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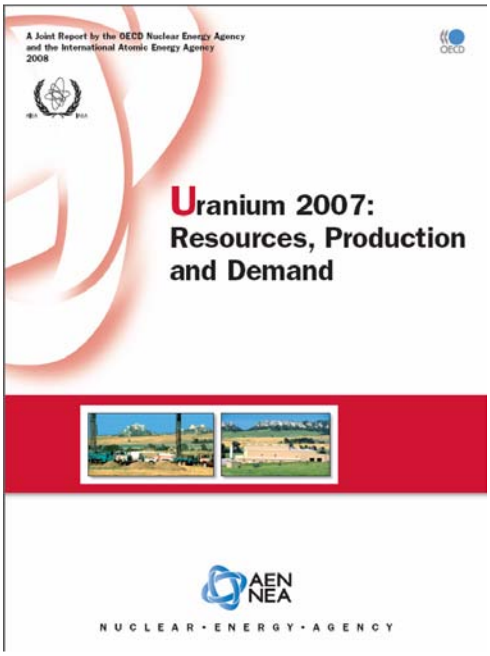
Future of Uranium Resources: Facts and Perceptions



Uranium 2007: Resources, Production and Demand **(The Red Book)**

Since the mid-1960s, with the cooperation of their member countries/states, the OECD Nuclear Energy Agency (NEA) and the International Atomic Energy Agency (IAEA) have jointly prepared biennial updates on world uranium resources, production and demand. This is published as a report commonly known as *The Red Book*. The newly published 22nd edition reflects information current at the beginning of 2007. The Red Book features an assessment of current uranium supply and demand and projections up to 2030. The basis of this assessment is a comparison of uranium resource estimates according to geological certainty vs. production costs and mine production capability and also takes into account the anticipated uranium requirements arising from projections of installed nuclear capacity.

In comparison with the 2005 edition of the Red Book all estimates have been increased reflecting the current strong growth of activities in the uranium field including worldwide exploration. The recently reported identified resources with production costs <130 US $/kgU are almost 5.5 million tonnes U, an increase from the previous report of 0.7 million tonnes U (from ~4.8 million tonnes U in 2005). This is a continuing trend. Over the last fourteen years (7 Red Book editions), there has been a substantial increase in remaining uranium resources of more than 2.4 million tonnes U, despite more than 0.5 million tonnes U having been mined.

Uranium production is, however, still substantially lower than the demand. In 2006 about 40 000 tonnes U were produced, while the requirements were about 66 000 tonnes U. The shortfall is made up from supplies of already mined uranium (so-called secondary sources) including excess government and commercial inventories, dismantling of nuclear warheads, re-enrichment of depleted uranium tails and spent fuel reprocessing. During the last 14 years such secondary sources have contributed about 40% of the demand. The increased price of uranium coupled with an expected rising demand has led to extensive uranium mine development activity worldwide.

Message from the Director

Welcome to the September issue of the Fuel Cycle and Waste Newsletter. I hope that the different articles presented will give you a flavour of the diverse activities performed within the Division covering uranium exploration and production, fuel manufacturing and behaviour, spent fuel management, radioactive waste management and decommissioning, research reactor operation and fuel cycle. If you want to get a fuller picture please visit the web pages referred to at the back cover.

The lead article in this issue deals with uranium resources. This is very appropriate at a time with increasing expectations for new nuclear power and with a great volatility in the spot market for uranium. New uranium mines will be needed and we see a large increase in the requests from Member States for support in uranium exploration, mining and production. Such support will be important to ensure an early planning of the activities to avoid creating some of the legacies from earlier uranium activities.

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The reported identified resources (5.5 million tonnes U) corresponds to 83 years supply at the current rate of consumption. However, this does not reflect the true situation. All mineral resource figures are dynamic over time and change with commodity price developments. Uranium is no exception. The reported increase in resources from 2005 to 2007 corresponds to 11 years of 2006 uranium demand. This demonstrates the impact of increased uranium prices on total resource numbers. The uranium resource figures officially presented in Red Books are only a part of the already known resources and are not an inventory of the total amount of recoverable uranium contained in uranium deposits. Examples where uranium resources are already known, but not reported, are the Russian Federation, the USA, Australia and other countries. There are many reasons why resources are not reported. One reason is that they have not been fully evaluated economically and so do not fit into the reporting parameters. With favourable market conditions additional discoveries can be expected, as was the case during past periods of heightened exploration activity.

The demand (requirements) for uranium is also expected to grow. Using information published in the IAEA report 'Analysis of Uranium Supply to 2050' with some updates on recent developments, the presently identified resources would cover the demand for another 50 years under the defined middle scenario. This compares well with resource life-time figures of 30–50 years for some other commodities (e.g. Cu, Zn etc.). Markets are in balance and changes depend on the entire cycle of: increased demand – increased price – increased financing – increased exploration activities – increased number of resources, etc. The uranium production cycle is still far away from being a *normal* commodity production cycle, however the stability in it will surely lead to stabilization of relationships as well as clarifying all relationships as a consequence of identifying new uranium resources.

Uranium resources are thus adequate to meet the expected development in demand. But the resources in the ground need to be mined. As currently projected, primary uranium capabilities including existing, committed, planned and prospective production centres could satisfy projected high case uranium requirements through 2028, provided mine expansions and openings of new mines proceed as planned. As this is unlikely secondary sources will continue to be important, albeit as a lower fraction of the total supply.

Uranium exploration (curtesy Cammeco Corporation)

Doubling uranium production within 10 years, especially after a 25-year-long depression, raises many questions. One of the most important, but still underestimated, is the education and training of a new generation of uranium industry workers. Many newly designed operations are relatively small having an annual capacity below 2000 t U. Thus there will be many of them operating to achieve the required production and each operation will need a certain number of professionals. There are many limitations to obtaining these human resources, in particular the limited number of experienced people available to teach, train and consult, because they are already busy in the resurgent uranium industry. Also "buying" such resources from other mining industries (oil and gas, coal, gold, copper, zinc etc.) will be difficult. All these industries are also developing quickly and are facing similar problems. Creation of an international network for training and education in uranium production cycle activities would be one step forward in resolving this problem.

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Nuclear Energy Series

The IAEA has implemented a new publication series called the Nuclear Energy Series (NES). The NES system is intended to increase the consistency, effective use and recognition of selected nuclear energy publications. This system incorporates relevant existing publications, adds structure and visibility, and systematically fills important gaps where necessary.

The rational behind the development of the NES is to provide a visible and clear structure. Elements within the NES are being organised in logical levels according to an individual publication's purpose, subject area and level of detail.

The Basic Principles, a single top level publication, describes the rationale and vision for the peaceful use of nuclear energy. The aim is to identify the basic principles which nuclear energy systems must meet to satisfy growing global energy needs.

Nuclear Energy Objectives describe what needs to be considered and achieved in various Areas at different stages of implementation to assure the basic principles are satisfied. The NES is broken down at this level into the following Areas: General, Nuclear Power, Nuclear Fuel Cycle and Radioactive Waste Management.

Guidance on specific subjects within the individual Areas is being developed to provide further detail in support of the identified objectives. Reports provide even more detail and/or specific technical information on these subjects.

A new publication review and approval methodology has been launched in parallel with the revised structure. Proposals for new or revised publications are briefly described in Document Preparation Proposals (DPPs). DPPs are then reviewed by a Document Coordination Team (DCT), chaired by the Deputy Director General of the Department of Nuclear Energy. The DCT ensures adequate review of the DPP – from other IAEA departments – and considers where the publication fits in the logical structure described below.

Nuclear Energy Series - Clickable Map

The overarching goal of the NES is to produce a logical, intuitive and user-friendly publication system for the benefit of interested individuals and organisations in all IAEA Member States. To help achieve this goal, a web interface has been developed, accessible from the IAEA website (http://www.iaea.org/OurWork/ST/NE/NESeries/ClickableMap/). There, a clickable document map is available as is a more in-depth description of the entire NES.

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Coordinated Research Projects in Nuclear Fuel Cycle & Materials Section

Coordinated Research Projects (CRPs) currently being conducted and managed by the Nuclear Fuel Cycle and Materials Section reflect increasing Member State interest in the performance and technology of fuels, spent nuclear fuel (SNF) storage issues and SNF reprocessing and recycling options. Specific examples are as follows:

1. Fuel Performance Modelling under Extended Burn-up (FUMEX)

The effective and reliable performance of zirconium alloy clad uranium oxide fuel at extended burn up in water cooled reactors is a major factor defining the competitiveness and safety of nuclear power production. Evaluation fuel performance by modelling is not only an important part of the licensing process but is also needed to predict fuel behaviour and allow improvement in reliability and performance. The FUMEX CRP promotes interaction and discussions amongst fuel modellers for better understanding of physical processes and phenomena to facilitate improvements to both codes and their models.

In its initial phase, FUMEX-I worked to predict fuel temperature and to see how closely analytical predictions matched controlled experimental values. Later, FUMEX-2 was launched in December 2002 and focused on the predictive capabilities of different codes in terms of fuel temperature and fission gas release at extended burn-up of light water reactor (LWR) fuel, i.e., >50 MWd/kg. FUMEX-2 has been completed and a technical report is under preparation.

FUMEX-3 is due to begin in December 2008. There have been expressions of interest from over thirty institutions and it is expected that there will be over twenty participants, with some combined teams. The specific objective of the CRP is to improve the predictive capabilities of codes used in fuel behaviour modelling for extended burn-up, under conditions where restructuring of the pellet rim had been observed by post irradiation examination (PIE), and under transient conditions. The focus is on the topics of fission gas release, pellet to clad interaction and dimensional changes at extended burn-up above 60 MWd/kg for LWRs and up to 20 MWd/kg for PHWRs.

2. Fuel Structural Materials and Water Chemistry Management in Nuclear Power Plants (FUWAC)

FUWAC was initiated to help interested Member States ensure primary coolant chemistry is optimised to reduce corrosion of the fuel cladding and to eliminate, as far as practicable, the deposition of crud on the fuel which can cause problems of power distribution and accelerated corrosion. The CRP was started in 2006 and 16 teams from different Member States are participating representing a diverse array of water reactor designs; namely, PWR, BWR, WWER and CANDU. The objective is to understand the phenomena leading to corrosion and deposition on fuel, particularly in regard to aging plants which may well have experienced a variety of water chemistry regimes over their lifetimes. The research teams are undertaking a wide range of projects to investigate the processes operating in the primary coolant. In addition to theoretical studies and operational data analysis, the participating teams are carrying out autoclave experiments and measuring dissolved species transport. With an improved understanding of the fundamental processes it will be possible to provide informed advice to operators on optimising the water chemistry in their particular plant.

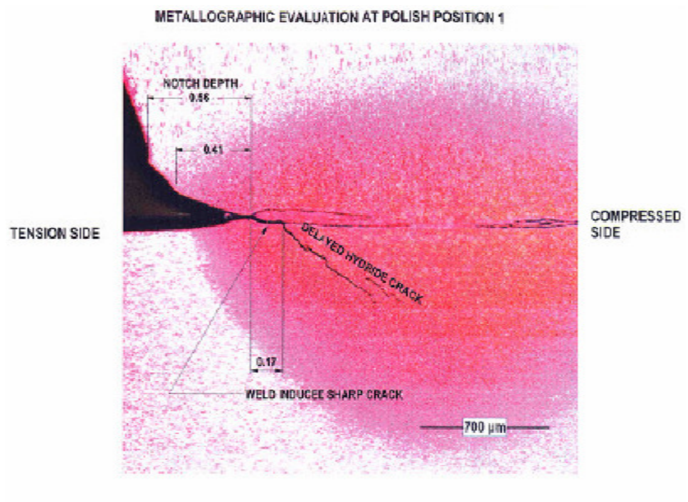
3. Hydrogen and Hydride Degradation of Mechanical and Physical Properties of Zr-Alloys - Delayed Hydride Cracking (DHC) of Zirconium Alloy Fuel Cladding

The first phase of the CRP on DHC (DHC-1, 1998-2002) dealt with zirconium alloy for CANDU and RBMK pressure tubes (coolant tubes) using experimental methodologies transferred from the Atomic Energy of Canada Limited (AECL) laboratory at Chalk River. By following strict round robin testing procedures and inter-laboratory comparisons, a very consistent set of experimental results was obtained, revealing a well proven dependence between DHC velocity and yield stress as well as structural reasons for differences in DHC rates in Zr pressure tube materials of different origin. The DHC-1 results were reported at the 15th International Symposium on Zirconium in the Nuclear Industry, held on 24-28 June 2007 in Sunriver, USA and published as IAEA-TECDOC-1410 in 2004 (http://www-pub.iaea.org/MTCD/publications/PDF/te_1410_web.pdf).

Based on the success of DHC-I, DHC-2 was started in 2005 with a similar approach using zirconium alloy cladding materials. The experimental methodology was developed in the laboratory of Studsvik Nuclear AB of Sweden. The series of round-robin exercises revealed testing procedural improvements in all participating laboratories in Argentina, Brazil, Lithuania, Pakistan, Republic of Korea, Romania and the Russian Federation. Thus it was possible to arrange a series of independent studies of different cladding materials in national labs. DHC-2 is in the final stage. The results will be presented at the Water Reactor Fuel Performance meeting on 19-22 October 2008 in Seoul, Republic of Korea (http://www.wrfpm2008.org/index.html) and a comprehensive technical document will be published in 2009.

4. Accelerator Simulation and Theoretical Modelling of Radiation Effects (SMoRE)

The objectives of this CRP are focused mostly on the improvement, development and testing of core structural materials for higher burn-up in advanced water-cooled and fast reactors. The identified goals will be addressed by accelerator simulation of high-dose irradiation and complementary theoretical modelling. Coupling accelerator studies with modelling has the potential to increase understanding of radiation damage in high dose materials, validation of complex materials models, and increased use of novel characterization techniques for enhanced understanding of the basic radiation problems and processes. The outputs of the CRP will contribute to the extension of knowledge in radiation effects and the development of core structural materials with improved radiation-resistant properties.



Metallographic sample section from the commissioning test of the DHC test apparatus in Canada

5. Spent Fuel Performance and Research (SPAR)

Long term interim storage of spent nuclear fuel (SNF) is a reality as most developed and developing countries have adopted a 'wait and see' attitude to SNF management. Reliable long term storage is essential to maintain all spent fuel management options open. In some countries storage periods of 100 years or more are considered. Although the experiences of spent fuel storage so far are very good, such long term storage raises the need to investigate and verify the continued integrity of fuel as well as the integrity of storage facilities. Spent fuel should maintain its integrity to a level that would enable its subsequent handling and/or transportation either for disposal or for reprocessing.

Presently, spent fuel is mostly stored wet in at-reactor (AR) or away-from-reactor (AFR) facilities. Storage of spent fuel in a dry and inert atmosphere is being used increasingly as many AR pools are approaching their full capacity, even after extensive re-racking. Wet storage will, however, remain the preferred approach for interim storage during the first decade after final discharge from a reactor. After sufficient decay (*cooling*), and especially for long storage durations storage under inert conditions or in air becomes the preferred alternative, given the passive nature of dry storage systems.

The first CRP on this topic, BEFAST was initiated in the 1990s, followed by SPAR. The current program, SPAR II was initiated in 2004 with its focus on performance, corrosion and the hydriding aspects of zirconium alloy clad uranium oxide and mixed uranium plutonium oxide fuels for water cooled reactors. Countries that participated in SPAR II were Argentina, Canada, France, Germany, Hungary, Japan, Slovakia, Spain and Sweden. The representatives of the EC - Julich Research Centre also contributed to the programme. The need for SPAR has been reinforced in recent years since the licenses for some of the storage facilities will have to be extended or renewed. Data on fuel and storage systems after prolonged storages will be needed to support these licensing extensions.

Several possible deterioration mechanisms of fuel and storage materials have been identified and have been the topics of the coordinated investigations. Hydrogen effect on fuel including delayed hydride cracking (DHC), creep, corrosion and fuel pellet oxidation were some of them. Although there are some indications that detrimental effects of these mechanisms on spent fuel integrity are unlikely under the stresses and strains encountered during spent fuel storage, they still require further research and investigation. Some of the specific topics that have been addressed in SPAR II include:

- the development of a metal/hydride model for zircaloy cladding with mixed hydride structure,
- failure criteria for zircaloy cladding using a damage-based metal/hydride mixture model,
- fuel rod failure evaluation under simulated cask side drop conditions,
- global forces acting on spent fuel rods and deformation patterns resulting from transportation accidents,
- transverse tearing and rod breakage resulting from transportation accidents,
- longitudinal tearing resulting from transportation accidents.

The last research coordination meeting of SPAR II was held in June 2008 and a technical document will be published in 2009, when the next phase, SPAR III, will be launched.

6. Process-losses in Separation Processes in Partitioning and Transmutation (P&T) Systems in View of Minimizing Long-term Environmental Impacts

P&T of SNF involves a series of chemical, metallurgical and nuclear operations by which all the actinides (Pu, Am, Cm, Np) and some selected fission products (^{99}Tc, ^{129}I, etc.) are separated from the discharged spent fuel and recycled as fuel/targets. P&T facilitate effective utilization of natural uranium resources and have the potential to reduce volume, long term radio-toxicity and decay heat of high level waste, thereby minimising the repository space requirements. Precise evaluation of minor actinide (MA) elements in the waste and minimization of their losses from the separation process can contribute considerably to an improved protection of the environment. A CRP on this topic was initiated in 2003 with an aim to understand the environmental impact considering losses in the P&T steps. Four RCMs have been held to enable Member States to develop methodologies for reducing radiotoxic discharges to environment from nuclear fuel cycle activities and pave the way for the sustainability of nuclear energy. Institutes in the following Member States have joined this CRP: China, Czech Republic, Germany, India, Japan, Republic of Korea, Russian Federation and USA. The following subjects-areas of research were examined:

- Basic studies to compare a dry partitioning process with an aqueous partitioning process;
- Defining proliferation resistance attributes of partitioning processes;
- Advanced characterization methods for actinides for measuring the possible material hold-up;
- Minimization of actinides losses in the waste fraction from the partitioning process;
- Establishment of separation criteria of partitioning process to minimize environmental impact;
- Defining environmental impact associated with partitioning processes.

A technical document on the above topic will be published in 2009.

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Estimation of Plutonium and Minor Actinides using NFCSS

The Nuclear Fuel Cycle Simulation System (NFCSS) has been developed by the IAEA to support its programmatic activities as well as to provide Member States with a tool to estimate long term nuclear fuel cycle material and service requirements. It has been developed as a web based tool which allows users to access and use NFCSS through any PC connected to the internet. The NFCSS is a scenario based simulation system. The users can define scenarios using their data, then run the scenario and get the results from the system.

The NFCSS is available on http://www-nfcis.iaea.org and the users will be able to use it through an authorization process. The application form is available in the NFCSS part of the same site.

In this article, some of NFCSS's capabilities are shown using simple scenarios to estimate the reprocessed plutonium and minor actinide amounts for recycling and non-recycling cases. The results from NFCSS can be displayed as material flows for a selected year (see Fig. 1) or as accumulated amounts over time (see Fig. 2–5).

Scenario 1 with PWRs

The French reactor park was selected for the scenario with the assumptions shown in Table 1. Two cases were created: case 1 is with Pu recycling and case 2 is without Pu recycling. Results from the simulation are shown in Fig. 1-3, e.g. accumulation of Pu and Minor Actinides.

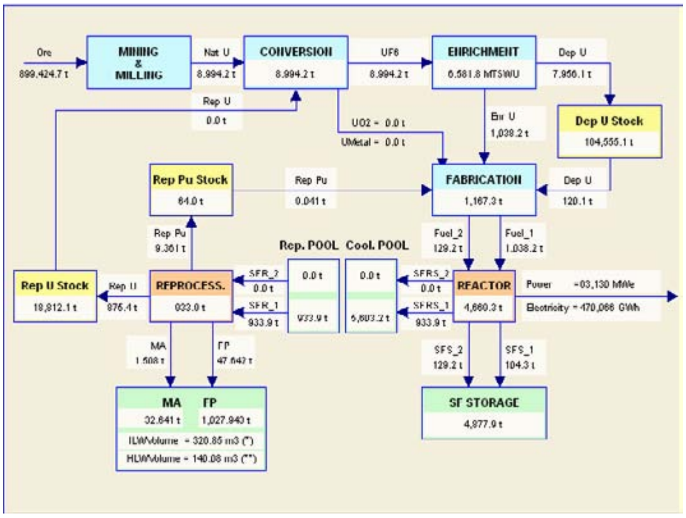

Fig. 1: Fuel cycle diagram showing the material flow result for year 2028 for recycling option

Scenario 2 – PWR and PHWR intercomparison

Another study was made to compare the plutonium and Minor Actinide discharge from PWR and PHWR fleets with the same power of 10,000MWe. The assumptions are given in Table 2:

Figure 4 shows that the discharged amount of minor actinide is much lower in the PHWR case for the same power level. As opposed to the minor actinide discharge, Fig. 5 shows that the discharged amount of Pu is much higher in the PHWR case.

Table 1

Reactor Type	*PWR 900*		*PWR 1300*	
Total Power	30 770 MWe		32 360 MWe	
Thermal Efficiency	32.85 %		35 %	
Load Factor	85 %		85 %	
Enrichment Tails Assay	0.25 %		0.25 %	
Fuel Residence Time	4 Years		4 Years	
Initial Enrichment	3.950 %		4.535 %	
Discharge Burnup	45 GWd/tHM		55 GWd/tHM	
UOX Reprocessing Ratio	100 %		80 %	
MOX Reprocessing Ratio	0 %		0 %	
Total Pu in MOX	7 %		-	
Overall MOX Fuel Ratio	*Case 1*	*Case 2*	*Case 1*	*Case 2*
	20 %	0 %	0 %	0 %

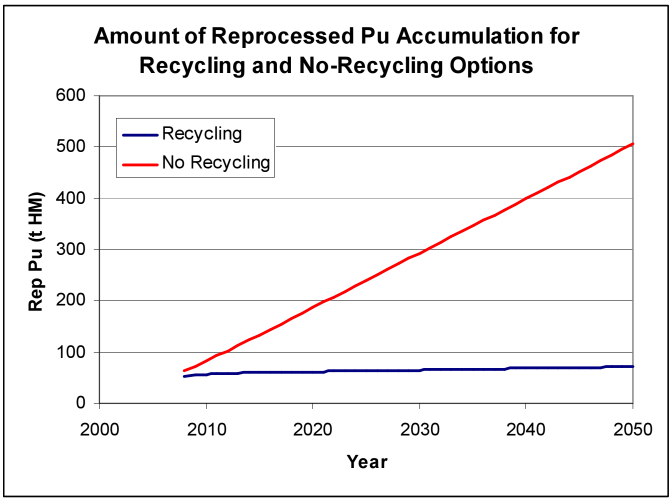

Fig. 2: The amount of Reprocessed Pu accumulation for recycling and no-recycling options

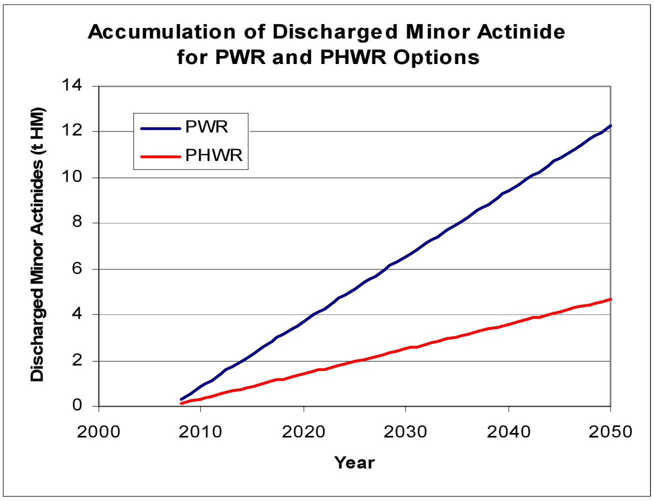

Fig. 4: The accumulated amount of minor actinide discharge from PWR and PHWR for a 10000 MWe fleet

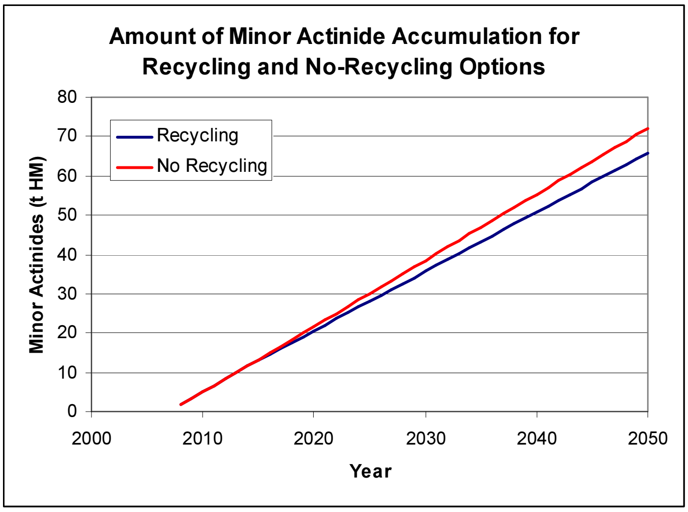

Fig. 3: The amount of minor actinide accumulation in high level waste for recycling and no-recycling options

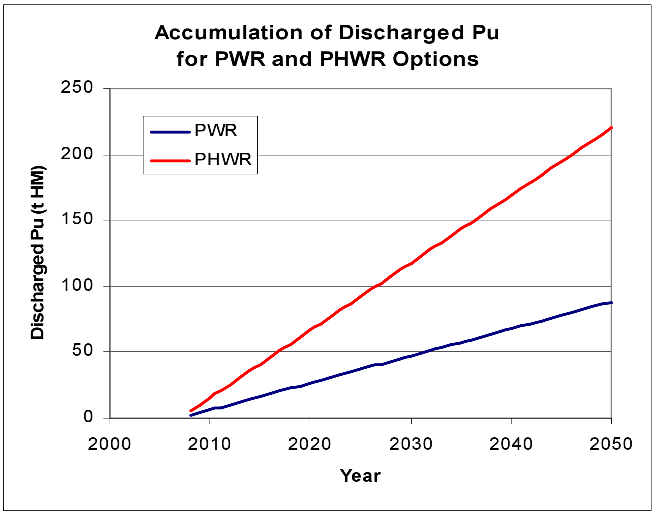

Fig. 5: The accumulated amount of Pu discharge from PWR and PHWR for 10000 MWe fleet

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Table 2

Reactor Type	***PWR 900***	***PHWR***
Total Power	10 000 MWe	10 000 MWe
Thermal Efficiency	32.80 %	32.80 %
Load Factor	85 %	85 %
Enrichment Tails Assay	0.25 %	0.25 %
Fuel Residence Time	4 Years	1 Years
Initial Enrichment	3.950 %	0.711 %
Discharge Burnup	45 GWd/tHM	7 GWd/tHM
UOX Reprocessing Ratio	0 %	0 %

Stainless Steel Cladding and Fuel Assembly Materials for Liquid Metal-cooled Fast Reactors – Fabrication, Properties and Irradiation Behaviour

IAEA Technical Meeting (TM) in Hyderabad, India

One of the major issues of LMFR fuel is to develop high performance cladding and wrapper materials which should be able to withstand high temperatures (650-700°C), high stress level and significant fast neutron (E >0.1 MeV) irradiation (200 dpa or more) with minimum void swelling, creep and fuel clad chemical interaction. In addition, the fuel structural materials must be easily available, affordable and should have good fabrication and joining properties.

The TM discussed the manufacturing, structure-property co-relation and irradiation behaviour of cladding tubes and wrappers based on conventional austenitic stainless steels namely SS 316, D 9 and their equivalents, ferritic steels (HT 9, T 91) and oxide dispersion strengthened (ODS) steels. Nearly 33 experts and some 17 observers participated in the meeting. In all, 25 papers were presented in 6 technical sessions. A visit to the 'Stainless Steel Tube Plant (SSTP) of the Nuclear Fuel Complex was a part of the TM.

The meeting concluded that austenitic stainless steels are not suitable as fuel cladding and wrapper materials for high burnup (>150 dpa) LMFR fuel because of irradiation induced void swelling. The ferritic-martensitic steels (HT 9 and T 91) have low void swelling but are associated with the problem of radiation induced ductile brittle transition temperature (DBTT). The ODS steel is emerging as the candidate structural material for high burnup LMFR fuel assembly based on its very low void swelling and favourable DBTT behaviour. However, ODS steel has so far been produced only on a pilot scale, following the powder metallurgy route in France, Japan, the Russian Federation and the USA. The irradiation database of ODS steel has so far been up to 150 dpa and there is a need for irradiation- testing up to 200 dpa and beyond. The IAEA was requested to initiate a collaborative research project and database on out-of-pile properties and irradiation behaviour of LMFR fuel structural materials.

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Minor Actinide Fuel / Target: Fabrication, Processing, Properties and Database

Partitioning and Transmutation (P&T) of plutonium and minor actinide (MA) elements (americium, neptunium and curium) as well as long lived fission products have been investigated in several Member States to reduce the radio-toxicity of spent fuel with a view to minimize the long-term burden to a geologic repository where the final waste is disposed permanently. Several fuel cycle scenarios considering multi-recycling of Pu and MAs in conventional thermal nuclear energy systems as well as innovative nuclear energy systems such as fast reactors and accelerator driven sub-critical reactors are being evaluated. Apart from reducing the radio-toxicity, the MA-based fuel could also enhance the proliferation resistance of the fuel cycle.

Introduction of minor actinides based fuel / target needs specific considerations, which are different from those for conventional UO_2 or $(U\text{-}Pu)O_2$ fuel. In this context, there are increased R&D activities on the development of specialized candidate fuels (targets) with a relatively high minor actinide content in the appropriate material viz., metal-alloy, oxide, nitride and coated particle. These fuel forms include pellets, dispersed fuels and coated particle fuel.

The IAEA is preparing a technical document which reviews the current status and future trends in the processing of MAs and their pertinent properties for the fabrication of nuclear fuels (targets) to incinerate MAs in thermal as well as fast neutron spectrums.

A large number of physico-chemical and thermo-mechanical data are required for the design and fabrication of MA-based fuel or specialized targets. The effectiveness of separation of MAs from other elements is determined by the relative difference in the physico-chemical properties of MAs. Generation of experimental data for the materials containing MAs would involve enormous impediments such as i) requirement of shielded facilities (in some cases highly purified argon atmosphere) in dealing with MAs and ii) decay heat, decay products and self-radiolysis limiting the applicability of many experimental measurement techniques. Hence, available information is very limited and scattered.

In this context the IAEA is developing a bibliographic database (MADB) by collecting available information on physico-chemical and thermo-mechanical properties of MA based alloys & compounds used for advanced nuclear fuel cycles. The information will be published soon on the IAEA web-site.

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Status and Development of the IAEA PIE Database

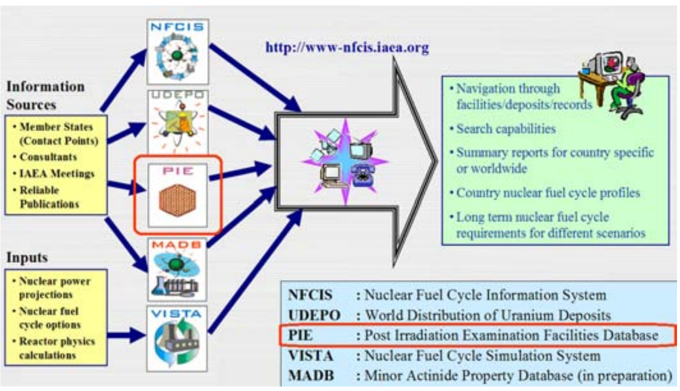
Background

While the number of states with nuclear power programmes is growing, the number of hot cells in the world in which post irradiation examination (PIE) can be performed has diminished during the last decades. This creates problems for countries that have nuclear power plants and require PIE for fuel surveillance, safety control and nuclear materials studies; including the development of new radiation resistant materials for advanced and innovative nuclear applications. It highlights the need for more efficient use of existing PIE facilities relying on wider international exchange of information about their capabilities and helps interested Member States select PIE facilities most relevant to their particular needs.

IAEA Involvement

With this in mind and according to the recommendation by the technical working group on Water Reactor Fuel Performance and Technology (TWGFPT), the IAEA initiated the development of a PIE Facilities Catalogue within the framework of the coordinated research project on Examination and Documentation Methodology for Water Reactor Fuel, which was published as an IAEA Working Material in 1996. In 2002/03 the catalogue was converted into a database and updated through questionnaires distributed to hot laboratories in the IAEA Member States. In 2005/06 an interactive mode of the PIE Database was developed that allowed hot-lab managers to modify and amend its contents on-line via the internet. Now it is a part of the IAEA Integrated Nuclear Fuel Cycle Information Systems website (iNFCIS) http://www-nfcis.iaea.org/.

The database consists of five main areas describing PIE facilities, i.e. acceptance criteria for irradiated components, cell characteristics, PIE techniques, re-fabrication/instrumentation capabilities and storage and conditioning capabilities. An example of its facility report/general and cell characteristics interface is shown in the figure below.



The content of the database represents the status of the participating laboratories and helps interested users select the most appropriate facilities and examination techniques. The database can also be used to compare the PIE capabilities worldwide with current and future requirements, as well as to provide development incentives for laboratories with limited PIE techniques.

An important advantage of the IAEA PIE Database is the procedure of the professional reviewing of all new inputs made on-line. The official reviewer is the authoritative PIE specialist from the OECD Halden Project, Mr Haakon Jenssen. Only after his approval the new or modified data is made visible on the web by the IAEA administrator. Such additional independent checking makes the Database more reliable and better organized.

Following an agreement with the EC HOTLAB project the IAEA PIE Database was merged with a European PIE Catalogue created within that project. After finalization of the on-going reviews of all integrated information, the IAEA PIE Database will be the only publicly accessible world-wide source of the subject information.

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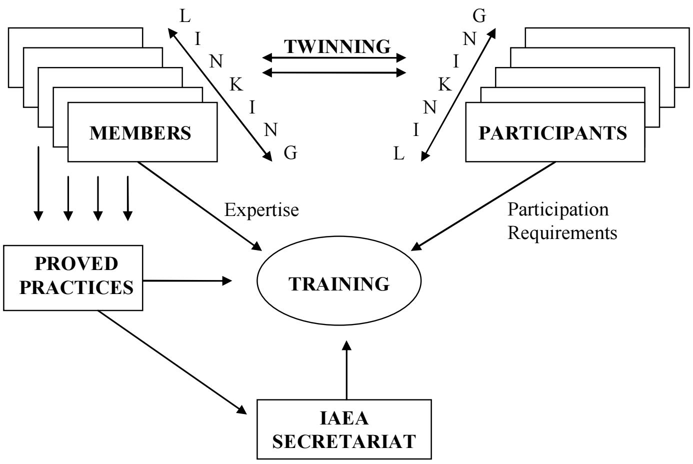
An International Low Level Waste Disposal Network - DISPONET

Many Member States lack a repository for their low level radioactive waste. The development of such a repository calls for a multidisciplinary approach, including adequate managerial skills. Even if most of the technical disciplines needed for this purpose are available in interested countries (e.g., hydrogeology, geotechnical engineering, etc.) special knowledge is required to plan, develop, and operate such a facility and to demonstrate its safety. Transfer of this knowledge through staff training and expert advice to the developing programmes is systematically provided by the IAEA with support of experienced repository operators.



Recently, the demand for assistance has been growing in all regions of the world, exceeding current available capacities of those providing this assistance. Thus, new and more effective approaches for information transfer need to be introduced. To address this problem, the IAEA wishes to support organizations that are either currently engaged in, or actively planning for, disposal programmes, through their inclusion in a network to effectively cooperate and coordinate relevant actions.

Following the experience achieved from the launch and subsequent success of other such networks (i.e., Underground Research Facilities – URF, and International Decommissioning Network – IDN), the IAEA proposes to launch the International Low-level

Waste Disposal Network (DISPONET). DISPONET will be non-commercial in developing its activities and emphasizes proven practices and the experience of successful practitioners. DISPONET shall consist of experienced organizations (the members) sharing proven practices in radioactive waste disposal with the beginners in the field (the participants), in developing their disposal programmes. The IAEA's role is to organize and facilitate cooperation among members and participants and among members themselves.

The leading principle is that each involved institution shall in some way benefit from the participation in the network. Member advantages are seen in the optimal uses of their resources when assisting the IAEA in its activities, in establishing links with other advanced and beginning repository operators, and in formulating and applying proven practices in low level waste disposal. Participants benefit from increasing their capability in waste disposal through the assistance provided and optimizing resource utilization by short-circuiting the learning curve. DISPONET may also create a forum to share approaches to specific issues such as disposal of atypical waste, such as graphite, radium, and disused sealed sources.

Creation of DISPONET was supported by a consultant's meeting convened at the IAEA's headquarters in Vienna on 21-22 April 2008. DISPONET objectives, scope, structure, activities, and methods of work were proposed and potential topics identified for actions to be performed in the starting phases of the network.

The inauguration meeting to formally launch DISPONET and approve a preliminary programme of activities for 2009/10 will take place in Vienna on 28-29 October 2008. The meeting is open to both potential Members and Participants. Information about the network will also be provided during the General Conference (see Side events on 1 October 2008). Actual information on DISPONET will be accessible through the internet website of the IAEA Waste Technology Section (http://www.iaea.org/OurWork/ST/NE/NEFW/wts_home.html).

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Retrievability in Geological Disposal

Various IAEA Member States are discussing whether and to what degree reversibility (including retrieveability) might be built into management strategies for radioactive waste. This is particularly the case in relation to the disposal of long-lived and/or high level waste and spent nuclear fuel (SNF) in geological repositories. It is generally accepted that such repositories should be designed to be passively safe with no intention to retrieve the waste. Nevertheless, various reasons have been discussed for including the concept of reversibility and the ability to retrieve the emplaced wastes in the disposal strategy. The intention is to increase the level of flexibility and to provide the ability to cope with or to benefit from, new technical advances in waste management and materials technologies and to respond to changing social, economic and political opinion.

A new technical document from IAEA explores the technological implications of retrieveability in geological disposal concepts. Publication is expected by autumn 2008. Scenarios for retrieving emplaced waste packages are considered and the document identifies and describes related technological provisions that should be incorporated into the design, construction, operational and closure phases of the repository. This is based on a number of reference concepts for the geological disposal of radioactive waste (including spent nuclear fuel) which are currently being developed in Member States with advanced development programmes.

In a number of countries, it is becoming increasingly important to include provisions for waste retrieval because retrieveability is a legal and/or regulatory requirement in certain cases. Accordingly, the potential benefits and detriments that retrieveability may provide are discussed, possible retrieveability strategies are outlined and a summary of some of the non-technical considerations and implications are provided, which include also discussions on IAEA safeguards and safety implications, cost factors involved and management of repository information and expertise.

Various repository concepts are discussed, with a summary of the types of radioactive waste that are typically considered for deep geological disposal. The main host rocks considered are: igneous crystalline and volcanic rocks, argillaceous clay rocks and salts. Typical design features of repositories have been provided with a description of repository layouts, an overview of the key features of the major repository components, comprising: the waste package, the emplacement cells and repository access facilities, paying special attention to the buffer, backfill, and/or closure of these openings.

The requirement to be able to retrieve waste from a geological repository has technological implications in terms of the design of the disposal system and the associated repository infrastructure. Certain common repository design features (e.g. the use of long-lived waste containers) are inherently beneficial in terms of the ability to retrieve waste. However, certain provisions are required to facilitate waste retrieval and the effort involved in any retrieval operations will depend on several factors, which have been outlined by reference to example repository design concepts. In the context of retrieveability, the environmental conditions within the repository have potential implications in terms of the timescales of waste container integrity and the operational safety of personnel. During a potentially long period of repository implementation and operation, some critical decisions need to be made about how, when, and if various implementation steps should be taken. This may include decisions as to whether the emplaced waste has to be retrieved. Monitoring information can assist the repository operator (and society) in making these decisions. More detailed information supporting the analysis (programme, waste inventory, repository design, and retrieval concept) is provided in country annexes to the report.

Main conclusions of the study are:

- Several Member States are incorporating reversibility and/or retrieveability provisions in their development plans for geological repositories, largely in response to public concerns.
- The timescales when retrieval is likely to be practicable on technical grounds is of the order of hundreds of years.
- Retrieval of waste from a repository may be feasible during repository operations or following closure. Depending on the concept, however, waste retrieval is likely to become progressively more difficult during the operating life of the facility and beyond.
- Waste retrieval may have a negative impact on both conventional and radiological safety. Any potential deleterious effects could be reduced by appropriate provisions, especially by incorporating the provision for retrieveability as early as possible in the design process.
- Any retrieveability provision must not negatively impact upon the long-term safety of the disposal system.
- There may be significant additional costs associated with retrieval provisions.
- Many disposal concepts have inherent provisions for retrieveability (e.g. long-lived containers, removable backfill) and some concepts include specific design provisions (e.g. waste package handling facilities that are designed for both emplacement and retrieval). Retrieval of waste from repositories without specific provisions is also possible, but may be more difficult and costly.

Additional work may be useful in confirming the results of studies to date on retrievable concepts and waste retrieval processes. In particular, it would be useful to gain further practical experience of the removal of engineered barriers and the retrieval of waste packages in different types of geological repositories.

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WATRP Review of Slovenian National Repository for Low- and Intermediate Level Radioactive Waste Programme

The IAEA provides international peer review services in radioactive waste management to those Member States that have established radioactive waste management programmes. Such services are provided within the Waste Management Assessment and Technical Review Programme (WATRP).

Upon request from a Member State, or an organization within a Member State, the IAEA convenes an international panel of experts which performs an independent peer review according to the terms of reference established by the requesting Member State or organization. The mechanisms used for this purpose are (a) review of source material, (b) technical exchange with experts of the requesting Member State or organization in a WATRP meeting, and (c) preparation of a review report with findings, conclusions and recommendations.

Ljubljana, Slovenia

The advantage of such a peer review for the requesting Member State or organization is the obtaining of independent international experts' opinions and advice on (a) proposed or ongoing radioactive waste management strategies or programmes, or (b) planning, siting, operation or decommissioning of facilities. WATRP can contribute to improving the confidence level of waste management systems planned or in operation, and help to ensure that the systems perform in a safe and reliable manner. WATRP can also assist in improving public acceptability of national programmes.

An international peer review of the Technical Programme for the Development of the Slovenian National Repository for Low- and Intermediate Level Radioactive Waste was successfully implemented by the IAEA on 21-25 January 2008 at the request of the National Radioactive Waste Management Agency, ARAO. As defined in the Terms of Reference, the international team which comprised senior experts in RWM from Belgium, Canada, France, Slovakia and the UK, focused its review on three main areas:

- The repository design bases and the suitability of the basic engineering design for LILW disposal at the proposed site;
- The site selection process, site assessment criteria and site characterization ; and,
- ARAO's proposed future activities that are intended to lead to a detailed engineering design and a license application.

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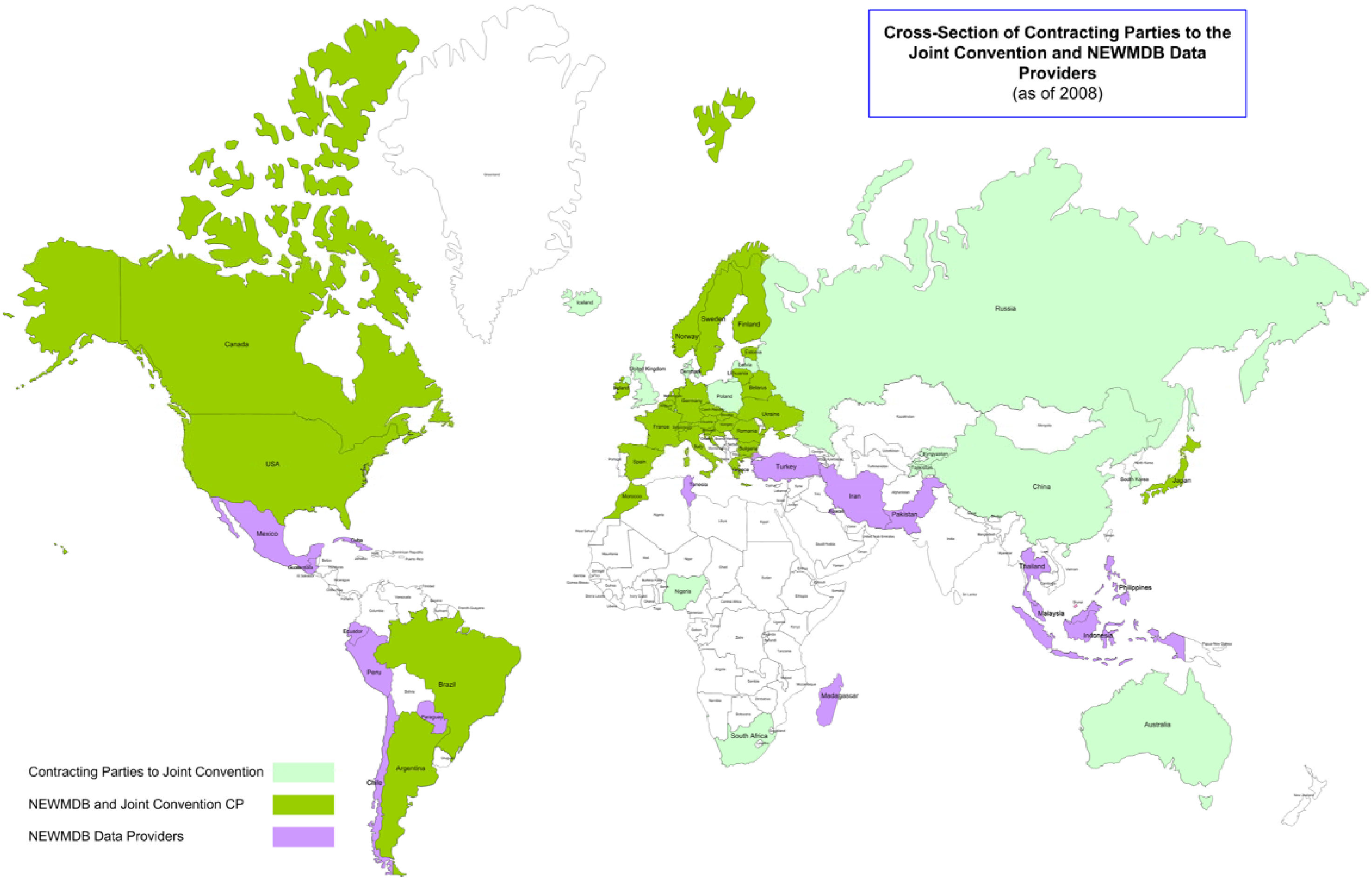
A New Tool for the Reporting of National Radioactive Waste and Spent Fuel Inventories

In recent years, many Member State representatives that provide data concerning spent fuel and radioactive waste management to the IAEA have asked for a way to convert that data into a format that is useful for national reporting, particularly for the Joint Convention on the Safety of Spent Fuel and the Safety of Radioactive Waste. The Joint Convention obligates its contracting parties to provide a comprehensive overview of their spent fuel and radioactive waste management infrastructure and inventories every three years.

The NEWMDB is the IAEA system for the collection and public dissemination of radioactive waste management information from our Member States (http://www-newmdb.iaea.org). NEWMDB combines waste data submitted by IAEA Member States with access to publications, reports, and other data concerning radioactive waste management world-wide.

The new data presentation tool is a special report generator designed to facilitate the writing of national radioactive waste and spent fuel inventory reports. The impetus for this feature was a desire of Member State counterparts (country coordinators to the NEWMDB) to enable them to extract their data back out of the system in



Cross-Section of Contracting Parties to the Joint Convention and NEWMDB Data Providers
(as of 2008)

a way that complies with the guidelines and requirements for national reporting under the Joint Convention The tool is currently available to authorized Member State contacts, including country coordinators for NEWMDB, and national contact points for the Joint Convention. Restricted access is necessary to maintain the confidentiality of spent fuel and non-public waste management information.

What are the advantages of this new tool? First, it provides the data necessary to satisfy the requirements of the Joint Convention and gives the possibility to generate the necessary reports. This can be tremendously useful to Member States and contracting parties to the Joint Convention as it saves time and helps to make the information submitted more consistent in both content and format. The second advantage is the ability for Joint Convention contact points to analyse the information provided by the other contracting parties much faster and easier than in the past. It does this by enabling authorized users to generate comparison reports. The third advantage lies in the ability of the Member State representatives to select the content for these reports, thus providing a tool that can be used to satisfy requests for similar information at any time and for any reason (e.g., internal governmental requests, questions from the media, etc.). The fourth advantage, and an important one, is the use of data that has already been collected and is consistent from year to year. The reporting of consistent data helps to build public confidence in the information provided by Member States with respect to their nuclear and radioactive waste management programmes.

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Eurobarometer Survey on Radioactive Waste 2008

In order to examine European citizens' attitudes towards nuclear energy and radioactive waste in particular, the European Commission Directorate-General for Energy and Transport launched the Eurobarometer survey on *Attitudes towards radioactive waste* in February/March 2008, the result of which has been published in July 2008. This survey is a follow-up to three previous surveys that were conducted in 1998, 2001 and 2005. This study examines Europeans' attitudes and their knowledge levels regarding radioactive waste and the ways of (safely) managing it. The following are some key findings of the current survey.

- The study most notably shows that citizens feel poorly informed about radioactive waste and that their attitudes and their actual knowledge of radioactive waste strongly depend on whether their countries have nuclear power plants or not.
- Support for nuclear energy has increased considerably in the European Union since 2005 and the share of supporters is now nearly identical (44%) to the share of opponents (45%). Respondents in countries that have operational nuclear power plants are considerably more likely to support nuclear energy than citizens in other countries.
- It appears that the safety aspect of managing radioactive waste is crucial for opponents of nuclear energy. Nearly four in ten of these respondents would change their opinion about nuclear energy if there was a permanent and safe solution for managing radioactive waste.
- There is an overwhelming consensus in the European Union (EU) as a whole, that a solution for managing high level radioactive waste should be found now, rather than leaving it for future generations. Deep underground disposal is seen as the most appropriate solution for long-term management of high level radioactive waste by 43% of Europeans on average. Almost nine out of ten respondents consider that each EU Member State should establish a management plan for radioactive waste with a specified fixed timetable.
- Information about how radioactive waste is managed is most trusted when it comes from independent sources such as scientists and non-governmental organisations. Moreover, Europeans have a pro-active attitude towards decision making. A majority of EU citizens would prefer to be directly consulted and to participate in the decision making process, should an underground disposal site be constructed near their home.

The complete report is available at: http://ec.europa.eu/public_opinion.

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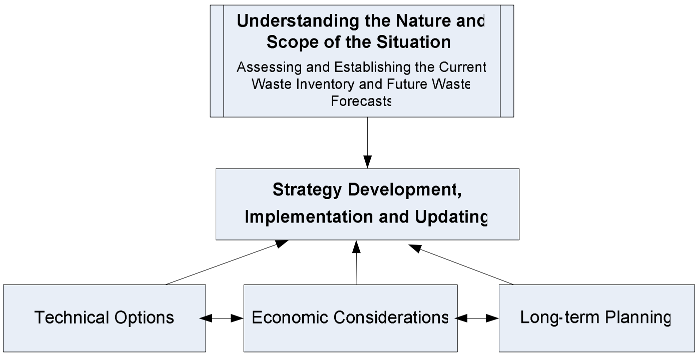
Radioactive Waste Assessment Methodology and Economics of Radioactive Waste Management

Two new technical documents are under development that should support implementation of the guidance document on implementation of radioactive waste management strategies. These are *Radioactive Waste Assessment Methodology* and *Economics of Radioactive Waste Management*.

These two publications are intended to be used in conjunction with two others: *Policies and Strategies for Radioactive Waste Management* (under preparation) and *Review of the Factors Affecting the Selection and Implementation of Waste Management Technologies*, IAEA-TECDOC-1096 (published in 1999). Together, these four documents form the basis for establishing and funding appropriate systems and infrastructure for the management of radioactive wastes.

The linkages between these matters are illustrated with the figure below.

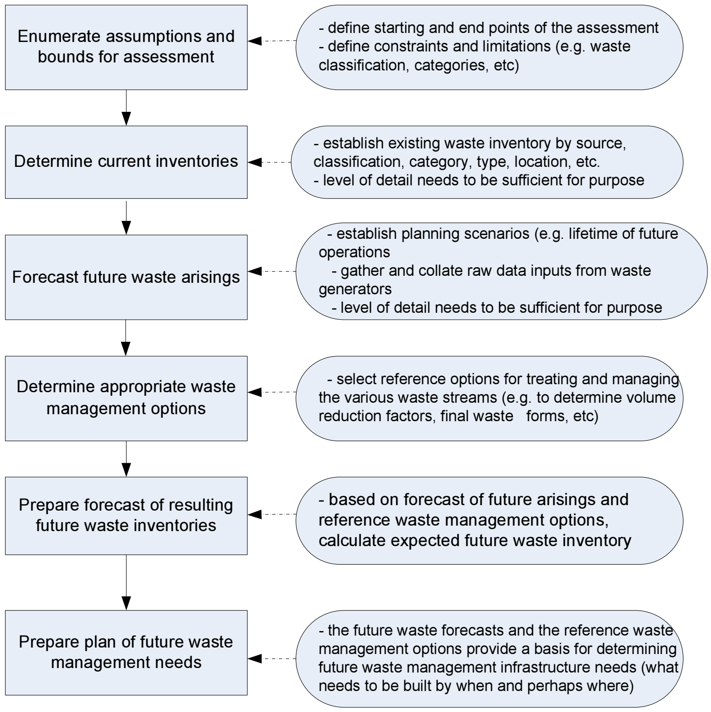


Radioactive Waste Assessment Methodology will provide practical guidance for longer-term planning of technical options for waste management activities by use of standardized, comprehensive considerations and methodologies for performing an assessment of local, national and regional waste inventories and forecasts, and the resulting waste management needs. It covers the full range of nuclear activities, including uranium mining, nuclear fuel cycle facilities, nuclear research reactors and research centres, nuclear power plants, RWM facilities, medical isotope production and usage facilities, industrial applications, and any other facility that may generate RW or by-products.

Economics of Radioactive Waste Management will outline a methodology for estimating the costs of RWM activities, assess the liability for specific RWM strategy and provide examples of application of this methodology in a typical start-to-end evaluation of life cycle RWM costs for alternative strategies.

It will provide an evaluation of life cycle costs and liabilities for the management of waste streams including, but not limited to, the management of legacy waste stored or disposed of in the past and newly generated RW from nuclear applications, nuclear power generation and associated nuclear fuel cycles, and closure and decommissioning of nuclear facilities including the WM facilities themselves.

Basic Methodology for Assessing Waste Management Needs



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Recent Activities of the International Decommissioning Network (IDN)

The IDN Steering Committee met on 12-13 June 2008 in Vandellos, Spain and the meeting was attended by members from Australia (ANSTO), Canada (AECL), France (CEA), Slovakia (VUJE), South Africa (NECSA), Spain (ENRESA) and the USA (DOE). The meeting was chaired by the IDN scientific secretaries, Paul Dinner and Patricio O'Donnell. The group picture was taken against the background of a decontaminated storage bunker, whose wall-markings depict a key theme for the IDN - the successful achievement of facility clearance.

The plans for the extension of the regional TC-project on decommissioning planning in Europe, were presented. This extension represents a major breakthrough for the IDN, in that it provided a means for the IAEA to support the activities of the IDN. The activities proposed for this project, which strongly emphasize hands-on and practical demonstrations, were discussed. Members indicated their willingness to host groups of scientific visitors to their centres to observe upcoming decommissioning activities, such as reactor block dismantlement in Australia, remote dismantlement of graphite reactor blocks in the US, clearance practices in Canada, conversion-plant dismantlement in South Africa, and small radioactive waste treatment facilities in Slovakia.

Members of the steering committee also expressed their strong support for ENRESA's efforts to organize as soon as possible their previously proposed technical activity for practical demonstration of materials management and clearance.

New *Basic* courses in decommissioning were also discussed. One, offered by CEA-INSTN based in Grenoble is structured along the lines of the IAEA curriculum and could be offered as early as Q1/2009. ANL (USA) has offered to provide a cost free version of its well-established decommissioning course, also in 2009. A DOE internal training course developed in the mid 1990s, that could be used in concert with future IAEA decommissioning training activities, has been reviewed by DOE staff to confirm its continued relevance, and permission to use it has been given.

IDN Steering Committee meeting participants – Vandellos, Spain, 12-13 June 2008

Upcoming decommissioning activities of interest to all IDN participants include the Avignon meeting at the end of September 2008: (https://www.sfen.fr/index.php/plain_site/decommissioning_challenges), and EPRI in Lyon, 28-30 October 2008: (www.iaea.org/OurWork/ST/NE/NEFW/documents/2008_EPRI_Intl_D&D_Notice.pdf).

Also, mark your calendars for the Decommissioning Forum in Vienna, 3-7 November 2008. This new event, called the FORUM, will combine the IDN annual Technical Meeting and a report on results and lessons learned form the Magnox decommissioning peer-review exercise held in July 2008.

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Special Report

D&D of Fuel Pools: A Huge Legacy Worldwide

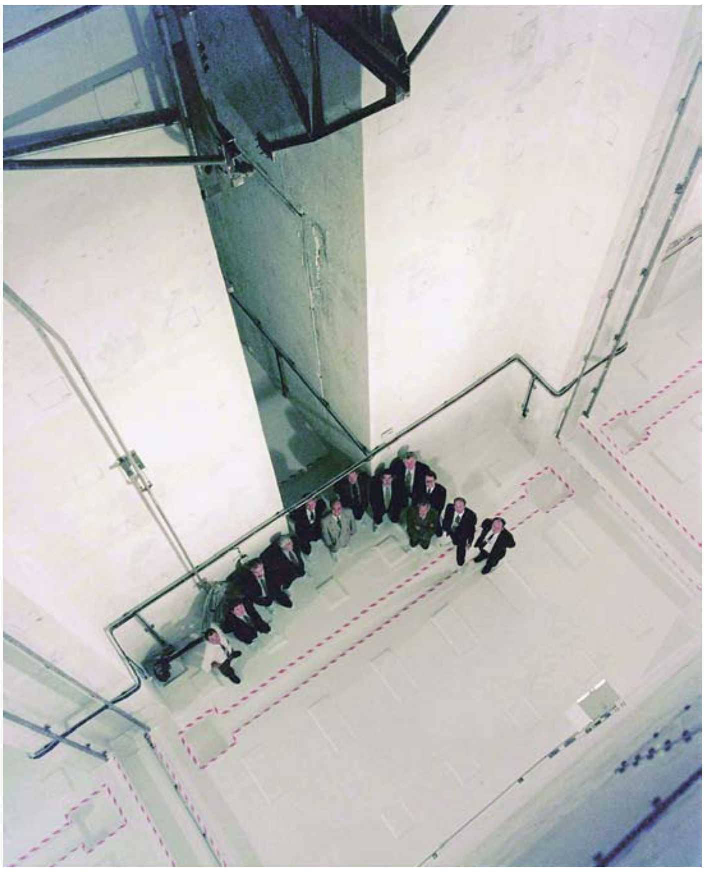
Nearly all nuclear reactors and many other nuclear fuel cycle facilities (e.g. reprocessing plants or waste storage facilities), use pools (sometimes referred to as *ponds*) for high-activity material storage. A common feature is to store spent fuel during and beyond facilities' operational lifetimes. Over a service lifetime that can reach decades, the pool water grows contaminated by activation and fission products, and possibly fuel debris. The presence of sludge is commonplace. Pool floors and walls become contaminated as the result of surface deposition of radioactive corrosion and fission products and possible penetration of contamination. In some cases contamination may penetrate to the building foundation, underlying soils or even groundwater. In the longer term, this is a sizeable decommissioning issue. It should be noted that this issue is quite common also in developing countries due to the ubiquitous presence of these facilities. In addition to spent fuel pools, there are other pool-type facilities (e.g. research reactors) that are contaminated through similar mechanisms. The following two examples illustrate certain typical aspects of ongoing fuel pool decommissioning projects.

UNITED KINGDOM

Spent fuel cooling ponds built for the UK's Magnox programme pose one of the most difficult cleanup challenges in the world. The First Generation Magnox Storage and De-canning Facility (MSDF) was constructed in the mid 1950s at Sellafield and performed a vital and integral role in the UK civil nuclear power programme. It operated for nearly 30 years, storing irradiated Magnox fuel in a concrete open air pool before stripping the fuel of its cladding prior to reprocessing at a separate Sellafield facility. During operational service a massive 27 000t of fuel was stored, de-canned and then exported from the plant. It received its last batch of fuel in 1992 before entering its post-operational cleanout (POCO) phase.

However, its unique cleanup challenges were created in the mid 1970s due to a lengthy and unforeseen shutdown at the Magnox Reprocessing Plant and also a vastly increased throughput of fuel due to electricity shortages. These factors caused the spent fuel to be stored in the pool for longer than the designed period, resulting in the corrosion of the fuel's magnesium oxide cladding and degradation of the fuel itself. Ultimately this led to increased radiation levels and extremely poor underwater visibility in the pool.

In the absence of waste treatment and disposal routes, legacy pools, in particular MSDF, accumulated significant inventories of waste materials, including sludge from the corrosion of fuel cladding, fuel fragments and other debris. Although these practices were regarded as entirely acceptable at the time, their consequences pose a number of challenges to cleaning out and decommissioning the plant. The facility contains large quantities of spent fuel, sludge and other materials that are classified as intermediate level waste (ILW).



SGHWR pool, UK, during a stakeholders' visit after release (following decontamination, the spent fuel pool can be released for unrestricted use)

The safe and accelerated decommissioning of the facility is very high on the national agenda of the Nuclear Decommissioning Authority (NDA), which owns all civil nuclear assets in the UK, including Sellafield. In terms of the priorities for the overall cleanup of the pool, there are four elements, which are interdependent:

- Sludge removal and processing into a safe, passive state for interim storage;
- Fuel removal for reprocessing or encapsulation as waste and placement into storage;
- Skip retrieval for decontamination, size reduction and encapsulation and interim storage;
- Removal of miscellaneous waste for size reduction and encapsulation and interim storage.

Considering its potential capacity to become mobile, sludge represents the biggest radiological risk and is therefore the primary focus of cleanup work. The NDA has made the cleanup of the sludge in the fuel storage pool a priority and the Nuclear Installations Inspectorate has instituted a regulatory specification that requires 90% of the sludge (300 cubic meters) be removed to interim steel containment tanks by August 2009. Recent progress on cleanup has been made with the installation of a local effluent treatment plant, capable of cleaning 125 cubic meters of pool water per day. Future plans call for installing a local sludge treatment plant (LSTP) adjacent to the pool. The LSTP will include shielded tanks to store the sludge prior to treatment.

[Sources: Nuclear Engineering International, Decontamination and Decommissioning – A Ponderous Hazard, 23 August 2006; Peres, M.W., A Comparison of Challenges Associated with Sludge Removal, Treatment & Disposal at Several Spent Fuel Storage Locations, HNF-31048-FP rev 1, presented at WM'07 Symposium, 2007 Tucson, AZ]

UNITED STATES OF AMERICA

When Fluor Hanford, prime clean-up contractor to the Richland Operations Office (RL) of the U.S. Department of Energy, completed removing more than 4 million pounds (1 600 000 kg) of deteriorated spent fuel from the K Basins in October 2004, the job of cleaning out the aging basins was not finished. About 52 cubic yards (40 cubic meters) of sludge clogged the basins.

In May 2007, the last of the sludge, a non-homogeneous mixture of tiny bits of corroded uranium fuel (uranium oxides, hydrates, and hydrides), pieces of fuel cladding, debris such as windblown sand and environmental particulates, rack and canister corrosion products, ion exchange resin beads, polychlorinated biphenyls, and/or fission products was collected and removed from the K East Basin. At the same time, Fluor Hanford employees finished removing larger fragments of spent fuel found while collecting the K East Basin sludge. They also removed well over 400 tons of solid nuclear debris and fuel racks that had choked the K Basins.

One factor that made the sludge so hazardous was that its approximately 1 million curies (37 000 TBq) were contained in such a small volume. Furthermore, it was in a more mobile form than the spent fuel - it had the potential to leak into surrounding soils and ground water more readily if not captured. Several different forms of sludge existed in the K Basins.

Retrieving the sludge as it swirled through the over 1 million gallons (4 000 000 L) of water in each basin was an immensely challenging process. It required workers to stand on grating 20 ft (7 m) above the basin floors and approximately 4 ft (1.2 m) above the surface of the water while vacuuming the sludge into large underwater containers. They used long-handled tools with special attachments called end-effectors on the ends to scoop, scrape, or chase the sludge up into the wands and the containers. For most of the three years of sludge vacuuming, they could barely see below the water's surface and could never see the bottom of the basins. As a result, they used cameras, monitors, and lights to guide their work.

Workers found pumping sludge exhausting work. It was reported that the work was like *vacuuming under the bed in your child's room from a small hole in the ceiling above, without first picking up the toys*. This was referring to using the long vacuuming tools through small holes in basin grating and working around scattered piles of underwater debris.

The best single decision was to pause sludge vacuuming and remove debris first. In addition to about 80 tons of large fuel racks, the K Basins held a confounding array of contaminated solid waste. It came in all shapes, sizes, and levels of contamination, had spent different lengths of time in the basins, and came with varied characteristics such as sharp edges, slippery surfaces, odd shapes, stickiness, and other variables. It covered and hid pockets of sludge and was in turn disguised by sludge. Failed pumps, hoses, cords, thousands of fuel canisters and lids, routine and long-handled tools, brackets, and other pieces congested the basins.

The wide variation in debris sizes and characteristics made it hard to handle any piece of debris in a routine manner. The crews had to be creative each day, in each work evolution, and they really rose to the challenge. Fluor Hanford employees devised ingenious tools for capturing debris and deployed them attached to the 20-ft-long (6 m) poles. These devices included a *pancake flipper* tool to turn over small identification disks resting with their flat sides to the basin floor, underwater cutting devices, and a box-like washing machine. Smaller debris was bundled into underwater debris baskets before being brought to the surface for load-out. Because of high contamination levels in the basin, workers removing the debris wore two waterproof protective clothing and used respirators. Electric hoists and underwater lights were necessary to guide the work. Fuel racks varied in length from 10 to 15 ft (3 to 5 m) and weighed from 300 to 500 lb (150 to 230 kg) apiece. It took a crew of 15 to remove each rack.

In March 2008, the draining of the Hanford Site's K East Basin was completed. The draining of the basin paves the way for its demolition. The empty basin will be filled with a sand-like material that will provide a working platform for the heavy equipment that will be brought in to tear down the basin structure. With the removal of the concrete basin, the soil underneath it, which was contaminated by water leaks, can be accessed.

[Sources: M. Gerber, The Sludge Cleanout of Hanford's K Basins, Radwaste Solutions, Jan-Feb 2008, 20-31; and Nuclear News, Contaminated Water Drained from K East Basin, May 2008, 60-62].

Spent fuel pool decontamination

CONCLUSIONS

The removal of sludge and water is only preliminary to actual decontamination of the fuel pool. Particularly if floors and walls were uncoated, the concrete is prone to absorb contamination. Experience from Magnox pools in the UK shows typical penetration of a few centimetres. Contamination can even migrate through concrete cracks and leak into the environment, as in the Hanford case. To release the spent fuel pool for reuse may require first high pressure jet water lances and then a lengthy scarification (i.e., scabbling) of concrete layers (see figure above for Latina GCR, Italy). Occasionally, remote operation is required, such as at Trawsfynydd NPP, UK). One innovative technique being planned for at Bradwell NPP, UK is to cause desorption of concrete contamination from pool floors and walls by lowering the water pH.

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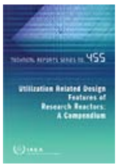
Recent Publications

Nuclear Energy Series No. NP-T-5.4
Optimization of Research Reactor Availability & Reliability: Recommended Practices (2008) **NEW!**



Technical Reports Series No. 455
Utilization Related Design Features of Research Reactors: A Compendium (2008)

Technical Reports Series No. 456
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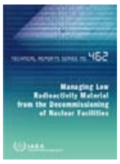
Considerations of Waste Minimization at a Design Stage of Nuclear Facilities (2008)



Technical Reports Series No. 462
Managing Low Radioactivity from the Decommissioning of Nuclear Facilities (2008)

Technical Reports Series No. 463
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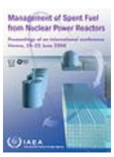
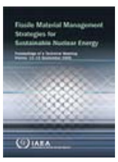


STI/PUB/1295
Proceedings of June 2006 International Conference on Management of Spent Fuel from Nuclear Power Reactors (2007)



STI/PUB/1288
Proceedings of Sept. 2005 Technical Meeting on Fissile Material Management Strategies for Sustainable Nuclear Energy (2007)

IAEA-TECDOC-1535
Nuclear Fuel Cycle Simulation System (VISTA) (2007)

IAEA-TECDOC-1537
Strategy and Methodology for Radioactive Waste Characterization (2007)

IAEA-TECDOC-1538
Categorizing Operational Radioactive Waste (2007)

IAEA-TECDOC-1547
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IAEA-TECDOC-1579
New Developments and Improvements in Processing of 'Problematic' Radioactive Waste (2008)

Radioactive Waste Management Profiles No. 8
A Compilation of Data from the Net Enabled Waste Management Database (NEWMDB) (2007)

Upcoming Meetings in 2008

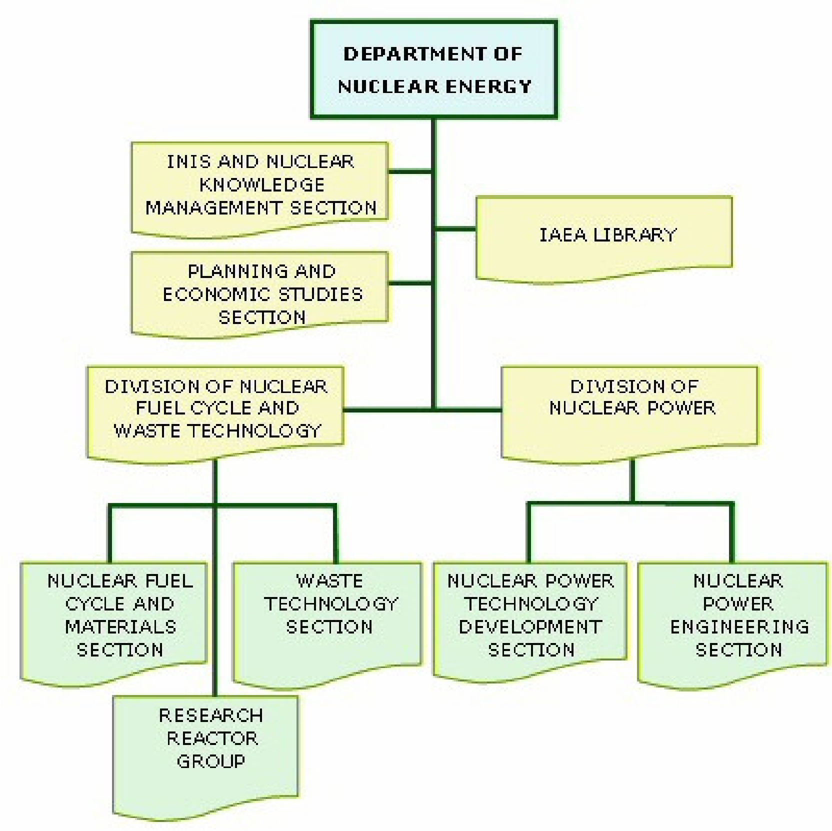
Date	Title	Place	Contact
9-11 September	Technical Meeting on Borehole Repositories for the Disposal of Disused Radioactive Sources: Technical and Institutional Considerations	Vienna Austria	L.Nachmilner@iaea.org
13-16 October	Technical Meeting on Storage Facility Operations and Lessons Learned	Vienna Austria	Z.Lovasic@iaea.org
15-17 October	Technical Meeting on the Implementation of Sustainable Global Best Practices in Uranium Mining and Processing	Vienna Austria	J.Slezak@iaea.org
28-31 October	Technical Meeting on Economics of Radioactive Waste Management	Vienna Austria	Z.Drace@iaea.org
3-7 November	Annual Forum for Regulators and Operators in the Field of Decommissioning: International Decommissioning Network (IDN) Activities and Outcomes of the International Peer Review of Decommissioning	Vienna Austria	P.Dinner@iaea.org
3-7 November	Technical Meeting on the Viability of Sharing Disposal Facilities: Technical and Institutional Considerations	Vienna Austria	B.Neerdael@iaea.org
10-15 November	Technical Meeting on Reference Design for Storage Facility for Low-level Radioactive Waste from Nuclear Applications and/or Disused Sealed Radioactive Sources	Vienna Austria	S.Samanta@iaea.org
10-21 November	Workshop on Training in Basic Radiation Materials Science and its Applications to Radiation Effects Studies and Development of Advanced Radiation Resistant Materials	ICTP Italy	V.Inozemtsev@iaea.org
12-14 November	Technical Meeting to Maintain and Update the Nuclear Fuel Cycle Information System	Vienna Austria	M.Ceyhan@iaea.org
17-20 November	Technical Meeting on Uranium Exploration and Mining Methods	Amman Jordan	J.Slezak@iaea.org

Planned Meetings in 2009

9-11 February	International Working Group Meeting of Research Reactors	Vienna Austria	P.Adelfang@iaea.org
23-27 February	Technical Meeting on HLW Processing and SNF Encapsulation	Vienna Austria	S.Samanta@iaea.org
16-20 March	Technical Meeting on Organization, Principles and Technical Options for Waste Minimization	Vienna Austria	Z.Drace@iaea.org
31 Mar. - 3 April	Annual WATEC Meeting	Vienna Austria	J.M.Potier@iaea.org
20-24 April	Technical Meeting on the IAEA Network of Centres of Excellence	Tournemire France	B.Neerdael@iaea.org
20-24 April	Workshop on Training in Development of Radiation Resistant Materials	Trieste Italy	V.Inozemtsev@iaea.org

Division of Nuclear Fuel Cycle and Waste Technology (NEFW) WebSite Links

Division Introduction - NEFW Home: http://www.iaea.org/OurWork/ST/NE/



Nuclear Fuel Cycle and Materials Section (NFCMS)

— Main activities
http://www.iaea.org/OurWork/ST/NE/NEFW/nfcms_home.html

— Technical Working Group on Nuclear Fuel Cycle Options (TWGNFCO)
http://www.iaea.org/OurWork/ST/NE/NEFW/nfcms_twgnfco.html

— Technical Working Group on Water Reactor Fuel Performance and Technology (TWGFPT)
http://www.iaea.org/OurWork/ST/NE/NEFW/nfcms_twgfpt.html

— Databases (NFCIS, UDEPO, VISTA, PIE)
http://www.iaea.org/OurWork/ST/NE/NEFW/nfcms_infcis.html

Waste Technology Section (WTS)

— Main activities
http://www.iaea.org/OurWork/ST/NE/NEFW/wts_home.html

— International Radioactive Waste Technical Committee (WATEC)
http://www.iaea.org/OurWork/ST/NE/NEFW/wts_watec.html

— Technical Group on Decommissioning (TEGDE)
http://www.iaea.org/OurWork/ST/NE/NEFW/wts_tegde.html

— Databases (NEWMDB, DRCS)
http://www.iaea.org/OurWork/ST/NE/NEFW/wts_information.html

Research Reactor Group (RRG)

— Main activities
http://www.iaea.org/OurWork/ST/NE/NEFW/rrg_home.html

— Technical Working Group on Research Reactors (TWGRR)
http://www.iaea.org/OurWork/ST/NE/NEFW/rrg_twgrr.html

— Research Reactor Database
http://www.iaea.org/OurWork/ST/NE/NEFW/rrg_RRDB.html

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