

# Nuclear Fuel Cycle and Materials Technologies

## Objective

*To advance the development and implementation of an increasingly safe, reliable, economically efficient, proliferation resistant and environmentally sustainable nuclear fuel cycle, providing the maximum benefit to Member States. To implement relevant actions under the [IAEA] Action Plan [on Nuclear Safety], including the collection of data on damaged fuel and storage facilities at the Fukushima Daiichi nuclear power plant and the strengthening of information exchange on nuclear fuel under severe conditions.*

## Uranium Resources and Production

Sustainable uranium production is critical for sustainable development of nuclear power. In 2015, the Agency focused on efforts to help Member States increase sustainable uranium production and to use uranium resources more efficiently. In this connection, it organized the Leadership Academy on Sustainable Uranium and Critical Materials Production from Phosphates and Other Sources, held in August in Nanchang, China (Fig. 1). Over 50 experts from 25 countries discussed the challenges faced by the mining industry, and by the uranium industry in particular. Participants also discussed the project design, management and implementation skills and competencies that are critical for projects to extract uranium from phosphates and other unconventional sources.



FIG. 1. The Leadership Academy on Sustainable Uranium and Critical Materials Production from Phosphates and Other Sources was hosted by the East China University of Technology, in Nanchang, China. (Photograph courtesy of ECUT.)

In November, at the 52nd Meeting of the Joint OECD/NEA–IAEA Uranium Group, held in Vienna, 48 delegates from 30 countries discussed the latest estimates of worldwide uranium supply and demand. The discussion results will serve as input to the forthcoming *Uranium 2016: Resources, Production and Demand*, also referred to as the ‘Red Book’. At a Technical Meeting on Spatial and Quantitative Uranium Resource Assessments held in November in Vienna, 35 delegates from 21 countries discussed how methodologies for estimating undiscovered resources developed for other minerals could be applied to uranium resources.

A Technical Meeting on Public and Community Acceptability of Uranium Mining and Milling, held in December in Vienna, attracted 34 participants from 18 countries. The meeting highlighted the importance of assuring the public that uranium is being mined responsibly, as a lack of public acceptance might result in government intervention, leading to delay, hindering or even closing of mining operations.

As part of a technical cooperation project entitled ‘Supporting Sustainable Development of Uranium Resources’, the Agency continued to assist 30 countries in Africa through activities designed to address common priorities concerning uranium exploration, mining, processing and regulation. Over 150 regional and international experts participated in four workshops and training courses, held in Egypt, Namibia, Uganda and the United Republic of Tanzania. The focus was on aspects of geology, technology and management that can accelerate the progression of uranium projects from initial discovery to commercial production. The Agency also provided assistance to francophone African Member States through a project funded by the Peaceful Uses Initiative aimed at supporting sustainable uranium mining in less prepared areas. As part of the project, two workshops on uranium mining and processing, including health, safety and environmental aspects, were held in Vienna, in April and November, attended by 25 experts from 10 countries.

The Agency launched a new coordinated research project (CRP), entitled ‘Uranium/Thorium Fuelled High Temperature Gas Cooled Reactor Applications for Energy Neutral and Sustainable Comprehensive Extraction and Mineral Product Development Processes’, with participants from 15 Member States. The project will explore innovative technologies for applying thermal and chemical processes to extract valuable materials, including uranium, from a variety of ore types. These techniques provide the added advantage of producing smaller volumes of solid residues rather than the usual wet tailings and mud, which are difficult to manage. The Agency also started a new CRP on geochemical and mineralogical characterization of uranium and thorium deposits. The project, which involves the participation of 13 Member States, will examine new analytical techniques available for understanding uranium deposit models and improving exploration, production and environmental management methods.

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## Nuclear Power Reactor Fuel

During the year, the Agency continued its work on the development, design, manufacture, use and performance of fuel for all types of nuclear power reactors. As called for in the IAEA Action Plan on Nuclear Safety, particular emphasis was given to the development of fuels with increased accident tolerance and to the analysis of fuel behaviour in accident conditions.

In April, the Agency published *Quality and Reliability Aspects in Nuclear Power Reactor Fuel Engineering* (IAEA Nuclear Energy Series No. NF-G-2.1). The publication provides high level guidance on achieving the criteria specifically related to the design, manufacture and use of nuclear fuel established in *Nuclear Fuel Cycle Objectives* (IAEA Nuclear Energy Series No. NF-O).

The Agency also published *Modelling of Water Cooled Fuel Including Design Basis and Severe Accidents* (IAEA-TECDOC-CD-1775), the proceedings of a Technical Meeting held in 2013

in Chengdu, China, that focused on lessons learned from the accident at the Fukushima Daiichi nuclear power plant. And as part of the ongoing CRP entitled ‘Near Term and Promising Long Term Options for Deployment of Thorium Based Nuclear Energy’, initiated in 2012, the Agency published *Performance Analysis Review of Thorium TRISO Coated Particles during Manufacture, Irradiation and Accident Condition Heating Tests* (IAEA-TECDOC-1761).

A CRP entitled ‘Evaluation of Conditions for Hydrogen-Induced Degradation of Zirconium Alloys during Fuel Operation and Storage’, launched in 2011 with 15 partners from 14 Member States, was completed in 2015. The project produced consistent sets of data on the initial stages of crack development that define conditions when fuel integrity can be lost.

## Management of Spent Fuel from Nuclear Power Reactors

In June, the Agency hosted the International Conference on Management of Spent Fuel from Nuclear Power Reactors — An Integrated Approach to the Back End of the Fuel Cycle. Held at the Agency’s Headquarters in Vienna, the conference attracted over 200 participants from 41 Member States. The participants agreed on the need for an integrated approach to spent fuel management, especially in the areas of processing, storage, transport and disposal. The need to adopt a holistic view for the management of spent fuel was also identified. The Director General highlighted the importance for countries embarking on a nuclear power programme to develop ‘cradle to grave’ plans for both spent fuel and radioactive waste, and encouraged those with existing nuclear power programmes to share their experience with newcomer countries. During the year, the proceedings of the previous conference, held in 2010, were issued in a book entitled *Management of Spent Fuel from Nuclear Power Reactors*.

In November, the Agency hosted a workshop for countries developing new nuclear power programmes aimed at promoting such cradle to grave practices. Held at the Agency’s Headquarters in Vienna, the workshop’s seven participants from six Member States engaged in detailed discussions on the consequences of different options for spent fuel and radioactive waste management.

An integrated approach to spent nuclear fuel management ensures that interdependencies between the different steps to disposal are taken into account from safety, technical and organizational standpoints. To support such an approach in the back end of the fuel cycle, the Agency published *Potential Interface Issues in Spent Fuel Management* (IAEA-TECDOC-1774) in 2015.

In June, the Agency hosted a Technical Meeting on managing plutonium in the absence of a fast breeder reactor or alternative fuel cycle programme, with 13 participants from six Member States and the Nuclear Energy Agency of the Organisation for Economic Co-operation and Development. The meeting participants reviewed the challenges related to the back end of the fast reactor fuel cycle and discussed emerging technologies for reprocessing used fast reactor fuels.

Having — and maintaining — the right scientific, technical and engineering skills is crucial to ensuring ongoing safety and to delivering a comprehensive and safe fuel cycle. To support knowledge and skills retention, in 2015 the Agency intensified its efforts to develop e-learning materials on spent fuel management. Member States and users of the spent fuel management network will be able to access the materials through the Cyber Learning Platform for Nuclear Education and Training (CLP4NET) on the Agency’s web site.

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