

Nuclear Fuel Cycle and Materials Technologies

Objective

To strengthen the capabilities of interested Member States for policy making, strategic planning, technology development and implementation of safe, reliable, economically efficient, proliferation resistant, environmentally sound and secure nuclear fuel cycle programmes.

Uranium Production Cycle and the Environment

Analysis and exchange of information on uranium resources, production and demand in Member States are essential for the steady supply of uranium fuel for nuclear power plants in operation and under construction. Information as of 1 January 2007 shows an increase of 15% over 2004 levels in identified uranium resources (i.e. those resources with production costs of less than \$130 per kg U) to 5.5 million tonnes, which is sufficient, at the 2006 consumption rate, for almost 100 years. Total world production remained at a similar level to that reported last year (around 40 000 tonnes; Fig. 1) and accounted for some 60% of the annual ura-

anium demand of 66 500 tonnes. The uranium market remains uncertain in the medium term due to continuing limited information on available secondary supplies and on new uranium production centres. In the second half of the year the spot price for uranium dropped from the peak it reached in June of \$135 per lb U_3O_8 (\$351 per kg U) and became more stable at around \$90 per lb U_3O_8 (\$234 per kg U). Exploration activities continued to increase worldwide, stimulated by the strong price increase.

The increasing interest in uranium production pushed up demand for skilled labour and for information exchange, and produced a large increase in related technical cooperation proposals to the Agency for implementation in 2009–2011. In 2007, these proposals were reviewed and ten were selected for implementation in Africa, Latin America and Asia. Also in 2007, the Agency organized two training meetings in Vienna covering special mining and milling technologies and recent developments in uranium exploration. A third training meeting was held in Swakopmund, Namibia, at which issues related to the uranium production cycle, for example mining technology and environmental control, were discussed for the benefit

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FIG. 1. Uranium production by country in 2006 (total 39 600 t U).



FIG. 2. Participants at a technical meeting in Halden examining fuel rod instrumentation.

of African Member States. Through the technical cooperation programme, the Agency also provided China and Egypt with advice on methods for uranium exploration.

Nuclear Power Reactor Fuel Engineering

Several Agency activities during the year addressed fuel performance. A technical meeting held in Halden, Norway, in September considered techniques for fuel research and highlighted the methods and instrumentation used to obtain fuel performance data during reactor operation (Fig. 2). Such data were used in a CRP on fuel modelling at extended burnup (FUMEX-II), which was completed in 2007. The results show that modern fuel performance codes generally perform well at burnups up to around 70 GW·d/t U, and there are satisfactory predictions of fission gas release from most codes.

Initial results in 2007 from a CRP on fuel and water chemistry (FUWAC) have clarified the causes and conditions for crud formation on fuel in WWER and LWR systems, and of boron deposition in such crud. This will help operators better manage water chemistry in their reactors, since changes in water chemistry influence both fuel oxidation rates and the migration of corrosion products from steam generators to the fuel, where they can accumulate and lead to fuel failures.

Spent Fuel Management

Annually, some 10 500 tonnes of heavy metal in the form of spent nuclear fuel is discharged from

operating nuclear power reactors. The management of this spent fuel is an important factor influencing the future of nuclear energy, and deals with issues related to long term interim storage and spent fuel treatment. Less than 20% is currently reprocessed, and no final repositories are scheduled to open much before 2020 — and then only in a very few countries. As the amount of spent fuel in storage climbs steadily, so does the need for efficient management of all issues related to the long term interim storage of spent fuel. Five Agency reports issued in 2007 provide insights and advice on such storage issues.

'Burnup credit' refers to a refinement of the traditional assumption in criticality safety analyses that spent fuel has the same reactivity as fresh fuel. Spent fuel in fact has less reactivity, depending on its burnup. Taking burnup into account reduces unnecessary over-design. The reports published in 2007 present methods for incorporating burnup credit in analyses, identify areas where international cooperation would be especially valuable in improving methods and make the case for developing international guidelines.

The reports also present methods for choosing, in any given situation, the best long term and near term strategies, the best casks for storage and transport, the best storage options and the best approach to contract management. They also present design approaches to improve cask performance while recognizing that different designs are needed in different situations. They emphasize the increasing value of fuel data so that fuel can be managed most efficiently at all steps of its life cycle, for example through zoned cask loading where cooler spent fuel is positioned to shield hotter fuel.

Topical Advanced Nuclear Fuel Cycle Issues

In 2007, activities covered the fuel and fuel cycle issues of fast reactors and high temperature gas cooled reactors (HTGRs), partitioning and transmutation, burning plutonium and minor actinides in fast reactors, reuse options of reprocessed uranium, thorium utilization and issues related to proliferation resistance in the nuclear fuel cycle. Assistance was provided

on fuel cycle issues through the Agency's International Project on Innovative Nuclear Reactors and Fuel Cycles.

Technical reports were compiled in cooperation with experts from Member States in the areas of fast reactor fuel technology, the back end of the fast reactor fuel cycle and the current status of and future trends in minor actinides. The reports cover state of the art information on plutonium and minor actinide bearing oxide, carbide, nitride and metallic fuels for fast reactors, their fabrication, properties and irradiation behaviour and aqueous and pyroelectrolytic routes for partitioning of spent fast reactor fuels. The reuse options of the increasing quantities of reprocessed uranium were summarized in *Management of Reprocessed Uranium: Current Status and Future Trends* (IAEA-TECDOC-1529), which was published in February.

In the area of HTGR research, the Agency, in collaboration with the European Commission and the ReActor for Process heat, Hydrogen And ELectricity generation (RAPHAEL) group, conducted a course in December on coated particles

in Petten, the Netherlands. The course trained graduate students and young researchers in fuel design, fabrication, characterization techniques, irradiation and post-irradiation examination, and waste processing and storage, for coated particle fuel used in high temperature reactors.

Member State interest in using thorium based fuels is increasing, and a technical meeting on thorium fuel cycle options for PHWRs, LWRs and HTGRs was held in October at the Çekmece Nuclear

Research and Training Centre, Istanbul. Information was exchanged on thorium availability, processing thorium ores, manufacturing, and proliferation resistance issues of the thorium fuel cycle.

Integrated Nuclear Fuel Cycle Information System

Interest in the Agency's databases and simulation systems in the area of the nuclear fuel cycle continues to increase. Registered users increased in 2007 by some 25%. The databases that provide information on worldwide nuclear fuel cycle activities include the Nuclear Fuel Cycle Information Systems, World Distribution of Uranium Deposits, Post-irradiation Examination Facilities Database, Minor Actinide Property Database and Nuclear Fuel Cycle Simulation System (formerly known as VISTA). A web based application has been developed for using NFCSS through the Internet. All databases and NFCSS applications are available at <http://www-nfcis.iaea.org/>.

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