

Nuclear Fuel Cycle and Materials Technologies

Objective

To advance the development and implementation of an increasingly safe, reliable, efficient, proliferation resistant and environmentally sustainable nuclear fuel cycle (NFC), providing the maximum benefit to Member States. To assist and support Member States in strengthening their capabilities and improving practices in radioactive waste management (RWM), decommissioning and remediation of contaminated sites and to support States embarking on nuclear power and developing countries to develop necessary RWM infrastructure. To collect data on damaged fuel and storage facilities and to assist Member States discuss and share ideas and information on nuclear fuel behaviour under severe conditions. To assist Member States in decommissioning nuclear sites affected by accidents and to remediate off-site contaminated areas.

Uranium Resources and Production

The Agency's UDEPO (World Distribution of Uranium Deposits) database provides reliable, up-to-date information on the technical, geographical and geological characteristics of uranium deposits around the world. It covers not only operational mines but also depleted or dormant uranium mines, in order to provide an overview of past operations and future possibilities, in addition to the information on existing uranium production. Significant progress was made towards updating and expanding UDEPO to include more spatial and statistical data. Information on more than 700 additional uranium deposits was collated and about 800 location coordinates were added to existing deposits, primarily as a result of the UDEPO consultancy meeting held in Vienna in June.

The Agency held two workshops on uranium exploration and assessment methods in Argentina in 2016 — one in Mendoza, in April, with 71 participants from 13 Member States and one in Buenos Aires, with 46 participants from 15 Member States. The workshops highlighted uranium exploration methods and new techniques for quantifying uranium potential. The Agency took part in the 53rd meeting of the Joint OECD/NEA-IAEA Uranium Group, held in Buenos Aires in October with 32 participants from 19 Member States. During the meeting, the OECD Nuclear Energy Agency (OECD/NEA) and Euratom provided an update on uranium production cycle activities in their member countries.

The 26th edition of the joint IAEA-OECD/NEA publication *Uranium 2016: Resources, Production and Demand*, also referred to as the 'Red Book', was published in November (Fig. 1). It reported that, as of 1 January 2015, the annual world uranium production of 55 975 tonnes of uranium provided about 99% of current annual world reactor requirements, with the remainder supplied by previously mined uranium. The uranium resource base is considered to be more than adequate to meet projected requirements for the foreseeable future. The Agency also published *In Situ Leach Uranium Mining: An Overview of Operations* (IAEA Nuclear Energy Series NF-T-1.4), in December. The report provides an overview

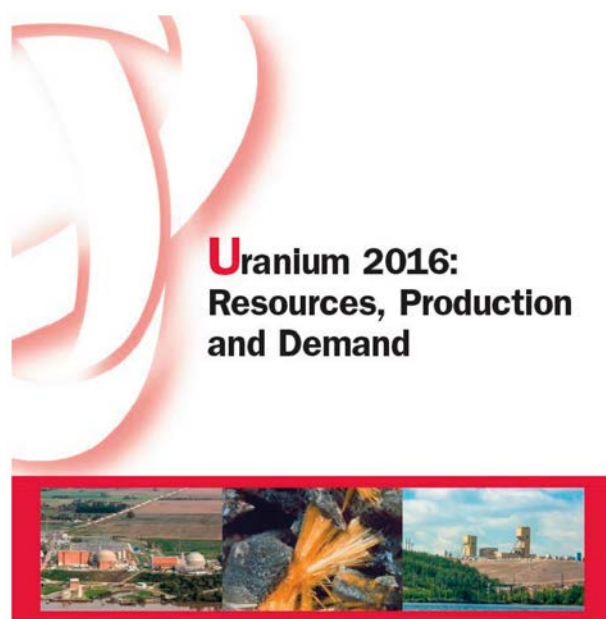


FIG. 1. The joint IAEA–OECD/NEA publication *Uranium 2016: Resources, Production and Demand*, also referred to as the ‘Red Book’, was published in November.

of in situ leaching (ISL) technology and its application, covering operational experience worldwide for a number of active and dormant ISL mines.

The Agency’s technical and training meetings on the uranium production cycle were well attended throughout 2016. In total, more than 500 participants from over 50 Member States attended meetings on uranium and related topics held by the Agency in Argentina, Austria, Brazil, Mongolia, Morocco, Nigeria, Sri Lanka and the United States of America.

Nuclear Power Reactor Fuel

The Agency supported cooperative research and assisted Member States in sharing information on the development, design, manufacture and performance assessment of fuel for all types of nuclear power reactor. Particular emphasis was given to the development of fuels with increased accident tolerance and the analysis of fuel behaviour under accident conditions. In June, the Agency held the second Research Coordination Meeting (RCM) of the coordinated research project (CRP) entitled ‘Fuel Modelling in Accident Conditions’ (FUMAC), launched in 2014 with 21 partners from 17 Member States. The participants presented the results of the activities carried out since the first RCM, demonstrating the capability of existing fuel performance codes to describe fuel behaviour under accident conditions. The CRP entitled ‘Reliability of High Power, Extended Burnup and Advanced PHWR Fuels’, which was started in 2014 with six partners from six Member States, held its second RCM in Buenos Aires, Argentina, in May. Participants discussed fuel performance issues arising from increased power and burnup in fuels for pressurized heavy water reactors, such as increased release of gaseous and volatile fission products, pellet–cladding interaction, and degradation of thermophysical properties of fuel and stress corrosion cracking.

In June, the Agency published *Accident Tolerant Fuel Concepts for Light Water Reactors*, the proceedings of a Technical Meeting held at Oak Ridge National Laboratory, United States of America (IAEA-TECDOC-1797). *High Burnup Fuel: Implications and Operational Experience*, the proceedings of a Technical Meeting held in Buenos Aires, Argentina, was published in August (IAEA-TECDOC-CD-1798).

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In October, the Agency held a consultancy meeting in Vienna to begin drafting a review of fuel failures from 2006 to 2015. The report will be an update of *Review of Fuel Failures in Water Cooled Reactors* (IAEA Nuclear Energy Series No. NF-T-2.1), published in 2010 and covering the period from 1994 to 2006.

Management of Spent Fuel from Nuclear Power Reactors

The CRP entitled ‘Demonstrating Performance of Spent Fuel and Related Storage System Components during Very Long Term Storage’ was concluded in 2016. The project’s third and final RCM was held in April in Santander, Spain, followed in June by a consultancy meeting held in Vienna to finalize a report on the findings. In October, the first RCM of a CRP entitled ‘Spent Fuel Performance Assessment and Research — Phase IV’ (SPAR-IV) was held in Vienna. This new CRP is aimed at developing a technical knowledge base on the long term behaviour of power reactor spent fuel and storage system materials. Eleven partner institutions from nine Member States will provide input on operating experience and research.

The Agency held consultancy meetings on management strategies for separated plutonium, lessons learned in the development of fuel cycles, and heat removal in spent fuel storage. Experts attending the meetings shared information and best practices on these topics. At two other consultancy meetings, held in Vienna in April and December, experts finalized the technical content of seven e-learning modules covering the various steps of spent fuel management prior to disposal, including reprocessing.

At a Technical Meeting on Advanced Fuel Cycles for Waste Burden Minimization, held in Vienna in June, 15 participants from 7 Member States discussed spent fuel processing technologies in terms of waste strategies, and assessed the technological readiness of various fuel cycle options and their related implementation challenges. At another Technical Meeting held in Vienna in June, 21 experts from 13 Member States and the European Commission shared best practices in applying the concept of ‘design extension conditions’ to operating spent fuel storage facilities.

Radioactive Waste Management, Decommissioning and Environmental Remediation

The Agency addressed the wide range of radioactive waste challenges across its Member States through more than 70 technical cooperation projects in 2016. In November, the Agency conducted a peer review of the project to build and operate France’s first deep geological disposal facility for high and intermediate level radioactive waste. During the year, it further developed draft guidelines and a self-assessment module for ARTEMIS, the Agency’s new Integrated Review Service for Radioactive Waste and Spent Fuel Management, Decommissioning and Remediation. In 2016, the Agency received three requests from Member States for an ARTEMIS mission.

New e-learning materials on decommissioning, radioactive waste management, environmental remediation and the management of disused sealed radioactive sources (DSRSs) were added to the learning management system on the Cyber Learning Platform for Network Education and Training (CLP4NET).

Radioactive waste management

In November, the Agency organized the International Conference on the Safety of Radioactive Waste Management, held in cooperation with the European Commission and the OECD Nuclear Energy Agency (OECD/NEA). The meeting was attended by

276 participants from 63 Member States. Conference participants highlighted the need for continued assistance to Member States for building and strengthening the capacities of both regulators and operators.

In response to Member State interest in multinational disposal facilities, the Agency published *Framework and Challenges for Initiating Multinational Cooperation for the Development of a Radioactive Waste Repository* (IAEA Nuclear Energy Series No. NW-T-1.5), in March.

To further promote the benefits of reporting inventories of spent nuclear fuel and radioactive waste, the Agency continued its close cooperation with the European Commission and the OECD/NEA on preparing the tripartite report ‘Status and Trends in Spent Fuel and Radioactive Waste Management’. This report incorporates authorized submissions from 47 Member States, covering over 90% of the nuclear power plants ever constructed, and is supported by the Agency’s Net Enabled Waste Management Database.

The Agency continued to operate and improve its waste benchmarking system for water cooled, water moderated reactors. This benchmarking is aimed at helping Member States share best practices between waste management operators of this type of nuclear power plant in order to minimize waste arising during operation.

In May, the Agency published *Processing of Irradiated Graphite to Meet Acceptance Criteria for Waste Disposal* (IAEA-TECDOC-1790), the final report of a CRP bearing the same name.

Decommissioning and environmental remediation

Over 540 participants from 54 Member States and four international organizations attended the International Conference on Advancing the Global Implementation of Decommissioning and Environmental Remediation Programmes, held by the Agency in Madrid, Spain. Conference participants raised awareness of the growing need to address the legacy of past nuclear activities, identified priority areas and recommended strategies for improving the safe and effective implementation of decommissioning and environmental remediation programmes.

During 2016, the Agency published two reports on topics in this area: *Managing the Unexpected in Decommissioning* (IAEA Nuclear Energy Series No. NW-T-2.8), in March, and *Advancing Implementation of Decommissioning and Environmental Remediation Programmes – CIDER Project: Baseline Report* (IAEA Nuclear Energy Series No. NW-T-1.10), in April.

Management of disused sealed radioactive sources

The Agency provided support for assessments of the available options for the management of DSRs, including co-disposal with other waste at suitable facilities, recycling and repatriation, and disposal in dedicated boreholes. Borehole disposal projects were at various stages of development in several countries, including Ghana, Malaysia and the Philippines.

A number of successful operations were conducted in 2016 to remove DSRs from user premises and to bring them under proper storage conditions. The repatriation of four French origin Category 1 DSRs — one each from Lebanon and Tunisia and two from Cameroon — was completed during the year. One Category 1 disused source was removed from a teletherapy head in Uganda and transferred to safe and secure storage. Two Category 1 disused sources were removed from a hospital and placed into safe and secure storage in Jordan. The Agency initiated removals of Category 1 and 2 sources in several Member States, including Albania, Burkina Faso, Lebanon and the former Yugoslav Republic of Macedonia, with removals scheduled for completion in 2017 (Fig. 2). Agency-supported operations to train local personnel and to condition DSRs were completed in Indonesia, Malaysia, Nepal, the Philippines, Thailand and Viet Nam.

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The Agency extended access to the International Catalogue of Sealed Radioactive Sources and Devices to many nominees in Member States, making the identification of DSRs found in the field easier. Efforts to add more details on sources and devices were initiated in 2016, to further improve the usefulness of the catalogue.



FIG. 2. Preparing for removal of a Category 1 disused sealed radioactive source from Lebanon.