Nuclear Fuel Cycle and Waste Management

Objective

To support Member States in raising awareness and promoting sustainable (safe, secure, effective, innovative) fuel cycle and life cycle management for nuclear energy programmes and nuclear applications users, and contingency planning for a post-incident situation. To support Member States in strengthening their capabilities and human resources, or having access to the best available knowledge, technologies and services.

Uranium Resources and Processing

The new publication *A Preliminary Inventory and Assessment of Uranium Resources in Mine Wastes* (IAEA-TECDOC-1952) provides an initial framework to integrate the goal of comprehensive extraction in the uranium mining industry with environmental and remediation considerations in achieving zero waste.

The Agency published *World Distribution of Uranium Provinces and World Distribution of Thorium Deposits*, also referred to as the 'uranium map' and the 'thorium map', respectively, that display, at a scale of 1:35 000 000, the distribution of uranium and thorium deposits and related resource statistics worldwide.

The 57th Meeting of the Joint OECD/NEA–IAEA Uranium Group was held virtually to coordinate the preparation of the periodic assessment of the global supply of natural uranium and to examine these supply capabilities in relation to the projected demand for natural uranium.

Nuclear Power Reactor Fuel

The new publication *Coolant Chemistry Control and Effects on Fuel Reliability in Pressurized Heavy Water Reactors* (IAEA-TECDOC-1942) presents up to date knowledge on the topic including corrosion phenomena in primary heat transport systems and consequent effects on fuel reliability in pressurized heavy water reactors.

The Agency's *Progress on Pellet–Cladding Interaction and Stress Corrosion Cracking: Experimentation, Modelling and Methodologies Applied to Support the Flexible Operation of Nuclear Power Plants* (IAEA-TECDOC-1960) captures the conclusions of a Technical Meeting held in 2019, providing an overview of pellet–cladding interaction and stress corrosion cracking studies, and reports on progress made since the early 2000s.

Participants in the Technical Meeting on the Design, Fabrication and Irradiation Behaviour of Small Modular Reactor Fuels, held virtually, exchanged information on recent experiences in, and future improvements needed for, the development of small

modular reactor fuels and provided input for future Agency publications on this topic.

The First Research Coordination Meeting on Testing, Modelling and Simulations for Accident Tolerant and Advanced Technology Fuels, held virtually, provided an opportunity to assess research plans proposed by participants in relation to the overall objectives of the related coordinated research project (CRP).

Management of Spent Fuel from Nuclear Power Reactors

The new publication *Phenomenology, Simulation and Modelling of Accidents in Spent Fuel Pools* (IAEA-TECDOC-1949) summarizes the results of a Technical Meeting that reviewed the analysis, simulation and modelling of severe accidents in spent fuel pools.

The Agency published *Status and Trends in Pyroprocessing of Spent Nuclear Fuels* (IAEA-TECDOC-1967), which identifies gaps and technologies requiring further development in pyrometallurgical processes applied to spent nuclear fuel recycling.

The publication *Spent Fuel Performance Assessment and Research: Final Report of a Coordinated Research Project* (SPAR-IV) (IAEA-TECDOC-1975) gives an overview of technical issues related to wet and dry storage and summarizes the objectives and major findings of the related CRP.

Radioactive Waste Management

At an Agency Workshop on Waste Management for Fusion, experts developed specific guidelines for radioactive waste management for future fusion demonstration and pilot power plants.

The Agency published *Decontamination Approaches During Outage in Nuclear Power Plants — Experiences and Lessons Learned* (IAEA-TECDOC-1946), which describes new or improved decontamination techniques and processes to reduce radiation exposures and secondary waste during nuclear power plants outages.

The Joint IAEA–ICTP International School on Radioactive Waste Package Performance Testing, held virtually, promoted exchange of experience of low and intermediate level waste performance testing.

The Agency conducted an Integrated Review Service for Radioactive Waste and Spent Fuel Management, Decommissioning and Remediation (ARTEMIS) peer review mission to Ireland. The country had requested this Agency review to fulfil its obligations under Article 14.3 of European Council Directive 2011/70/Euratom of 19 July 2011 establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste.

Management of disused sealed radioactive sources

The Agency continued its support for the management of disused sealed radioactive sources in Colombia, the Congo, Cyprus, Ecuador and Tunisia. The removal of a high activity caesium-137 source from Bahrain was carried out with virtual oversight from the Agency, owing to COVID-19-related constraints.

The Global Radium-226 Management Initiative was launched during the 65th regular session of the General Conference, providing a platform to facilitate contact between donor and recipient countries in addressing issues of existing radium-226 stocks.

Decommissioning and Environmental Remediation

Decommissioning

The publication *Data Analysis and Collection for Costing of Research Reactor Decommissioning: Final Report of the DACCORD Collaborative Project* (IAEA Nuclear Energy Series No. NW-T-2.12) includes a detailed analysis of decommissioning costs for 20 research reactors, with diverse designs and located in various countries. It provides information on unit factors for research reactor decommissioning, and a basis for estimating uncertainties and contingencies and for assessing the impact of decommissioning planning and characterization activities.

The Agency conducted an ARTEMIS review of the Japan Atomic Energy Agency's *Back-end Roadmap*, considering the overall adequacy of all steps in the 70-year decommissioning and waste management programme. A final report identifying good practices, recommendations and suggestions was delivered to the host.

The Agency conducted the fifth international peer review to assist the Government of Japan in the implementation of the revised 'Mid-and-Long-Term Roadmap towards the Decommissioning of TEPCO's Fukushima Daiichi Nuclear Power Station Units 1–4'. The review team provided advice on project management, interactions with the public, research and development, and maintenance of infrastructure on site.

The Agency organized the Nuclear Back End Webinar Series, which helped disseminate good practices and lessons learned in decommissioning nuclear facilities, in addressing progress and prospects at the Fukushima Daiichi and Chornobyl nuclear power plants, in costing of research reactor decommissioning, in circular economy principles and in decommissioning within multi-facility sites.

Environmental remediation

The publication *Managing the Decommissioning and Remediation of Damaged Nuclear Facilities* (IAEA-TECDOC-1989) summarizes the outcomes of the Agency-led International Project on Managing the Decommissioning and Remediation of Damaged Nuclear Facilities, and provides guidance for decommissioning and remediating accident damaged nuclear facilities based on case studies and lessons learned.

The Agency delivered ten webinars in collaboration with members of the Network on Environmental Management and Remediation on contaminated site remediation and management of naturally occurring radioactive material, including four working groups (Africa, Asia, Europe and Latin America) addressing regional challenges.

The Agency conducted a Workshop on the Characterization of Radioactively Contaminated Land, which included hands-on training in taking measurements and interpreting results at the Agency's Seibersdorf laboratories (Fig. 1).

FIG. 1. Participants undergo training in sampling during the Workshop on the Characterization of Radioactively Contaminated Land.

CASE STUDY

China Begins Construction of Its First Underground Research Laboratory for High Level Waste Disposal

In 2021, supported by the Agency with over three decades of research, China began the construction of its first underground laboratory for the disposal of high level waste (HLW). It will help determine the area's suitability for future geological disposal of such waste, generated in China's more than 50 operational nuclear power reactors. Scientists will use the laboratory to characterize and assess the geological, hydrological, geochemical and engineering characteristics of the rocks at the site.

HLW can remain radioactive from thousands to hundreds of thousands of years. The internationally accepted solution for its safe and secure long term management is geological disposal in facilities several hundred metres underground.

The Agency has been supporting China in identifying a suitable site for a HLW repository since 1999. The country's strategy for HLW disposal started with laboratory studies and preliminary site selection. In 2021, underground in situ testing started and will continue to 2050. The construction of the disposal facility is planned from 2041 to 2050, assuming the in situ testing confirms the area's suitability.

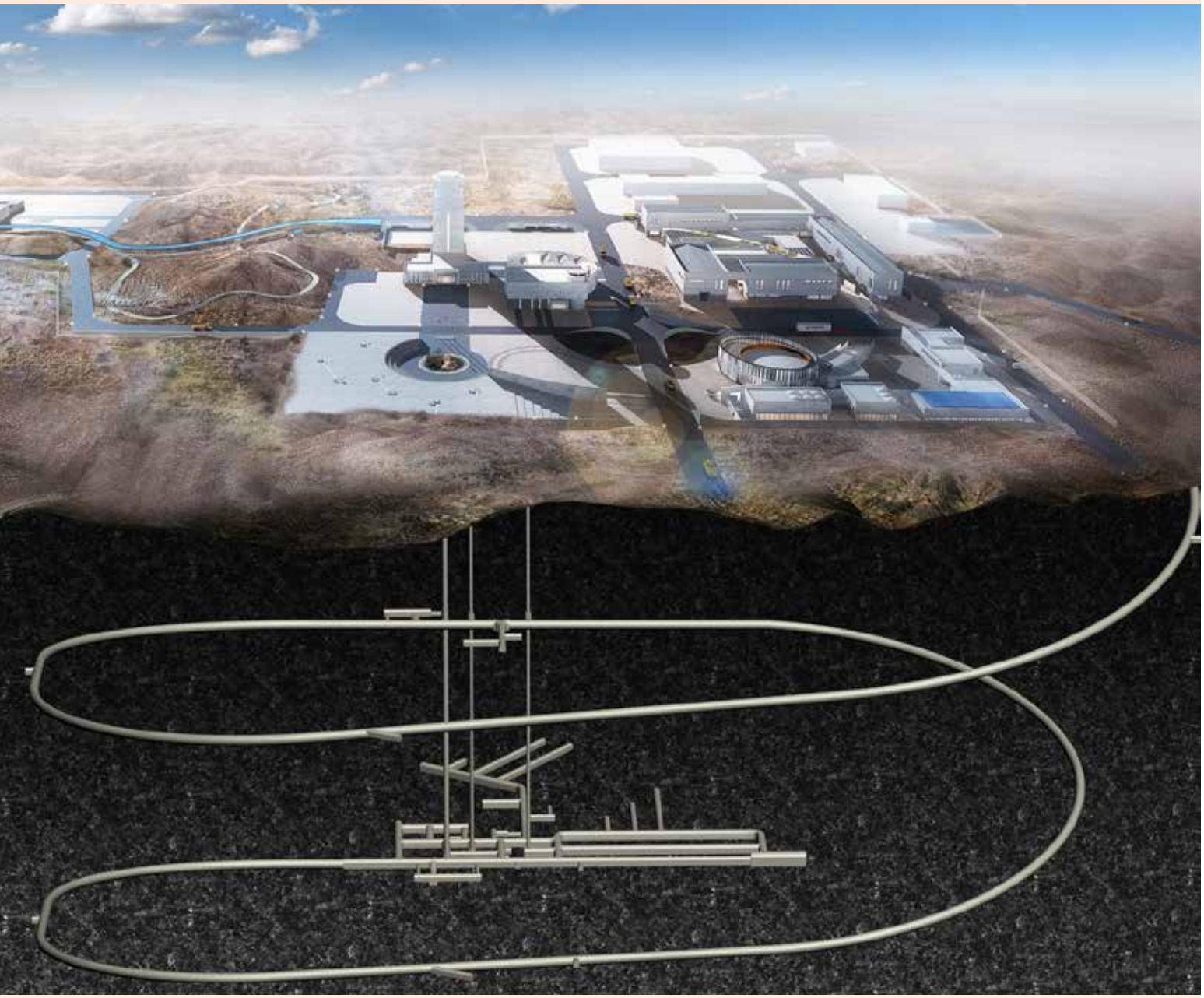
With the Agency's support, 35 Chinese and 11 international experts took part in a six-week virtual expert mission in 2021 to provide input, guidance and recommendations to support plans for the in situ laboratory.

"The construction of an underground research laboratory is an opportunity for advancement in the science and engineering of geological disposal facilities and an essential component in a sustainable energy future for countries," said Stefan Joerg Mayer, Head of the Agency's Disposal Team. "Due to the constraints of the pandemic, we designed, organized and lead an innovative virtual mission to provide expert assistance to China in the construction of this new research and development facility."

The mission took place through a series of 14 on-line, interactive meetings. The experts reviewed and assessed the plans for the construction of the underground research laboratory. They also reviewed the preparations being made for the development of a safety case for the disposal facility as well as for stakeholder engagement.

"The Beijing Research Institute of Uranium Geology (BRIUG) requested the Agency to provide support on characterization of the rock mass, as well as scientific research, prior to the construction of the underground research laboratory," said Petra Salame, Agency Programme Management Officer. "Through this innovative way of organizing the expert mission, we were able to bring together a team of senior experts who addressed a broad range of topics that were proposed by our Chinese counterparts."

The broad range of areas covered resulted in recommendations related to construction, as well as guidance related to the implementation of the laboratory research and development plans during the construction phase.



The underground research laboratory will allow Chinese scientists to fully characterize the site's geology and determine its suitability for a high level waste repository. (Photograph courtesy of the Beijing Research Institute of Uranium Geology.)