

# Nuclear Fuel Cycle and Waste Management

## Objective

To raise awareness and promote the implementation of a safe and sustainable fuel cycle and life cycle management for nuclear energy programmes and nuclear applications users, and contingency planning for post-incident situation. To support Member States in strengthening their own capabilities and trained human resources, or having access to the best available knowledge, technologies, services.

## Uranium Resources and Processing

The Agency issued *Geological Classification of Uranium Deposits and Description of Selected Examples* (IAEA-TECDOC-1842), which provides a new classification scheme with improved definitions of uranium deposits and encompasses the recent advances in understanding of uranium geology and deposit genesis. It also published *World Distribution of Uranium Deposits (UDEPO) 2016 Edition* (IAEA-TECDOC-1843), presenting information on worldwide uranium deposits, including, for the first time, preliminary statistical and tabular analysis of the data. The information from these publications was released as an on-line interactive and integrated digital map entitled *World Distribution of Uranium Deposits, Second Edition*. The map (Fig. 1) provides information by types of deposit and features enhanced functionality with layers and query capability.

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FIG. 1. The second edition of the World Distribution of Uranium Deposits (UDEPO) map.



FIG. 2. Workshop participants at a trial mine of the Gattar uranium deposit, Egypt.

In May, the Agency organized a Regional Training Course on Achieving and Maintaining Good Operational and Environmental Performance of Uranium Projects in the African Region, held in Hurghada, Egypt. At the workshop, 31 participants from 13 Member States, including early to mid-career scientists, engineers, technicians and regulators as well as senior professionals, concluded that considering environmental, radiation protection, social and industrial safety issues is important at all stages of uranium projects (Fig. 2).

In June, the Agency issued *Uranium Resources as Co- and By-products of Polymetallic, Base, Rare Earth and Precious Metal Ore Deposits* (IAEA-TECDOC-1849) to raise awareness of the potential presence of uranium in ore deposits that are not commonly thought of as containing uranium, and thus to highlight potential additional sources of uranium.

The Agency's Interregional Workshop on Case Study of In-situ Leach Project: From Exploration to Closure, held in Beijing in August, enabled 55 participants from 9 Member States to exchange technical knowledge on in situ leaching of uranium, with an emphasis on China's experience. In October, the Agency organized an Interregional Workshop on Aspects of Effective Safety Practices and Implementation of a Conventional Safety Programme in Uranium Mines and Mills, in Adelaide, Australia. At the workshop, 17 participants from 15 Member States exchanged information on good practice in industrial mine safety programmes, an essential complement to radiation protection at uranium mines and mills.

The Agency issued *Unconformity-related Uranium Deposits* (IAEA-TECDOC 1857) in November, describing existing and emerging technologies for effective integration of geological, geophysical and geochemical data to recognize a deposit's 'footprint'. Improved understanding of the characteristics of such deposits is expected to help refine exploration and evaluation strategies.

The 27th edition of the joint IAEA–OECD Nuclear Energy Agency publication *Uranium 2018: Resources, Production and Demand*, also known as the 'Red Book', was published in December. It provides the most recent review of world uranium market fundamentals and presents a statistical profile of the world uranium industry, including data from 41 uranium producing and consuming countries. One of the main findings of the publication is that the world's supply of uranium is more than adequate to meet projected demand for the

foreseeable future, provided investment is secured to ensure that identified resources can be brought into production in a timely manner. Also in December, the Agency published *Quantitative and Spatial Evaluations of Undiscovered Uranium Resources* (IAEA-TECDOC-1861), providing an overview of aspects of the uranium production cycle, including an evaluation of the global uranium supply and demand situation.

## Nuclear Power Reactor Fuel

Forty experts from 12 Member States attended the Technical Meeting on Light Water Reactor Fuel Enrichment beyond the 5% Limit: Perspectives and Challenges, held in Moscow in August. Participants exchanged views on national perspectives, R&D progress and results, and related licensing issues for the use of fuel enrichment above the 5% limit in light water reactors.

The Agency issued *Accelerator Simulation and Theoretical Modelling of Radiation Effects in Structural Materials* (IAEA Nuclear Energy Series No. NF-T-2.2), summarizing the findings and conclusions of the coordinated research project (CRP) entitled 'Accelerator Simulation and Theoretical Modelling of Radiation Effects (SMoRE)'. The four year project supported Member States in the development of advanced radiation resistant structural materials for use in innovative nuclear systems.

During the Technical Meeting on Nuclear Fuel Cycle Facilities: Information System and Ageing Issues, held in Vienna in October, ten experts from ten Member States presented and discussed country reports on nuclear fuel cycle facilities and their general trends and projections.

## Management of Spent Fuel from Nuclear Power Reactors

A Technical Meeting on the Management of Spent Fuel at Shutdown Reactor Sites, Including Those to Be Shut Down Prematurely was held in Vienna in June, attended by nine experts from eight Member States and an international organization. At the meeting, operators discussed different plans for managing spent fuel at shutdown nuclear power plants and the issues associated with spent fuel management over the long term. The information obtained during the meeting will be consolidated and published as an IAEA Technical Document and used to update global inventories of spent fuel at shutdown reactor sites.

In July, 29 experts from 19 Member States participated in the Technical Meeting on Integrated Approaches to the Back End of the Fuel Cycle, where they discussed and analysed how decisions made in one part of the nuclear fuel cycle may affect its back end. The meeting participants also identified processes and best practices for a holistic approach to the fuel cycle, with an emphasis on all potential impacts on spent fuel (re)processing, recycling, storage, transport and disposal.

## Radioactive Waste Management

Member State demand for the Agency's peer review and advisory services continued to increase. At the request of Member States, the Agency completed five Integrated Review Service for Radioactive Waste and Spent Fuel Management, Decommissioning and Remediation (ARTEMIS) missions, to Brazil, Bulgaria, France, Italy and Luxembourg, and a combined ARTEMIS and Integrated Regulatory Review Service (IRRS) mission to Spain. It received a further seven Member State requests for ARTEMIS reviews, to be conducted in the next few years.

The Agency organized a meeting in Vienna in November, where 14 experts shared lessons from recent ARTEMIS missions, which will be included in the ARTEMIS guidelines, as appropriate.

The Agency held a Technical Meeting on the Current Status of the Predisposal Management of Institutional Radioactive Waste at its Headquarters in Vienna in July. More than 30 participants from 25 Member States reviewed trends in the processing and storage of institutional radioactive waste, and areas that require special consideration and further development. These reviews will be published in a technical report that will also include case studies, in order to provide updated information on institutional radioactive waste processing and storage technologies and facilities. In March, the Agency organized a Technical Meeting on Methodologies and Approaches to Address Challenges in Managing Radioactive Waste from Past Activities, to gather the experiences of Member States in managing legacy waste inventories, including information on the barriers to implementing successful management of such inventories, strategies to facilitate cleanup activities and actions that need to be taken now in order to avoid waste streams becoming legacy waste in the future. The meeting, held in Vienna, was attended by 26 participants from 14 Member States.

The Agency finalized the structure of its Nuclear Communicator's Toolbox, which provides a range of resources to assist in the communication of nuclear matters to the public and the media. It also held a Technical Meeting on Learning from the Experiences of Local Communities on Stakeholder Involvement in Radioactive Waste Management Programmes, with 95 participants from 25 Member States and an international organization. The participants shared experiences and lessons learned on topics related to local stakeholder involvement in radioactive waste management and provided input for a new publication on this topic.

The Agency launched two new CRPs in the field of radioactive waste management in 2018. The CRP entitled 'Management of Wastes Containing Long-lived Alpha Emitters: Characterization, Processing and Storage' is aimed at increasing the understanding of the inventory, diversity and methods of handling wastes containing long lived alpha emitters. The CRP entitled 'Developing a Framework for the Effective Implementation of a Borehole Disposal System' focuses on the development of a standardized set of technical specifications, procedures, guidance and training material to address all aspects of a disposal programme and to make this disposal solution more readily implementable by Member States.

In 2018, the Agency completed the development of its on-line course on disused sealed radioactive sources (DSRSs) and published it on the Cyber Learning Platform for Network Education and Training (CLP4NET). To enhance the use of e-learning modules, the Agency made a number of e-learning modules available off-line, and developed and translated into other languages training courses based on e learning modules.

The Agency, in cooperation with the European Commission and the Nuclear Energy Agency of the Organisation for Economic Co-operation and Development, held the Annual Meeting on the Status and Trends Project on Spent Fuel and Radioactive Waste, in Luxembourg in July. At the meeting, 30 participants from 14 Member States reviewed the second project report, which provides an updated overview of the global arisings of spent fuel and radioactive waste and provisions for their long term management. The first project report, entitled *Status and Trends in Spent Fuel and Radioactive Waste Management* (IAEA Nuclear Energy Series No. NW-T-1.14), was published in January.

The Agency also published *Options for Management of Spent Fuel and Radioactive Waste for Countries Developing New Nuclear Power Programmes* (IAEA Nuclear Energy Series No. NW-T-1.24 (Rev. 1)), an update of guidance originally published in 2013. The revised publication provides a summary of key issues related to the development of a sound radioactive waste and spent nuclear fuel management system.

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## *Management of Disused Sealed Radioactive Sources*

At the request of Member States, the Agency completed a project to remove 27 Category 1 and 2 DSRSs from Bolivia, Ecuador, Paraguay, Peru and Uruguay. The five month project was completed in March with the transport of the sources to Germany and the United States of America for recycling. Another three Category 1 and 2 DSRSs were removed from Lebanon and sent back to Canada. The Agency also supported the training of about 80 experts from more than 45 Member States in conditioning, and safe and secure management of Category 3 to 5 DSRSs. Missions to condition DSRSs were conducted to Chile, Ghana, Indonesia, Jordan, Malaysia, Malta, Sri Lanka and Viet Nam.

Over 80 Member State delegates attended the Agency's side event entitled 'Innovative Solutions for the Effective Management of Disused Sealed Radioactive Sources' held in Vienna in September, during the 62nd regular session of the General Conference. The event highlighted different technologies for the management of DSRSs and how they are used in different national settings and conditions. It also featured a hands-on demonstration of safe handling of DSRSs (Fig. 3).



FIG. 3. Agency experts demonstrate safe handling of DSRSs (with mock objects) at the 62nd regular session of the General Conference.

## **Decommissioning and Environmental Remediation**

### *Decommissioning*

The second phase of the Agency's international collaborative project on Data Analysis and Collection for Costing of Research Reactor Decommissioning (DACCOR) made significant progress, including the development of methodologies and associated software to analyse uncertainties in cost estimates. At an Agency technical meeting held in Vienna in October, 29 participants from 26 Member States contributed to the development of the final report of the project, including determination of the detailed decommissioning costing cases to be addressed, costing implications of different strategies for facility characterization, and approaches to addressing uncertainty and risk in decommissioning cost estimates.

The Agency's on-site support in the decommissioning of the FOTON research reactor in Tashkent resulted in the release of the site from regulatory control in September, followed by the conventional demolition of buildings and structures on the site.

In November, the Agency conducted the fourth international peer review of Japan's Mid-and-Long-Term Roadmap towards the Decommissioning of TEPCO's Fukushima Daiichi Nuclear Power Station Units 1-4 and delivered a preliminary summary report on the progress made. The report acknowledges Japan's significant progress towards a stable situation since the accident in March 2011, which will enable Japan to focus more resources on detailed planning and implementation of decommissioning activities on the whole site.

The Agency published *Lessons Learned from the Deferred Dismantling of Nuclear Facilities* (IAEA Nuclear Energy Series No. NW-T-2.11), providing a consolidated review of experience and practical guidance on planning, managing and implementing the safe enclosure of shutdown nuclear facilities. It also launched an initiative to produce a report outlining training and human resources needs for decommissioning of nuclear facilities.

The Agency's International Decommissioning Network (IDN) continued to promote collaboration and information sharing, including through the development of the wiki based resource on decommissioning technologies and case studies from ongoing decommissioning projects. More than 100 case studies from decommissioning projects were uploaded to the IDN wiki in 2018, bringing the total number to 280. Together with descriptions of about 130 technological processes used in decommissioning, this information is shared with decommissioning experts all over the world as members of IDN.

### *Environmental remediation*

The Agency organized the ninth annual Plenary Meeting of the Network on Environmental Management and Remediation (ENVIRONET) in Vienna, from 30 October to 1 November. The meeting's 50 participants from 24 Member States reviewed the status of the different projects conducted under the auspices of ENVIRONET, discussed possible improvements and suggested future activities. By sharing outcomes of several projects through ENVIRONET, the Agency helped Member States to develop their remediation programme strategies, such as for the remediation of uranium mining legacy sites in Bulgaria.

In April, the Agency organized a Practical Training Course on Planning and Implementation of Nuclear Facility Decommissioning and Remediation of Radioactively Contaminated Sites, held at Argonne National Laboratory in the United States of America and attended by 20 experts from 17 Member States. The course presented aspects of decommissioning and remediation that can constrain or delay project implementation as well as potential mechanisms that can assist in overcoming them. The course will serve as the basis for the development of an Agency School of Environmental Remediation.

The Agency supported the first European NORM Association workshop and organized a Technical Meeting on Naturally Occurring Radioactive Material, held concurrently in Katowice, Poland, in November. Among the objectives of these events were the development of project guidance on inventory of naturally occurring radioactive material (NORM) waste at the national level, formulation of NORM policy and strategy, and cost estimates of NORM waste management approaches.

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