Nuclear Fuel Cycle and Materials Technologies

Objective

To enhance and further 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

The resurgence in the global uranium production industry continued in 2009, with new uranium mines opening in Kazakhstan and Malawi and several production centres — in Australia, Brazil, Namibia and the Russian Federation — looking to maximize output from their existing facilities and/or expand production. Exploration activity was reduced in some quarters, as many smaller companies ceased operating when financing became difficult to obtain as a consequence of the global financial crisis. However, some exploration areas saw little reduction of activity. In Namibia, for example, there were significant finds, and resource development work continued unabated.

Member State interest in uranium production continued to increase, with particularly strong interest in related technical cooperation projects from a number of developing countries. Many of these countries are now looking at nuclear power as an integral part of their energy plans, and in several cases the desire to use domestic energy resources has led to a significant increase in requests for training and support in the areas of uranium exploration, resource evaluation and development planning, and mine development planning and regulation. The Agency provided training in all aspects of uranium production to Member States in Africa, Asia and Latin America.

The Agency also published *Establishment of Uranium Mining and Processing Operations in the Context of Sustainable Development* (IAEA Nuclear Energy Series No. NF-T-1.1). Within the context of the four cornerstones of sustainability — environment, social issues, economics and governance — the report focuses on legacy issues and the timescales over which uranium mining and processing operations should be considered sustainable.

In June, the Agency organized a symposium entitled 'Uranium Raw Material for the Nuclear Fuel Cycle: Exploration, Mining, Production, Supply and Demand, Economics and Environmental Issues' (URAM-2009) in Vienna. The meeting concluded that despite the ongoing global financial crisis, growth in the uranium production industry continues to be strong, including in countries that are relatively new to the industry and interested in Agency assistance.

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Nuclear Power Reactor Fuel Engineering

Two CRPs were completed in 2009. The first, on optimization of water chemistry to ensure reliable water reactor fuel performance at high burnup and in ageing plants, investigated the causes and consequences of corrosion product deposition on fuel and the techniques available to water chemists to control such deposition. It provided information on current best practices and covered issues of concern for all major nuclear power plant types. The second CRP, on delayed hydride cracking of zirconium alloy cladding, included round robin testing that generated comprehensive experimental data on cracking velocities in Zircaloy-4 PWR, BWR, WWER and CANDU/PHWR cladding and led to the transfer of experimental methods from the host laboratory, Studsvik Nuclear AB in Sweden, to the project participants.

The Agency also convened a topical meeting in Vienna on 'Nuclear Research Applications and Utilization of Accelerators', as well as a technical meeting in Buenos Aires, to consider PHWR fuel experience and manufacturing technologies and to support efforts to improve fuel behaviour. The participants at the Buenos Aires meeting concluded

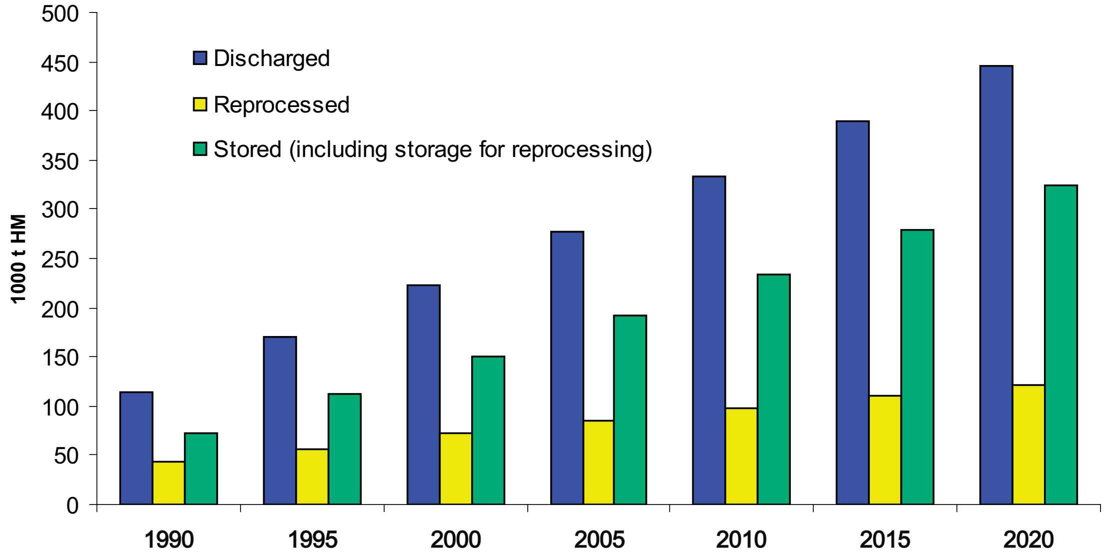

FIG. 1. Projections for the total amount of spent fuel in storage show an increase until 2020.

that although current PHWR fuel has proved to be extremely reliable, more work was needed to understand fuel performance at extended values of burnup and to develop advanced fuel designs.

Other technical meetings were held in Villigen, Switzerland, on advanced fuel pellet materials and fuel rod designs for water cooled reactors, and in Vienna as part of a CRP on the use of accelerator techniques and theoretical modelling to develop radiation resistant materials.

Spent Fuel Management

The implementation of safe and effective strategies for spent fuel management continues to be a high priority. Currently, only about 20% of discharged fuel is reprocessed, and the development of disposal facilities for spent fuel or high level waste has been delayed in many countries, with no repository scheduled to start operation before 2020. Under these circumstances, many countries have adopted the approach of long term storage of spent fuel for 100 years or longer, and the reports and activities of the Agency reflect the need for long term spent fuel storage (Figs 1 and 2).

The Agency completed a CRP on Spent Fuel Performance Assessment and Research (SPAR-II), which evaluated the performance of spent fuel in wet and dry storage and concluded that current storage technology can accommodate the trend towards extended storage times. The Agency also published reports on the *Management of Damaged Spent Nuclear Fuel* (IAEA Nuclear Energy Series No. NF-T-3.6) and *Costing of Spent Nuclear Fuel Storage* (IAEA Nuclear Energy Series No. NF-T-3.5). Together with the OECD/NEA, the Agency organized an international workshop on burnup credit application, to provide more realistic safety margins in criticality calculations while reducing the cost of spent fuel management.

FIG. 2. Dry storage casks at the Wolsong nuclear power plant site in the Republic of Korea.

Topical Advanced Fuel Cycle Issues

The sustainable development of nuclear energy requires the efficient use of fissile and fertile resources.[1] However, today's commercial

[1] In a nuclear reactor, fissile material undergoes fission by thermal neutrons producing energy, whereas fertile material absorbs neutrons and is converted into fissile material.

thermal reactors utilize less than 1% of uranium resources. Resource utilization can be improved by reprocessing the spent fuel and recycling the plutonium and uranium from reprocessing operations into fresh reactor fuel. Various aspects of such scenarios were examined in two closely related publications. One, entitled *Use of Reprocessed Uranium* (IAEA-TECDOC-CD-1630), covers the technical issues, while the other, *Use of Reprocessed Uranium: Challenges and Options* (IAEA Nuclear Energy Series No. NF-T-4.4), covers economic issues and long term prospects for the use of reprocessed uranium for nuclear energy generation.

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The persistent toxicity of some of the radionuclides (such as minor actinides) in discharged nuclear fuel is a major obstacle to achieving wide public acceptance of the disposal of spent fuel or high level waste. Several Member States have alternative reprocessing technologies and advanced partitioning processes to improve the management of minor actinides. Many of these processes aim to recover minor actinides and other long lived fission products to transmute them in fast reactors. The Agency has initiated substantial work in the area of partitioning and transmutation as a part of advanced fuel cycle activities and, in 2009, completed a CRP on process losses in separation processes in partitioning and transmutation systems to minimize the long term environmental impact. The CRP showed that after the removal of both plutonium and minor actinides through partitioning and transmutation, the radiotoxicity of high level waste will fall to the level of natural uranium ore within 500 years.

Significant efforts are under way in several Member States to develop high temperature gas cooled reactors (HTGRs) for process heat, hydrogen production and electricity generation. HTGRs have already demonstrated their high temperature capabilities by attaining reactor outlet coolant temperatures of up to 950°C, and are being further developed for their high temperature capabilities and enhanced safety features. In addition to their prospective use for heat, hydrogen and electricity production, HTGRs could also be used for burning plutonium and minor actinides. Finally, the Agency published *Status and Prospects for Gas Cooled Reactor Fuels* (IAEA-TECDOC-CD-1614).

Integrated Nuclear Fuel Cycle Information System

Reliable and accurate data on worldwide nuclear fuel cycle activities are extremely important to the nuclear community for national policy making, international cooperation and studies pertaining to sustainable global energy development. Such data are available through the Agency's Integrated Nuclear Fuel Cycle Information System (iNFCIS) (*http://www-nfcis.iaea.org/*), which provides information on global nuclear fuel cycle activities. The on-line databases include the Nuclear Fuel Cycle Information System, World Distribution of Uranium Deposits and the Post Irradiation Examination Facilities Database. In 2009, the Minor Actinide Property Database was also made available after expert review and intensive testing.

In 2009, iNFCIS saw a sharp increase in usage of over 40% compared with 2008, reflecting increased demand by experts, researchers and the general public (Fig. 3). Publications issued during the year based on iNFCIS data included *Nuclear Fuel Cycle Information System: A Directory of Nuclear Fuel Cycle Facilities — 2009 Edition* (IAEA-TECDOC-1613) and *World Distribution of Uranium Deposits (UDEPO) with Uranium Deposit Classification — 2009 Edition* (IAEA-TECDOC-1629).

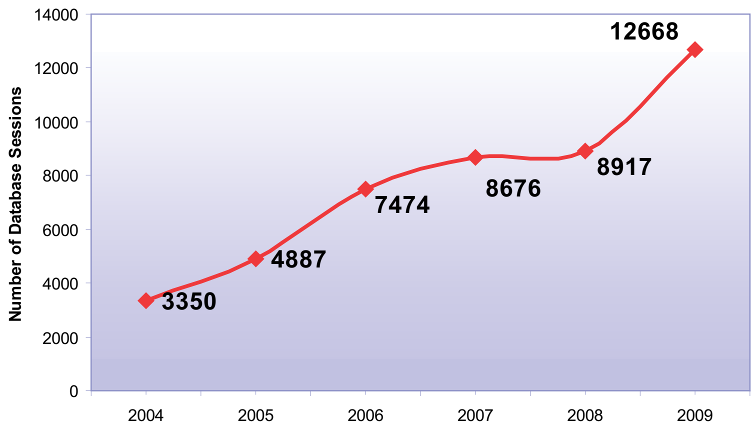

FIG. 3. Increase in the use of iNFCIS in 2009.