SUMMARY

of the

International Conference on Enhancing Nuclear Safety and Security Through Technical and Scientific Support Organizations (TSOs): Challenges and Opportunities in a Rapidly Changing World

Vienna, Austria

2–6 December 2024

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1. BACKGROUND

The International Conference on Enhancing Nuclear Safety and Security through Technical and Scientific Support Organizations (TSOs): Challenges and Opportunities in a Rapidly Changing World was held at the IAEA Headquarters in Vienna, Austria from 2-6 December 2024. This conference continued the tradition established by the four preceding conferences on this subject, which were held, respectively in Brussels, Belgium (2018), in Beijing, China (2014), in Tokyo, Japan (2010) and in Aix-en-Provence, France (2007).

The conference was attended by 370 participants, including 36 invited speakers, from 87 Member States and 7 international organizations.

Like the earlier conferences, this conference will play a vital part in national and international efforts to ensure the effectiveness of nuclear and radiation safety and security regulatory systems. This conference focused, in particular, on the development and strengthening of technical and scientific capabilities to achieve enhanced nuclear and radiation safety and security of facilities and activities, including operational legacy and emerging challenges as well as exchange and transfer of best practices with embarking countries interested in nuclear power to meet growing energy needs.

It is recognized that nuclear safety and security are to a great extent scientific in nature and that a regulatory body with responsibilities for nuclear facilities and other licensed activities involving radioactive material needs to have continuous access to technical and scientific expertise supporting regulatory functions. In this regard, one of the main conclusions of the 2018 conference highlighted the need to assist Member States in their strategies to develop their TSO capacities in order to promote TSOs' contribution to the independence and sustainable effectiveness of the national nuclear safety and security regulatory infrastructures. This fifth conference on TSOs will, in particular, present achievements that addressed the recommendations from the previous TSO conferences.

This conference was organized by the International Atomic Energy Agency (IAEA) in cooperation with the European Technical Safety Organizations Network (ETSON).

2. CONFERENCE OBJECTIVES

The purpose of the conference is to consider how to develop and strengthen technical and scientific capabilities to achieve enhanced nuclear and radiation safety and security of facilities and activities, including operational legacy situations and emerging challenges as well as the exchange and transfer of best practices with nuclear power embarking countries.

The conference will highlight the importance of scientific and technical capabilities to support regulatory decision-making for enhanced nuclear and radiation safety and security. While addressing challenges to the development, maintenance and enhancement of such capacities, the conference will:

- Enhance scientific and technical basis within the regulatory infrastructure for nuclear and radiation safety and security;
- Facilitate the exchange of best practices and enhance technical and scientific capacities between Member States including embarking countries;
- Enhance scientific knowledge and adaptability for new technologies in a rapidly changing world;

- Promote involvement of young generation in the TSO activities, including TSO awards for young professionals;
- Encourage Member States to apply the TSO Self Capability Assessment (TOSCA) methodology and enhance their national capability; and
- Enhance networking of stakeholders with TSOs notably to foster international collaboration.

3. OPENING SESSION

The International Conference aims to Enhancing Nuclear Safety and Security Through Technical and Scientific Support Organizations (TSOs): Challenges and Opportunities in a Rapidly Changing World. TSOs are independent organizations that provide expertise and services to national regulatory bodies on scientific and technical issues related to nuclear safety and security.

In opening the conference, Mr Rafael Mariano Grossi, Director General of the IAEA, noted the importance of scientific support organizations (TSOs), particularly as more countries turn to nuclear energy to meet their environmental and energy goals.

Mr Grossi stressed the IAEA's role in information sharing and coordination and highlighted the importance of mechanisms like the Technical and Scientific Support Organizations Self Capability Assessment (TOSCA). TOSCA helps ensure TSOs are prepared to support regulatory authorities in enhancing nuclear safety and security. This fits in with the IAEA's focus on the safe and secure development of nuclear power and its related activities, where TSOs play a supporting role in regulatory oversight, including for emerging technologies like small modular reactors and fusion technology.

The World Fusion Energy Group (WFEG) brings together public and private sectors, industry, academia and civil society in an effort to form a cohesive global fusion community able to accelerate the research, development, demonstration and deployment of fusion energy. Mr Grossi, who oversaw WFEG's inaugural ministerial meeting in November 2024, noted the role of the TSO community in helping to foster the group's cohesion. The IAEA and participating organizations require an effective network of technical and scientific support organizations (TSOs), he told a conference of more than 300 participants.

Mr. Jean-Christophe Niel, Conference President (France) thanked the IAEA for organizing the conference and emphasized the crucial role of TSOs in addressing the evolving challenges in the nuclear sector, including the long-term operation of ageing nuclear power plants (NPPs) and the integration of new technologies like small modular reactors (SMRs) and artificial intelligence (AI). He added that the conference underscores the need for international cooperation and the exchange of best practices among TSOs to enhance nuclear safety and security. Mr Niel pointed out the demographic challenge of an ageing workforce and the necessity to attract and train young professionals to ensure the sustainability of nuclear expertise. Mr. Niel declared the conference open.

Mr. Michel. Van haesendonck, Conference Vice-President (Belgium) recalled the history of the TSO Conferences starting from 2007 and summarized the results of the 2018 conference. He encouraged Member States to take advantage of the specialized advisory services on

strategic issues relevant to TSOs to contribute to setting up a suitable TSO capability at national level. He also emphasized the role and continued growth of the IAEA TSO Forum (IAEA TSOF) as a platform to encourage open dialogue among TSOs worldwide. He emphasized the importance and also encouraged the use of the TOSCA methodology which is universally applicable to both countries with established nuclear power programmes, as well as embarking countries. He also noted that efforts of the IAEA TSO Forum are regularly reflected in the IAEA resolutions, and he thanked the Member States of the IAEA for recognizing the value of the activities. Outside the conference venue, the TSO Café provided the poster sessions and an opportunity for networking and presenting of additional topics of cooperation between TSOs during the breaks. There were three keynote speakers following the opening session.

Mr. Christophe. Grudler (European Parliament) emphasized the non-negotiable importance of nuclear safety, highlighting the role of TSOs in ensuring strict safety standards and supporting regulatory decisions with robust scientific expertise. He highlighted the importance of international collaboration and knowledge sharing to maintain high safety standards, especially in the context of extending the life of current operating nuclear reactors. Mr. Grudler noted the potential and challenges of SMRs and nuclear fusion, calling for tailored safety approaches and a distinct regulatory framework for fusion. In the context of the rapid technological developments, he emphasized the growing priority of cybersecurity in nuclear safety and the need for transparency and scientific education to avoid misconception and gain public trust and support for nuclear energy.

Mr. Dinesh. Kumar. Shukla (India) emphasized the need for regulatory bodies to have a clear understanding of their support needs and to develop competencies in core regulatory functions, supported by TSOs. He highlighted the importance of knowledge-based regulation, especially for new and innovative technologies, and the role of TSOs in providing scientific and technical expertise in specialized technical areas. Mr. Shukla shared insights from India's nuclear programme, emphasizing self-reliance, robust R&D infrastructure, and the integration of TSOs in regulatory processes to ensure nuclear safety and security.

Ms. Tracey-Ann Elliott (Jamaica) emphasized the critical role of TSOs in ensuring nuclear safety and security, particularly in Small Island Developing States (SIDS), which face challenges such as limited resources, geographical isolation, and the need for regulatory capacity building. She highlighted that TSOs provided technical expertise, inform evidence-based policies, and drove innovation, while fostering public trust through transparent communication and education. Ms. Elliott spoke of the importance of enhancing TSO capabilities through targeted training – beginning even at the primary level, with definite integration at the secondary through to the tertiary level – technology adoption, and international collaboration, including joint research and harmonized standards. She concluded by underscoring the necessity of global cooperation, capacity building, and a shared vision for improving nuclear safety and security in SIDS.

4. OVERVIEW OF TOPICAL SESSIONS

SESSION 1: Current Technical and Scientific Challenges

There were eight presentations in the session from China, Ukraine, Japan, Bangladesh, Pakistan, Belgium, Russian Federation and Oman.

There were four presentations that covered the regulatory approach, strategies and recent research-based activities to extend the operational life of NPPs through comprehensive safety evaluations of ageing-related factors. The most critical issue in current technical and scientific challenges is related to management and assessment of ageing of structures, systems and components, and verification of the methodologies and tools. The other presentations described practical strategies of a TSO for classification, disposal, and management of challenging legacy radioactive waste; the role of TSO in providing technical and scientific support to independently assess factors impacting spent nuclear fuel management, including methodological support for testing storage and transport casks; optimization of radiation alarm assessment protocols and enhancement of security measures to detect and manage illicit radioactive materials; and the performance evaluation of occupational dose measurement system for the provision of personal dose monitoring services.

Overall, the session highlighted the concerns about the validation of different research work being carried out by the TSOs or the regulatory body. The identification of extra requirements (testing and inspections, modification etc.) and application of graded approach while reviewing the documents for extended life operation were underlined.

In summary, the session recognized the need for the following:

- Invest in continuous development of TSO capabilities through research and development, training, access to advanced tools, including artificial intelligence, and international collaboration to address challenges associated with long-term operation of NPPs.
- Support the regulatory bodies in reviewing development and implementation of detailed ageing management programmes for NPPs undergoing long term operation.
- Encourage knowledge sharing and best practices among TSOs globally for safe management of radioactive waste.
- Promote the adoption of advanced tools for enhancement of security measures to detect and manage illicit radioactive material.
- Strengthen technical cooperation by capitalizing on IAEA networks and tailor-made support (e.g. TOSCA Methodology).

SESSION 2: Emerging Technical and Scientific Challenges

There were six presentations in the session from OECD/NEA, United States of America, Ukraine, Pakistan, Belgium and Slovenia.

Two of the presentations covered the work of the OECD/NEA Working Group on the Analysis and Management of Accidents (WGAMA), emphasizing the advancements and international efforts in nuclear safety and efforts on knowledge transfer; initiatives producing leadership fundamentals; and a project named HARMONISE which advocates modernizing nuclear safety regulations, including addressing main principles such as defence in depth and ALARA to accommodate emerging technologies like advanced reactors and fusion systems.

The other presentations covered containment filtered venting systems that can be effective in mitigating severe accidents as presented in the study for the ACP1000 NPP design; advancing tools and expertise to support licensing of non-light water reactors (non-LWRs), which promise safety and efficiency improvements; and the importance of diversifying supply chains and safety related reactor equipment and modernizing systems for resilience during armed conflict.

The session highlighted work performed by TSOs to solve actual technical and scientific challenges. A common theme of the session was the importance of capacity building, knowledge management and knowledge transfer. Another theme was the importance of inter-organizational and international collaboration and cooperation, including harmonization.

In summary, the session recognized the need for the following:

- Foster international collaboration: Preserve experimental data for benchmarks and enhance knowledge exchange for emerging nuclear technologies, further harmonize safety assessment methods for advanced reactors through workshops and shared databases. Expand knowledge transfer programmes to prepare future experts.
- Further work for technology-neutral regulations: Develop flexible regulatory frameworks incorporating principles like defence in depth, ALARA, and wider use of passive safety systems for heat removal.
- Promote competency building and knowledge management: For emerging challenges, adaptability, strategic thinking, and effective communication is paramount. Leadership development is crucial for maintaining the safety and competence in TSOs, more practical work and exchange of experience is needed.

SESSION 3: Interaction of TSOs with Stakeholders

There were six presentations in the session from Canada, Japan, Poland, Russian Federation, Morocco and South Africa.

Two presentations addressed approaches for engaging with the public. One presentation described the approach taken to build trust through transparent engagement with indigenous communities and stakeholders. One presentation covered the potential use of community-based research and artificial intelligence to enhance community engagement in the regulation of nuclear sites.

Other presentations covered the interactions between a regulatory body and its internal and external TSOs. Efforts focused on improving communication, clarifying roles, and fostering collaboration. Insights on the development of a distributed TSO model were provided in another presentation. Challenges include establishing independent TSOs, enhancing collaboration, and ensuring compliance with safety standards. The remaining presentation described the work carried out to enhance the provision of radiation protection technical services based on national regulation and ISO/IEC 17025-2017 standard; and the critical role of a TSO in assisting the nuclear regulatory body, in nuclear security by providing scientific expertise, conducting safety assessments, drafting regulations, and evaluating inspection results.

The session highlighted that meaningful engagement can be challenging for many reasons. Availability of resources and funding for TSOs and stakeholders, stakeholder biases, and unique needs of some stakeholder groups were underlined. Efforts of TSOs should include seeking to understand the needs of stakeholders and tailoring their approach for stakeholder

groups, as required. The session also considered that more experience and lessons learned from coordination and collaboration between TSOs would be beneficial. This coordination requires resources, that needs to be considered as a challenge that is present for all, especially for embarking countries.

In summary, the session recognized the following:

- TSOs are central in the regulatory system, especially to address emerging challenges. They provide indispensable expertise for regulatory guidance.
- A general reflection should focus on how to achieve systems that maintain the research mentality and approaches and at the same time have clearly in mind the link to regulatory framework and regulatory processes.
- Effective stakeholder engagement is key: Transparent communication and robust stakeholder participation processes are crucial for public trust.
- Stakeholder biases, if unmanaged, can compromise public engagement processes. Advanced tools such as artificial intelligence, to address stakeholder bias may be useful.
- Cooperation among different TSOs can be difficult but should be considered and managed in order to achieve the ultimate goals of nuclear safety and security.
- The independence of the TSO should be guaranteed relying, among others, on transparency and research.

SESSION 4: Scientific and Technical Capacity Building

There were presentations in this session from Romania, Russian Federation, Ghana, Kenya, Saudi Arabia, Zimbabwe and Egypt.

Two presentations covered the need for adequate resources towards strengthening the regulatory framework, performing dedicated R&D activities, enlarging the research infrastructure, and enhancing the necessary competences to deal with innovative reactor designs; and the activities of a TSO that includes the analysis and evaluation of design solutions to ensure the safety of nuclear fuel cycle facilities and activities related to the management of radioactive waste to support the regulatory body.

Two presentations covered the investment of significant resources in education and training to meet the requirements of a country's future nuclear programme as well as existing facilities using radiation sources and ionizing radiation; and a regulatory body's strategic initiative to strengthen partnerships with TSOs, focusing on how the regulatory body implemented training and collaboration programmes based on the IAEA curriculum.

Three presentations covered the establishment of internals TSOs: a description of the technical capabilities of an internal TSO in relation to monitoring laboratories and the national network for continuous environmental monitoring and early warning system; the activities of an internal TSO in the training of radiation safety officers, facility awareness campaigns, radiological environmental impact assessments, and nuclear analytical techniques for Naturally Occurring Radioactive Material (NORM) assessment in mining and other industries; and the development of a support unit for nuclear and radiological emergencies as a part of infrastructure for a country embarking on its first NPP.

One presentation described the experience in using the tools and support offered by the IAEA for long term planning and evaluation of energy systems such as hydrogen energy and the development of innovative reactors.

The session highlighted the availability of experts: the need for experts for new technologies; of long experienced experts retiring; loss of talented staff and competition for limited number of experts in embarking countries; and the availability of R&D capacities to support regulatory functions (new or further expanded nuclear programmes). The session showcased the strategies to deal with the issues: international cooperation, national development efforts and R&D programmes. The session also addressed longer term sustainability of capacity building programmes, including knowledge management, knowledge transfer, and maintenance of laboratories and research infrastructures. The needs of capacity building efforts evolved according to the status of a country's nuclear programme. The importance of evaluating the effectiveness of capacity building programmes, emphasizing that in some cases funds may not be sufficient. International collaboration and comparison enhance capacity building in embarking countries.

The session also underlined that the licensing of innovative reactors and technologies is challenging, thus nuclear programmes require involvement of all stakeholders and allocation of additional resources to extend R&D and to enhance competences The development of research infrastructure fosters TSOs capabilities to support regulatory functions, as for example independent safety assessment and regulation development.

In summary, the session recognized the following:

- Capacity building is a fundamental, transversal process to create the necessary skills and competences to support nuclear safety and security.
- Capacity building is also a need shared, for different reasons, by non-nuclear, nuclear and embarking countries to contribute effectively to the global nuclear safety and security regimes.
- Capacity building is necessary for safety assessment and expertise, but also to support R&D programmes and exploit research infrastructures.
- At the same time, R&D programmes and research infrastructures can be very efficiently employed to develop skills and competencies in capacity building programmes.
- In a rapidly changing world, several opportunities as well as challenges emerge quickly (e.g. SMRs, advanced modular reactors, LTO and AI): Capacity building and knowledge upgrade and management are some of the most powerful tools to address properly these challenges and profit from the opportunities.
- Active involvement of TSOs in R&D activities strengthen their independence in providing support to regulators.

SESSION 5: Role of TSOs in an International Context and for Embarking Countries

There were presentations from Ghana, Egypt, Germany, Nigeria, Jamaica and Canada.

The presentations covered the role of TSOs in enhancing nuclear safety and security and the importance of scientific and technical capacity building and fostering the sharing of best practices with other embarking countries were discussed. One presentation covered the establishment of a separate scientific research centre, with a vision to serve as TSO in the future. Another presentation identified the key obstacles that hinder a country's TSOs' ability to contribute to the regulatory framework including inadequate infrastructure, outdated equipment, political and administrative issues, and limited collaboration with stakeholders, which are all compounded by funding gaps. To overcome these barriers, the need for

substantial investment in upgrading infrastructure and equipment, enhancing international partnerships, and securing consistent government funding were emphasized. A research centre and service provider in Jamaica described a future work plan, that includes the process of being recognized as a TSO, including for other Caribbean countries.

A presentation was made on the role of a TSO in enhancing nuclear security abroad, based on an international, multidisciplinary and systematic approach of robust and efficient cooperation. The key takeaways included the importance of national and international networks, multidisciplinary competencies, facing challenges with an open mind, and the need for political will. Another presentation provided an overview of cooperative activities between the Canadian Nuclear Safety Commission (CNSC) and the US Nuclear Regulatory Commission (USNRC) on reviews of advanced reactor and small modular reactor designs that are being proposed to be deployed in both countries. The CNSC and USNRC are committed to building on lessons learned, to enable enhanced collaboration which includes engaging other regulators.

The session highlighted that building scientific and technical capacity is fundamental for the effective functioning of TSOs. This includes investing in education, training and infrastructure to address scientific and technical challenges. Effective interaction between TSOs and stakeholders is vital for addressing nuclear safety and security concerns. The capabilities of TSOs will be strengthened through national and international cooperation and will also contribute to capacity building. A holistic approach to risk and hazard management is necessary to address the complex challenges in nuclear safety and security. This involves comprehensive strategies that consider all aspects of risk.

In summary, the session recognized the need for the following:

- Invest in the development and strengthening of TSOs to ensure they can effectively support nuclear safety and security. This includes enhancing their scientific and technical capabilities including education and training programmes, to develop a skilled workforce capable of addressing nuclear safety and security challenges. IAEA may work on a safety guide to help member states in developing and strengthening their TSOs.
- Promote international cooperation and collaboration, including embarking countries, to share best practices, lessons learned, and engage in joint projects. This will enhance the global capabilities of TSOs and improve nuclear safety and security.
- Foster effective interaction between TSOs and stakeholders through transparent communication and collaboration. This will help build trust and ensure comprehensive risk management.

SESSION 6: Holistic Approach to Risk and Hazard Management

There were presentations from France, China, Zimbabwe, United States of America, Poland, Bangladesh, Russian Federation, Belgium and Indonesia.

The presentations included the following: leadership for safety, defined as a process of influence, among other managerial processes taking place within a complex and regulated organization such as a nuclear or radiological facility, and the reasons why leadership for safety is a pertinent notion for TSOs, also to support the development of effective assessment

capabilities needed by the safety authorities; the importance of defining the role of TSOs and stakeholders in nuclear safety and security that extends beyond regulatory bodies to include customs officials, law enforcement, and emergency response teams; impact of organizational culture in assimilating standards of nuclear safety and security interface from a TSO perspective, including a research model to assess the effectiveness of nuclear safety and security regulatory infrastructures; experience in assessing and maintaining safety culture, including the self-assessment methodology; and national mapping to determine the strengths and weakness of the three main supporting functions of TSOs, namely: technical support, scientific support and support for human resource development.

Other presentations covered research on classification management of nuclear safety components, including a component evaluation practice, and graded management of components; the role of risk analysis research in safety decision making, including advanced methodologies and tools for assessing and prioritizing risks, supporting graded approaches and integrated safety assessments, and is thereby better equipped to support a balanced approach to innovation and safety; a methodology for determining the most unfavourable meteorological conditions for the needs of siting of NPPs versus operational early warning system in the event of a failure at the NPP, including a combination of these two approaches using proprietary field models and trajectories to determine how a hypothetical incident at a future NPP could impact the environment; and building capacity of a TSO for independent compliance verification measurements of radioactive waste, in accordance with the clearance levels prescribed by the regulatory body, that will be input to the development of a strategy for the oversight of the clearance of waste from an upcoming decommissioning and dismantling programmes.

The session highlighted the need for international collaborative research involving TSOs, regulators and academia to address current and emerging challenges preparing for the future in a rapidly changing environment. Integrating a graded approach and comprehensive safety assessment into the regulatory framework may pose a significant challenge. A comprehensive understanding of risks through application of modern technologies and data-driven approaches allows for safety assessments to significantly enhance the resilience of nuclear facilities and activities. Participants emphasized that prioritizing regulatory focus and incorporating lessons from past events helps facilities better prepare for potential threats, ensuring strong defences against both common and rare incidents. Research-driven practices and infrastructure create a comprehensive safety framework that integrates reliability, human factors, and hazard analyses, ensuring nuclear facilities are well prepared for both routine operations and unforeseen events.

In summary, the session recognized the need for the following:

- Strengthen safety and security culture, among others, by self-assessment through leadership programmes.
- Build technical and human resource capacity: Encourage Member States to apply self-assessment tools like TOSCA to evaluate and strengthen their national TSO capacities.
- Ensure capacity building for young professionals.
- Adopt advanced risk assessment and management techniques: Develop advanced methodologies and tools for assessing and prioritizing risks and integrated safety assessments to better support innovation and safety, especially in rapidly evolving technological environments.
- Leverage technology and encourage innovation: Encourage research and development to utilize innovative tools, such as artificial intelligence, big data analytics and digital

twins, to improve decision making in safety and security evaluations and optimizing safety processes.
- Promote inclusive stakeholder engagement: Include diverse stakeholders in discussions on nuclear risk and hazard management to learn from stakeholders' experiences, ensuring continuous improvement in safety and security practices.

5. SPECIAL SESSIONS

TOSCA Methodology

There were presentations from France, Germany, Armenia and Ghana.

The presentations provided an overview on the TOSCA methodology, as well as some of the challenges for implementing TOSCA methodology and lessons learned from national TSO workshops conducted in South Africa, Norway, Ghana and Armenia. Key success factors of the self-assessment exercise remain on the strong commitment and leadership of the top decision makers, as well as a deep/thorough understanding of technical issues and organizational interactions required.

It is considered that TOSCA as a 3D management tool (regulatory functions, national priorities and development steps) is mature and flexible enough for its implementation in various contexts.

In summary, the session recognized the need for the following:

- A major key success factor for the implementation of the TOSCA Methodology is the strong commitment of the top management (leadership) during the self-assessment of the organisations with the tool as well as a deep understanding of the managerial and technical topics.
- Involvement of all relevant stakeholders for better awareness of the needs of the regulatory system at national and - if necessary - at regional level.
- Long-term and sustainable implementation of the workshop results in the national strategic plan and periodical repetition of the self-assessment.

TSO ROLE

In Part 1 of the session, there were presentations from Belgium, Slovenia, France, and Switzerland.

The presentations provided an overview of Sustainable network for Independent Technical Expertise of Radioactive Waste Management (SITEX.Network), a European initiative with 20 members, aimed at enhancing the expertise function in radioactive waste management; a literature study undertaken by the SITEX.Network on the deep borehole repository (DBR) of high-level radioactive waste; another literature study on the five ‘S’ in radioactive waste management — safety, security, safeguards, society and sustainability — and the challenges associated with managing the interfaces between them; and two benchmarking activities of the SITEX.Network.

In summary to Part 1, the session recognized the following:

- The SITEX.Network plays a crucial role in enhancing the expertise function in radioactive waste management, providing independent technical and scientific support to regulatory decisions, separate from waste management organizations.
- Collaboration with national regulatory authorities and civil society organizations is essential for ensuring high-quality, independent expertise in radioactive waste management.
- The study on DBR indicates that it could be a viable option for certain categories of radioactive waste and small inventories. However, extensive R&D is necessary to establish a solid safety case for DBR.
- Managing the interfaces between the five 'S' in radioactive waste management presents challenges. SITEX's literature review aims to identify potential conflicts, gains, and challenges in integrating these aspects.
- Benchmarking activities are valuable for identifying best practices, strengths, and weaknesses in current methodologies. These activities also promote long-term dialogue and engagement among stakeholders.
- Research and development are vital for addressing complex issues in radioactive waste management. The SITEX Network's strategic research agenda guides future research efforts, ensuring comprehensive safety evaluations and advancements in the field.

In Part 2 of the session, there were presentations from South Africa and Norway, and a panel discussion with representatives from Slovenia, Egypt, and Türkiye.

The presentations described South Africa's experience of enhancing nuclear safety and security through TSOs; and on the challenges and opportunities in the development of a TSO and on the Norwegian Radiation and Nuclear Safety Authority's (DSA) vision for a regional TSO in Central Asia. And the JSI's role in Slovenia as an example of how integrating nuclear engineering education with comprehensive nuclear research supports effective TSO functioning.

In summary to Part 2, the session recognized the following:

- There is a need to develop and improve education and training programmes to support nuclear safety and security, including fostering synergy between researchers and safety assessment experts.
- Participation in international networks and collaboration is crucial.
- Each country and region face unique challenges in developing TSOs, but there are opportunities for improvement and growth through strategic planning and international cooperation.
- The development of a TSO plan, whether at national or regional level, is essential.
- The session also discussed the unique challenges faced by embarking/developing countries and highlighted the importance of following and adapting IAEA guidance on TSO role (such as IAEA TECDOC 1835, requesting for IAEA TSO assist missions, including the use of the TOSCA methodology) to fit into and build on existing national capacity by conducting a comprehensive/in-depth analysis of technical needs, requirements, challenges and opportunities at the national level, including sustainability aspects.
- Integrating research, education, and TSO activities provides significant benefits, strengthening the overall effectiveness and functionality of TSOs.

6. ETSON AWARD FOR YOUNG PROFESSIONALS

The ETSON network annually rewards papers written by a team of young scientists from different TSOs by offering ETSON Awards, to be officially presented and attributed at ETSON conference or IAEA TSO Conference. ETSON's Junior Staff Program aims to enable young engineers and researchers from TSOs to get to know each other better, to improve their technical knowledge through international collaboration, and to develop their own European network of safety experts, in order to strengthen the cooperation among TSOs.

There were presentations from Czech, UK, Slovenia, France, and Switzerland.

- Analyses of potential consequences after a sever accident in a RBMK-1000 during the Russia-Ukraine conflict.
- An Experimental Investigation on the Role of Gamma Radiation on Zirconium Alloy Corrosion using Electrochemical Techniques.
- Comparative Numerical and Experimental Study of Taylor Bubble Dynamics in Counter-Current Flow.
- Tracking radioactive contaminants in the environment at the micro/nano scale through isotope geochemistry – IRSN.
- Effect of surface state of Alloy 182 weld metal on stress corrosion cracking initiation in high temperature high pressure water – PSI.

Mr. Van Haesendonck presented the second prize to Annesha Das and her team from PSI, for their paper on Effect of surface state of Alloy 182 weld metal on stress corrosion cracking initiation in high temperature high pressure water.

Mr. Niel, presented the first prize to Louise Darricau and her team from IRSN, for their paper on tracking radioactive contaminants in the environment at the micro/nano scale through isotope geochemistry.

Mr. Van Haesendonck and Mr. Neil thanked the IAEA for giving ETSON the opportunity to organize the event at the TSO conference. They stressed that, as always with the ETSON Awards, the papers and presentations were all of the highest quality, and scientifically very enriching.

- ## CLOSING OF CONFERENCE

Mr. Niel thanked Mr Grossi, and Ms Evrard, for hosting this fifth TSO Conference. He also thanked the Director of NSOC, Mr. Fuming Jiang, the Conference's Scientific Secretary, Mr. Lingquan Guo, and Mr. Dohyoung Kim, as well as the team involved for their efficient work in preparing and supporting the Conference. The smooth coordination and dedication shown by the Secretariat has been instrumental in ensuring the success of discussions during the week. He also extended his deepest gratitude to all the participants for their active participation and valuable contributions. He thanked all chairs and co-chairs, and all members of the Programme Committee, for their ongoing involvement during the week. Finally, he provided a summary and conclusions of the Conference (see Section 8 of this report).

Ms. Evrard thanked Mr. Niel, Mr. Van Haesendonck and Ms. Cheng for their dedicated roles and steadfast commitment during the conference. Ms. Evrard described some of the IAEA's

support to its Member States with regard to TSOs. The Secretariat provided support to the IAEA TSOF, which had gathered growing interest from IAEA Member States since its inception in 2010 and currently has 31 members from 26 IAEA Member States. Based on the recommendations from the previous international TSO conferences, the Agency, in close cooperation with the TSOF members, has developed IAEA-TECDOC-1835 – the first IAEA publication dedicated to the specific practices and challenges to be met by the TSOs. The publication outlined the services provided to support regulatory functions as well as the associated activities and processes to maintain the needed level of expertise, state of the art tools and equipment. The IAEA has worked closely with international experts to develop TOSCA, which assisted TSOs to identify gaps for development and sustainability of their technical and scientific capabilities to support regulatory functions. Based on the TOSCA methodology, since 2019, several national TSO workshops have been conducted by the IAEA in Member States, and some of those Member States had presented their feedback and experience of the self-assessment experience at the TOSCA special session during the conference. Ms. Evrard extended her warmest congratulations to all participants on the success of the important conference. Ms Evrard closed the conference.

- **SUMMARY AND CONCLUSIONS OF THE CONFERENCE**

1. The Conference recognized the critical link between expertise and research. Research infrastructures are essential for ensuring the continued evolution of nuclear and radiation safety. Therefore, TSOs should ensure the availability of the relevant infrastructures. Research is one of the key contributors to competence building needed for science-based expertise at the state of the art. Moreover, research and transparency of expertise enhance the independence of TSOs.
2. TSOs must contribute to the safety of innovative technologies, through research and expertise. From that point of view, TSOs need to pay special attention to artificial intelligence (AI), fusion and small modular reactor (SMR) technologies.
2. Disruptive events, such as climate change, pandemic, armed conflicts, etc, underline the need to foster resilience in managing the safety of nuclear facilities and activities. TSOs play a crucial role in developing this resilience capacity.
4. International collaboration between TSOs is even more important. TSO networks such as TSO Forum, ETSON and other regional networks play a crucial role, including for embarking countries, alongside industry and regulatory bodies networks. These networks are instrumental for the exchange of good practices, the harmonization of safety approaches and research cooperation.
5. TSOs must strengthen the relationship between TSOs and regulatory bodies. The contributions of TSOs play a crucial role in the scientific robustness of the regulatory functions. The conference considers that the contributions of TSOs to the nuclear safety infrastructure should be taken into account in the IAEA peer review processes, e.g. via the TOSCA Methodology.
6. The Conference highlighted the importance of maintaining expertise by attracting and retaining the younger generation. TSOs have a unique opportunity to enhance the attractiveness of nuclear careers, particularly for the younger generation and for both men and women. Through their work, TSOs showcase the values of independence, scientific inquiry, and innovation - qualities that are essential in drawing new talents to our field. In order to ensure nuclear safety, it is vital and of paramount importance that the younger generation meet the highest scientific and technical standards, strives for a strong safety culture and develops appropriate leadership skills. Education and training are instrumental in this endeavour.
7. The Conference recognized that one of the most effective ways to build common, sustainable approaches to the major challenges of tomorrow is through the exchange of experience and knowledge via experts among TSOs. TSOs need to actively promote these exchanges, especially between mature TSOs and those in embarking countries. These exchanges will help harmonize practices and enhance the skillsets of personnel in countries with or without nuclear power and embarking countries.