simplifying technical conceptualizations through analogies and illustrations in developing public understanding, interest and trust in the safety and reliability of nuclear power;
- Tools such as the internet and social media for clear and concise communication (and public relations) with stakeholders especially young people;
- Including the subject of nuclear power as part of education programmes to inform future generations and encourage them to pursue a career in the nuclear field;
- The importance of non-nuclear power applications;
- The use of the nuclear industry as a tool for development world-wide and the effect of future technologies such as SMRs.

Performing Safeguards at the Fukushima Daiichi Site

Through a set of technical measures, the IAEA verifies that States are honouring their international legal obligations to use nuclear material and technology for peaceful purposes only.

To support the drawing of safeguards conclusions, the IAEA Department of Safeguards relies heavily on the timely access of inspectors to nuclear material and facilities. The conditions on the Fukushima Daiichi site after the impact of the 2011 Great Tohoku Earthquake and tsunami posed unprecedented and continuously evolving challenges in fulfilling this mandate.

This side event discussed the safeguards activities undertaken by the IAEA at the site in the 10 years since the accident, from the post-accident response until the current situation, the progress made in re-verifying the nuclear material that was left inaccessible by the accident, and the innovative technologies developed in response to the challenges on the site, such as verification for damaged structures. The challenge for the future is the transition from a post-accident site to a decommissioning site (including the new buildings).

Safety Related Aspects of ALPS (Advanced Liquid Processing System) Treated Waters after the Fukushima Daiichi Nuclear Power Plant Accident

In April 2021, Japan announced the Basic Policy on handling of the treated water stored at the Fukushima Daiichi nuclear power plant, which is to discharge the treated water into the sea surrounding the plant, subject to domestic regulatory approvals. Soon after, the Japanese authorities requested assistance from the IAEA to monitor and review those plans and activities related to the discharge of the treated water to ensure they will be implemented in a safe and transparent way. Rafael Mariano Grossi, Director General of the IAEA, committed to provide support to the Government of Japan before, during, and after the water discharge, and the IAEA Secretariat has started initial planning and implementation activities associated with its review. A Task Force comprised of the IAEA Secretariat,

as well as international experts, has been established and reviewing the Government of Japan's activities related to the treated water discharge.

The purpose of this Special Event was to hear from key officials from the IAEA and Japan, about recent progress and to share information about future activities. The main aspects covered were:

- The discharge of ALPS treated water will begin approximately two years after the announcement of the Basic Policy. Before and after the start of the discharge, enhanced marine monitoring will be conducted and made public by Japan in a thorough and transparent manner. This is based on over six years of technical discussions with continuous stakeholder involvement and communication with the international community.
- The Agency has been reviewing Japan's plans with respect to ALPS treated water using international safety standards as a benchmark; the review will occur before, during and after the planned discharge with components covering safety assessment, regulatory activities, sampling, and environmental monitoring (including corroboration of key data). Outputs of the IAEA review will include progress reports and updates to the public and international community at conferences, and briefings to Member States. Additionally, the IAEA will also conduct independent source and environmental monitoring to corroborate the data published by the Government of Japan. This work will be done in collaboration with IAEA and third-party laboratories.
- IAEA will publish the results of these reviews and distribute them amongst stakeholders, as appropriate. A website dedicated to this project has been established by the IAEA so that all stakeholders, including the public, have access to timely information.

PART III – THE PATH FORWARD

Panel 6 – Safety for Nuclear Development

The IAEA and Member States have a shared responsibility to ensure that the sharing of nuclear technology is executed in a way that adheres to the highest standards of nuclear safety, security, and non-proliferation. Currently, several countries are embarking on new nuclear power programmes, while others are expanding their existing uses of nuclear or radioactive material for industrial, medical, and research purposes.

This panel examined how vendors, recipients, and international organizations can all play a role in the system for ensuring that nuclear safety remains a global priority and highlighted the role of a robust nuclear safety infrastructure and system in enabling future nuclear development, building on INSAG-27.

Panellists agreed that safety is a pre-requisite to nuclear power generation as well as noting that:

- Multilateral cooperation and collaboration are vital.
- Regulatory independence is key, and development of national capacity is important as more and more countries develop nuclear power.
- Safety is the responsibility of the operator, but the regulatory body plays a vital role in ensuring that there is adequate financial support and that competence is developed and maintained.
- There is a need for appropriate regulatory structures, institutional and human resource capacities to be developed, using IAEA safety standards and advisory missions, to strengthen national systems for safety.
- Legal and national frameworks need integrated management systems, and knowledge management and transfer are vital as technical support organizations and vendors assist in capacity building.
- Design and operating experience must be shared.

- Responsible vendors will build national responsibility and provide support for the entire lifecycle of the facility and provide for the orderly transfer of intellectual property if and where needed.
- Safety must be built into the supply chain.
- The current framework needs to be re-examined for sustainability. With the advent of SMRs and advanced reactor technologies, international and national frameworks for safety will have to evolve.

Panellists also discussed the international potential for mutual recognition of safety assessments, as well as the concept of an international technical support organization created under the auspices of the IAEA.

Panel 7 – Building Inclusive Safety Leadership

Global and national labour markets are changing. Personnel with different backgrounds, attitudes, expectations and competencies are joining the nuclear sector. The purpose of the panel was to draw attention to the changing workforce demographics in operating organizations, regulatory bodies, technical support organizations and research organizations.

Panellists discussed strategies to address potential challenges and exchanged ideas on how nuclear sector practices keep pace with other industries to have an inclusive workforce and safety leadership in the mid-21st century. These included:

- Guarding against complacency, being open to other perspectives;
- Retaining strong government support for nuclear safety leadership;
- Setting example of safety culture for operators by regulators;
- Maintaining a consistent approach to safety culture throughout the supply chain and across all stakeholders;
- Using an integrated management system to integrate multi-cultural workforces under one cohesive organization;
- Recognizing that a listening attitude is as important as a questioning attitude in leadership;
- Harmonizing safety culture concepts, working towards making nuclear safety culture universal, with one interpretation, to ensure important messages cross cultural barriers. The IAEA can help by providing tools and advisory services;
- Learning from other industries, such as incorporating a mix of reflexive and reflected learning as in the aviation industry;
- Reducing uncertainty and training staff for other opportunities, e.g., decommissioning, in long term and phase out operations.

The panellists recognized that:

- Leadership and culture are equally as important to nuclear safety as technical aspects, such as defence in depth.
- Safety has to be the overriding priority, with leadership providing clear vision, values and expectations and following up to enforce those expectations, in order to establish a strong foundation for a culture for safety.
- Knowledge management and knowledge transfer are crucial to an inclusive workforce, in tandem with a leadership focus on succession planning and retaining talent.

Panel 8 – International Legal Instruments

Over the past four decades, several important international conventions and other international legal instruments have been adopted and progressively strengthened to achieve and maintain a high level of nuclear safety worldwide. International conventions are complemented by national policies for safety and regional agreements. Other initiatives also form part of the on-going international effort to strengthen nuclear safety, such as the Vienna Declaration on Nuclear Safety that was unanimously adopted by the Contracting Parties to the Convention on Nuclear Safety. The IAEA plays a critical role in maintaining the international legal framework for nuclear safety. The establishment of the IAEA safety standards through an international consensus process assists in the harmonization of nuclear regulations and helps States to comply with existing international legal instruments.

This panel discussed how the effectiveness of the international legal instruments for safety can be further enhanced. Panellists noted that:

- Safety is the responsibility of the operator, but conventions allow us to check on progress in lessons learned, as nuclear safety is always a work in progress. Contracting parties of conventions perform a peer review process.
- It is important to note that governments sign onto these instruments, not operators or regulators. The conventions are not applied directly but are reflected within national laws.

Suggested enhancements included:

- Using more modern communication tools to allow greater participation without the need to be present in Vienna (or another centre) might increase the effectiveness of existing legal instruments;
- Reviewing what the benefits to countries should be, especially the smaller ones as it is very intimidating for them to compile national reports;
- Using different types of legal instruments to aid effectiveness, such as the Code of Conduct, as Conventions are difficult to change.
- Examining how the multiple international legal frameworks could work better together.

Panel 9 – Communication, Engagement and Trust Building

The safe operation of nuclear facilities is ensured through the cooperation of multiple stakeholders, including operating organizations, regulatory bodies, and technical support organizations. Interfacing with decision makers and professional organizations, as well as communication with the public through local communities and the media needs to be transparent and clear. Availability of information from different sources and access to new formats of communication present opportunities but also challenges for conveying accurate and reliable information to decision makers, the media and the general public during both normal operation and in emergencies.

This panel discussed how information can be shared accurately and in a timely manner in a way that is understandable to the target audience and builds trust with the public. This was in the context of reinforcing effective communication. Depending on who is communicating to whom, when and why, the facts may be expressed differently and hence can induce uncertainty and mistrust.

The panel found that:

- The nuclear industry communicates risks well but is not as good at communicating the benefits of nuclear energy.
- Communication experts and social scientists have a key role to play in positively and effectively engaging the public, as do young enthusiastic influencers.
- Trust takes many years to build, through effective communication and continuous engagement. It has to be established before an accident.
- It is important to ensure an understanding of nuclear phraseology and to realize that there cannot be total consistency in messaging as stakeholders and target audiences are diverse. The differences in messaging need to be monitored.
- It is important to find and use the most appropriate communication channels and tools and ensure that the public has a clear idea about the appropriate places to go for information.
- The IAEA is a trusted source of information, especially for newcomers, but independent and government sources also have a role to play.
- Engaging with journalists (local, national, etc) openly and transparently and providing feedback on their communication is one of the best ways to reach the interested public.

The panel also debated the role of the public in nuclear decision-making, its benefits and risks in building trust but risked short-term thinking.

- The public and the media should be included as stakeholders in nuclear safety, but decisions are made by those in authority. Governments and regulators do need to listen to and understand their perspectives.

Learning from other areas was also a theme, especially from the COVID-19 pandemic where concepts of risk and balancing risks were fed, sometimes daily, into the public consciousness.

- There are clear parallels between nuclear risk perception and vaccine hesitancy.
- The pandemic did make clear that the public is not a homogenous entity and people do have a capacity for understanding risk vs benefits.
- it is still unclear how best to bring stakeholders into the decision-making process.

Sustaining effective communications in the long term was a particular issue highlighted by the panel, with panellists noting that to maintain relationships with stakeholders, we must communicate frequently, openly and in plain language. People need to trust the “messenger” in order to trust the message.

Panel 10 – Facing New Challenges

The rapidly changing world inevitably reflects on the nuclear energy landscape. Considering this changing environment and new technologies, enhancing safety in the next years remains a key task for governments, regulatory bodies, and operating organizations. Natural phenomena, economic trends and social expectations are difficult to foresee. New technologies impact energy demand and supply, and shape life. Events, such as pandemics, impact mobility of people and goods and affect nuclear supply chains.

During this panel, participants discussed trends and global developments that might have a direct impact on nuclear power in its current format:

- Current nuclear power plants are robust against the challenges of climate change but there are other challenges such as cyber safety and security, parts obsolescence in ageing nuclear facilities, and the challenge of capacity building for small and newcomer countries.
- The cost of nuclear energy has increased against other clean energy. Standardization would make nuclear energy more competitively priced and quicken deployment. Regulation like that established for the aviation industry might help, as well as moving away from technologies that have been only proven for nuclear applications.
- SMRs could also be the answer to the increasing costs facing nuclear power development programmes; however, they have no history in operation or regulation.
- As new technologies continue to emerge, the regulation of innovative designs will require global cooperation.
- Social media and new communication channels heavily influence public trust and support. The nuclear industry has to make its case as a safe, reliable and climate friendly source of energy in a clear and easily understood way.

Panel 11 Call for Actions – Maintaining the Momentum

Recognizing that discussion is not enough to defend against complacency and demonstrate the safety of the nuclear industry, this panel proposed actions for moving forward. Panellists used the key messages from the conference coupled with insights from speakers throughout the week to identify where future efforts and momentum would be most beneficial.

The panel discussion focused on four areas: enhancing openness, embedding the lessons of Fukushima Daiichi nuclear power plant accident, better preparing for the wider use of safe nuclear power, and transferring knowledge for the future. The conclusions of the discussions, reflected in this section, are summarised in the President’s Call for Action. The discussions are summarised in the statements below.

- (1) Enhancing openness: This is not just building trust but part of building robust national and international systems, with interactions and interfaces that make the systems work. It is important to talk and listen to make nuclear systems more robust.
 - There is a need to be better at getting out the messages around risks and benefits with better guidance on communicating, especially to young people. Part of this is how to better explain and communicate how safe is safe enough.
 - There is a need to improve Emergency Planning and Response and its transparency, expanding beyond the immediate stakeholder community to the public health community, as the response has an impact on the non-radiological effects of an emergency.
 - A more holistic approach to low-dose radiation is needed to differentiate between attribution and inference of risk. In protecting people against radiation exposure, both the radiation risks and the psychosocial effects of radiation protection need to be taken into account. The radiation health effects need to be balanced with the psychosocial effects and the effect of protective actions.
 - In recovering from a nuclear emergency, the answer to what is safe enough needs to be established in advance in the consultation phase and communicated to the public as a range of acceptable end states.
 - It is important to take into account the social aspect of improving safety. Trust building is not convincing people but providing them with information so that they can form their own opinions in an informed way. We need to talk and listen to local people; it is less about challenges and more about understanding and providing information, explaining what is being done and why.

(2) Being better preparing for the wider use of nuclear power: are we prepared for this change? It could mean that instead of around 400 operating nuclear power plants we could have perhaps over a thousand with many more countries having nuclear power programmes.

- There is a need for a review of the global structures and systems to drive forward a culture for safety and to ensure that there are appropriate governmental and institutional frameworks, in accordance with and in adherence to the IAEA safety standards, sufficient availability of technical support (especially for new users) and effective and efficient international collaboration. There is a need for more guidance to help foster a wider culture for safety in regulators, operators, policy and decision makers and the public. And to learn how to apply and nurture this culture.
- Culture for safety should also be for security.
- There is a need to equip people outside the nuclear industry with guidance and tools that incorporate the wider impact of a nuclear or radiological emergency on the public and on public health systems.
- There is a need to find more effective ways to communicate with society about the wider use of nuclear applications, clarify the scope and target of the communication and make use of knowledge from social and behavioural sciences. This communication has to be honest, open and transparent.
- There is a need to be prepared to recover as well as to respond to accidents. The transition to different phases occurs gradually and in different ways. There is a need for clear standards and guidelines for radionuclides in commodities, with international cooperation and commitment. This might avoid unnecessary harm due to a lack of understanding of the risk.
- It is important to recognize, anticipate and adapt with agility to changes in technology (digital, etc.) and society, with knowledge management, capacity building and young generation engagement. All of this has to be based on a questioning and listening attitude.

(3) Embedding the lessons from the Fukushima Daiichi nuclear power plant accident:

- New technology designs need to embed these lessons and regulators need to verify this. A complete picture of these activities will help to build greater confidence in safety, especially the application of defence in depth.
- Much has been done in existing nuclear power plants but not all of it has been documented or sufficiently explained to the public.
- It is important to engage the public in a holistic approach to decision making.
- Off-site radiation protection issues and the effects of evacuation and large-scale contamination need to be reviewed for good and poor practices. The question needs to be changed from the just a question of radiation doses to what is best for people's wellbeing overall.
- Risk and risk-informed decision making need to be better understood. The non-radiation effects of the Fukushima Daiichi nuclear power plant accident have had more impact than radiation exposure on people's health and well-being. There are lessons from other natural disasters about how to talk about risk, but there are also communication challenges of fear and stigma of radiation and misinformation.
- Learning never stops and there is continuous improvement for safety. It is the responsibility of operators, regulators and other stakeholders to improve the process of learning. Knowledge transfer from other industries is helpful as well as training in international cooperation. It is not a question of improving safety at any cost but a balance to further strengthen safety where reasonable to do so. Improving safety does not necessarily mean that nuclear applications were

previously unsafe. Safety and learning are continuous processes. There is a need to continue to look for ways to be safer based on the use of techniques, such as a cost–benefit analysis.

4) Transferring knowledge for the future: this knowledge is hard won.

- Experiences need to be shared openly. As an example, continued sharing of the experiences in Japan have been and will continue to be valuable to the international community, for instance with regard to decommissioning. Actions to facilitate the transfer of knowledge for other circumstances are needed.
- There is an audience for knowledge transfer. Actions to transfer knowledge are needed. Japan has now considerable experience on recovering from a nuclear accident, and there is a need to ensure that the next generation has access to that information. It may revolutionize decommissioning of nuclear power plants.
- Decommissioning is ongoing at the Fukushima Daiichi nuclear power plant and sharing information and transparency internationally is paramount for ensuring public trust.
- New technology has been developed for these particular circumstances. This large accident is unique in the very long timeframe for recovery and its circumstances, which provides opportunities to put into practice some specific lessons learned. Therefore, there is a need for a repository of knowledge that is searchable and accessible for people who might need it in future, showing what was done, why and how.
- There is an intergenerational aspect of knowledge transfer. The IAEA has developed tools like peer reviews and advisory services and capacity building in its various schools. These are available for future generations. A big strength of the nuclear sector is the ability to work together and there are a lot of opportunities for the harmonization of approaches.
- Greater gender equity and skill diversity in the sector is needed.
- Resources are necessary for knowledge transfer. More experienced countries need to help and support embarking countries in investing in technology and people. We all need to widen our interactions and we need smaller, more issue-focused meetings to widen our views.
- Another mechanism for knowledge transfer and collaboration is needed in addition to large meetings and conferences. Bilateral and regional collaboration are to be encouraged.
- There needs to be efficiency in working together. There is a need to prioritise, to focus on what matters the most for nuclear safety. There has to be coordination between international organizations working on the same topics. Some of our existing tools have reached maturity and there might be a need to review our legal instruments; the world is markedly different than when they were established. We need to develop advanced tools for the future.

A final question is how to maintain the momentum? The following were proposed:

- By conducting follow up discussions at regular intervals to optimize the value of the work done for this conference;
- By defining the conference outcomes as action-oriented items and facilitate their implementation in straightforward way;
- By sharing the findings from this conference with other topical events for more detailed consideration.

CLOSING SESSION

Summary and Conclusions – A Call for Action

Closing Remarks

M. Weightman gave his closing remarks, including a summary of his observations and a President's Call for Action to achieve the goal of "Safe nuclear power for all" as part of providing secure, clean energy for humankind and hence part of the solution to climate change. He noted the enablers for this goal: greater international collaboration, optimum decisions, balance, inclusive leadership, the international legal instruments and earning trust. He outlined the four areas covered in his Call to Action: enhancing openness, embedding the lessons of the Fukushima Daiichi nuclear power plant accident, better preparing for the wider use of safe nuclear power, and transferring knowledge for the future, with underlying actions to support them. These are contained in the President's Call for Action. He also called for a new mechanism to ensure that the actions were delivered. He suggested an annual side event at the IAEA General Conference to provide an overview and update on the progress made in relation to the actions, as well as to review the list of actions, and that such an event would be organized jointly with other international institutions and would be open for attendance. This will involve being committed to working together and addressing the actions effectively with vigour.

G. Caruso noted that there were 689 conference participants, 131 speakers and panellists, 216 observers with 68 countries and 7 international organizations and thanked everyone involved in preparing for and implementing the conference.

R. M. Grossi thanked the Conference President for his service to the nuclear community, noting that this conference was the right thing to do; it was not an autopsy of the accident, nor an exercise in regret and regurgitation. The community took stock and made progress in a shift that is embodied in the four areas noted by M. Weightman in his address. He encouraged participants to persevere in the effort to better inform stakeholders in a timely manner and to help the IAEA in its aims for better communication. His final message was to stay tuned for the changing world.

Author: Mike Weightman
President of the Conference

APPENDIX A – PROGRAMME OF THE CONFERENCE

MONDAY, 8 NOVEMBER 2021

09:00-10:00 OPENING SESSION Boardroom B/M1

Time	Name	Designating Member State/Organization
	<i>Naga Munchetty</i>	<i>Moderator</i>
09:00–9:10	Rafael Mariano Grossi	IAEA Director General
9:10–9:20	Takeshi Hikiyama	Ambassador of Japan
9:20–9:30	Mike Weightman	Conference President (United Kingdom)
9:30–9:40	Gustavo Caruso	Scientific Secretary

Keynote speakers

9:40–9:50	Lydie Evrard	IAEA Deputy Director General and Head of the Department of Nuclear Safety and Security
9:50–10:00	Hajimu Yamana	Japan Nuclear Damage Compensation and Decommissioning Facilitation Corporation

PART I - INTERNATIONAL ORGANIZATIONS PERSPECTIVE

10:00-12:00 SESSION A - CONTRIBUTION OF INTERNATIONAL ORGANIZATIONS TO GLOBAL SAFETY Board Room B/M1

Time	Name	Designating Member State/Organization
	<i>Mike Weightman</i>	<i>Session Chairperson United Kingdom/Conference President</i>
10:00–10:12	William Magwood	Organisation for Economic Co-operation and Development/Nuclear Energy Agency (OECD/NEA)
10:12–10:24	Ingemar Engkvist	World Association of Nuclear Operators (WANO)
10:24–10:36	Gustavo Caruso	IAEA/Department of Nuclear Safety and Security
10:36–10:48	Gillian Hirth	United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR)
10:48–11:00	Gerhard Graham	Preparatory Commission for the Comprehensive Nuclear Test Ban Treaty Organization (CTBTO)
11:00–11:12	Gerd Dercon	Food and Agriculture Organization of the United Nations (FAO)

Time	Name	Designating Member State/Organization
	Carl Blackburn	Food and Agriculture Organization of the United Nations (FAO)
11:12–11:24	Joaquim Pintado Nunes	International Labour Organization (ILO)
11:22–11:36	Lars Peter Riishojgaard	World Meteorological Organization (WMO)
11:34–11:48	Maria Neira	World Health Organization (WHO)
11:48–12:00	Mike Weightman	Session wrap-up

PART II - LEARNING LESSONS

14:00-15:30 **SESSION B - ENSURING THE SAFETY OF NUCLEAR INSTALLATIONS** **Board Room B/M1**

Time	Name	Designating Member State/Organization
	<i>Rumina Velshi</i>	<i>Session Chairperson Canada/Canadian Nuclear Safety Commission</i>
14:00–14:10	Keiichi Watanabe	Japan/Nuclear Regulation Authority
14:10–14:20	Fedor Aparkin	Russia/ROSATOM State Atomic Energy Corporation
14:20–14:30	Petteri Tippana	Finland/Radiation and Nuclear Safety Authority
14:30–14:40	Anne Pelle	France/Électricité de France
14:40-15:30	Q&A	

16:00-17:30 **PANEL 1 - ENSURING THE SAFETY OF NUCLEAR INSTALLATIONS – MINIMIZING THE POSSIBILITY OF SERIOUS OFF-SITE RADIOACTIVE RELEASES** **Board Room B/M1**

Name	Designating Member State/Organization
<i>Naga Munchetty</i>	<i>Panel Moderator</i>
Mark Foy	United Kingdom/Office for Nuclear Regulation
Michael Franovich	United States of America/Nuclear Regulatory Commission
Jinho Lee	Korea/Korea Institute of Nuclear Safety
Jean Christophe Niel	France/Institut de Radioprotection et de Sûreté Nucléaire
Rosa Sardella	Switzerland/Swiss Federal Nuclear Safety Inspectorate

TUESDAY, 9 NOVEMBER 2021

09:00-10:30 SESSION C - PREPARING AND RESPONDING TO A POTENTIAL Board Room B/M1
NUCLEAR EMERGENCY

Time	Name	Designating Member State/Organization
	<i>Christopher Hanson</i>	<i>Session Chairperson United States of America/Nuclear Regulatory Commission</i>
9:00–9:10	Tomohiko Makino	Japan/ Nuclear Disaster Management Bureau
9:10–9:20	Catarina Danestig Sjogren	Sweden/Swedish Radiation Safety Authority
9:20–9:30	Hessa Almarzooqi	United Arab Emirates/Federal Authority for Nuclear Regulation
9:30–9:40	Tasos Zodiates	International Labour Organization
9:40–09:50	Marcus Grzechnik	Australia/Australian Radiation Protection and Nuclear Safety Agency
09:50–10:30	Q&A	
10:30–11:00	<i>Coffee/Tea Break</i>	

11:00-12:30 PANEL 2 – PREPARING AND RESPONDING TO A POTENTIAL Board Room B/M1
NUCLEAR EMERGENCY—ROBUST PREPAREDNESS
ARRANGEMENTS

Name	Designating Member State/Organization
<i>Naga Munchetty</i>	<i>Panel Moderator</i>
Kajal Kumar De	India/Nuclear Power Corporation of India
Tomohiko Makino	Japan/Nuclear Disaster Management Bureau
Susan Perkins	United States of America/Nuclear Energy Institute
Patricia Wieland	Brazil/Brazilian Association for the Nuclear Activities Development

14:00-15:30 SESSION D – PROTECTING PEOPLE AGAINST RADIATION Board Room B/M1
EXPOSURE

Time	Name	Designating Member State/Organization
	<i>Nobuhiko Ban</i>	<i>Session Chairperson Japan/Nuclear Regulation Authority</i>
14:00–14:10	Abel Gonzalez	Argentina/Argentine Regulatory Authority
14:10–14:20	Evgeny Metlyaev	Russia/The Federal Medical and Biological Agency
14:20–14:30	Todd Smith	United States of America/Nuclear Regulatory Commission

Time	Name	Designating Member State/Organization
14:30–14:40	Gerry Thomas	United Kingdom/Imperial College London
14:40–14:50	Zhanat Carr	World Health Organization
14:50–15:00	Jacqueline Garnier-Laplace	Organisation for Economic Co-operation and Development/Nuclear Energy Agency
15:00-15:30	Q&A	

16:00-17:30 **PANEL 3 – PROTECTING PEOPLE AGAINST RADIATION EXPOSURE—ATTRIBUTING HEALTH EFFECTS TO IONIZING RADIATION EXPOSURE AND INFERRING RISKS** **Boardroom B/MI**

Name	Designating Member State/Organization
<i>Melinda Crane</i>	<i>Panel Moderator</i>
Trevor Boal	Australia
Christopher Clement	International Commission on Radiological Protection
Michiaki Kai	Japan/Nippon Bunri University
Wolfgang Mueller	Germany/German Commission on Radiological Protection
Masaharu Tsubokura	Japan/Fukushima Medical University
Shang Zhaorong	China/Nuclear and Radiation Safety Centre

WEDNESDAY, 10 NOVEMBER 2021

09:00-10:30 **SESSION E – RECOVERING FROM A NUCLEAR EMERGENCY** **Board Room B/MI**

Time	Name	Designating Member State/Organization
	<i>Carl-Magnus Larsson</i>	<i>Session Chairperson Australia/ Australian Radiation Protection and Nuclear Safety Agency</i>
9:00–9:10	Akira Ono	Japan/Tokyo Electric Power Company
9:10–9:20	Keiichi Yumoto	Japan/Ministry of Economy, Trade and Industry
9:20–9:30	Tatsuro Sagawa	Japan/Ministry of the Environment
9:30–9:40	Masaharu Tsubokura	Japan/Fukushima Medical University
9:40–9:50	Oleksandr Novikov	Ukraine/Special State Enterprise Chornobyl Nuclear Power Plant
9:50–10:00	Analia Canoba	Argentina/Argentine Regulatory Authority
10:00-10:30	Q&A	

Time	Name	Designating Member State/Organization
10:30–11:00	<i>Coffee/Tea Break</i>	

11:00-12:30 **PANEL 4 – INTERNATIONAL COOPERATION** **Board Room B/M1**

Name	Designating Member State/Organization
<i>Hannah Vaughan Jones</i>	<i>Panel Moderator</i>
Alfredo De Los Reyes	Spain/Nuclear Safety Council
Massimo Garribba	European Union/European Commission
Christine Georges	France/French Alternative Energies and Atomic Energy Commission
Olga Lugovskaya	Belarus/Gosatomnadzor
Khammar Mrabit	Morocco/Agence Marocaine de Sûreté et de Sécurité Nucléaires et Radiologiques
Suchin Udomsomporn	Thailand/Office of Atoms for Peace
Rebecca Weston	United Kingdom/Sellafield Ltd

13:30-14:30 **SIDE EVENT – PERFORMING NUCLEAR SAFEGUARDS AT FUKUSHIMA** **Board Room B/M1**

14:30–15:00 Coffee/Tea Break

15:00-17:00 **DG SPECIAL SESSION – SAFETY RELATED ASPECTS OF HANDLING ALPS TREATED WATERS AT THE FUKUSHIMA DAIICHI NPP**

Time	Name	Designating Member State/Organization
	<i>Hannah Vaughan Jones</i>	<i>Panel Moderator</i>
15:00-15:15	Rafael Mariano Grossi	IAEA Director General
15:15-15:18	Koichi Hagiuda	Japan/Ministry of Economy, Trade and Industry
15:18-15:30	Keiichi Yumoto	Japan/Nuclear Accident Disaster Response
15:30-15:50	Junichi Matsumoto	Japan/Tokyo Electric Power Company
15:50-16:10	Nobuhiko Ban	Japan/Nuclear Regulation Authority
16:10-16:40	Gustavo Caruso	IAEA/Department of Nuclear Safety and Security
16:40-17:00	Q&A	

17:00-18:30

PANEL 5 – SPECIAL YOUTH PANEL—YOUTH AND THE NUCLEAR INDUSTRY

Name	Designating Member State/Organization
Rafael Mariano Grossi	IAEA Director General
<i>Ilieva Illizastigui Arisso</i>	<i>Panel Moderator</i>
<i>Hayden Rogers Page</i>	<i>Panel Moderator</i>
Daiane Dantas Sardinha	Brazil
Kate Graham-Shaw	United States of America
Doovaraha Maheswarasarma	Sri Lanka
Ilia Meniailo	Russia
Natchapon Promprasert	Thailand
Travis Scott Smith	United States of America

THURSDAY, 11 NOVEMBER 2021**PART III – PATH FORWARD**

09:00-10:30

PANEL 6 – SAFETY FOR NUCLEAR DEVELOPMENT

Board Room B/M1

Name	Designating Member State/Organization
<i>Melinda Crane</i>	<i>Panel Moderator</i>
Alexander Bolgarov	Russia/ROSATOM State Atomic Energy Corporation
Fred Dermakar	Canada/CANDU Owners Group
Satyajit Ghose	Bangladesh/Bangladesh Atomic Energy Regulatory Authority
Lei Ma	China/National Nuclear Safety Administration
Lukasz Mlynarkiewicz	Poland/National Atomic Energy Agency
Samy Shaaban Ata-Allah Soliman	Egypt/Egyptian and Radiological Regulatory Authority
<i>10:30–11:00</i>	<i>Coffee/Tea Break</i>

11:00-12:30

PANEL 7 – BUILDING INCLUSIVE SAFETY LEADERSHIP

Board Room B/M1

Name	Designating Member State/Organization
<i>Hannah Vaughan Jones</i>	<i>Panel Moderator</i>
Grote Gudela	Switzerland/Eidgenössische Technische Hochschule Zürich
Maria Lacal	United States of America/Palo Verde Generating Station for Arizona Public Service Company
Naveed Maqbul	Pakistan/Pakistan Nuclear Regulatory Authority
Elvira Romera	Spain/Nuclear Safety Council
Christer Viktorsson	United Arab Emirates/ Federal Authority for Nuclear Regulation
Bohdan Zronek	Czech Republic/ČEZ Group

14:00-15:30

PANEL 8 – INTERNATIONAL LEGAL INSTRUMENTS

Boardroom B/M1

Name	Designating Member State/Organization
<i>Melinda Crane</i>	<i>Panel Moderator</i>
Dan Dorman	United States of America/Nuclear Regulatory Commission
Dana Drabova	Czech Republic/State Office for Nuclear Safety
Naoto Ichii	Japan/Nuclear Regulation Authority
Ramzi Jammal	Canada/Canadian Nuclear Safety Commission
Annatina Müller-Germanà	Switzerland/Swiss Federal Nuclear Safety Inspectorate
Bismark Tyobeka	South Africa/National Nuclear Regulator

16:00-17:30

PANEL 9 – COMMUNICATION, ENGAGEMENT, AND TRUST BUILDING

Board Room B/M1

Name	Designating Member State/Organization
<i>Hannah Vaughan Jones</i>	<i>Panel Moderator</i>
Sama Bilbao y Leon	World Nuclear Association
Penelope Harvey	United Kingdom/University of Manchester

Name	Designating Member State/Organization
Jean-Luc Lachaume	France/Nuclear Safety Authority
Pilar Lucio	Spain/Nuclear Safety Council
Liane Sauer	Canada/Canadian Nuclear Safety Commission
Vadim Titov	Russia/ROSATOM State Atomic Energy Corporation

FRIDAY, 12 NOVEMBER 2021

09:00-10:30

PANEL 10 – FACING NEW CHALLENGES

Board Room B/M1

Name	Designating Member State/Organization
<i>Melinda Crane</i>	<i>Panel Moderator</i>
Asok Kumar Dutta	India/Nuclear Power Corporation of India
Alexey Ferapontov	Russia/Rostechnadzor
Darrell Roberts	United States of America/Nuclear Regulatory Commission
Uwe Stoll	Germany/Gesellschaft für Anlagen- und Reaktorsicherheit GmbH
Sun Zaozhan	China/Nuclear and Radiation Safety Centre
Marta Ziakova	Slovakia/Nuclear Regulatory Authority

11:00-12:30

PANEL 11 – CALL FOR ACTIONS—MAINTAINING THE MOMENTUM

Board Room B/M1

Name	Designating Member State/Organization
Mike Weightman	United Kingdom/ Conference President and Chair Session A
Rumina Velshi	Canada/Chair Session B
Dan Dorman	United States of America/Session C
Nobuhiko Ban	Japan/Chair Session D
Carl-Magnus Larsson	Australia/Chair Session E
Lydie Evrard	IAEA Deputy Director General and Head of the Department of Nuclear Safety and Security
<i>12:30–14:00</i>	<i>Lunch Break</i>

14:00-15:00

CLOSING SESSION

Board Room B/M1

Name	Designating Member State/Organization
Mike Weightman	Conference President
Gustavo Caruso	Scientific Secretary
Rafael Mariano Grossi	IAEA Director General