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Fukushima Clean-up

The accident at the Fukushima NPP led to the contamination of large inhabited areas. The road map for the remediation and environmental management of these areas is under development in Japan. The IAEA is ready to support it.

The clean-up strategy takes into account a number of important considerations to select adequate countermeasures. These considerations include clean-up requirements and classification of contaminated areas that will impact on the choice of various technical options. The following attributes such as performance, constraints of implementation, effectiveness, waste generated, doses received during implementation, side-effects, experience and cost/benefit are used as major criteria for selection.

Based on lessons learned from past clean-up efforts, in addition to technical considerations, attention needs to be paid to social and communication issues to address public health and safety, possible psychological and social impacts, public information, awareness and involvement. Sharing of information on clean-up programmes, challenges, management of residues and home return schedules can go a long way to ensuring success of these efforts. It is well known that knowledge and adequate sharing of information considerably reduce anxiety.

Figure 1: Clean-up of contaminated roof
(Photo courtesy of the Anti-Disaster Headquarters of *Fukushima Prefecture).*

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The Nuclear World Continues to Change, Whether We Want It To Or Not

In the 2008 IAEA Scientific Forum I said in my opening remarks that "The nuclear world is changing, whether we want it to or not". It continues to be very true with new additional change drivers rising from the post-Fukushima world.

Lots of hard work is ongoing in different levels. The IAEA's DG Amano presented to the IAEA Ministerial Conference on Nuclear Safety five concrete proposals, which would contribute to establishing a realistic and enhanced post-Fukushima nuclear safety framework. The proposals were related to the need to strengthen IAEA Safety Standards and to ensure that they are universally applied; the need to systematically and regularly review the safety of all nuclear power plants; importance of national regulatory bodies, which play a crucial role in ensuring nuclear safety; the need to strengthen the global emergency preparedness and response system; and the IAEA's role in receiving and disseminating information.

The Ministerial Conference achieved its main goal, which was to pave the way for an enhanced post-Fukushima global nuclear safety framework. Since then, actions plans have been prepared to translate goals and visions into safer reality.

Today, it is important to remember that we are still in the early stages of learning and sharing lessons learned from the accident. We have preliminary understanding of what happened, but as the examples of Three Mile Island and Chernobyl have shown, it will take years before we get the full picture and are able to learn and share the lessons, i.e. to change the world.

Despite obvious post-Fukushima changes, it is also worth recognizing that the fundamental long term drivers of the global nuclear change indicating expansion of nuclear programmes remain the same as they were before the Fukushima accident. To mention some of them, the world population continues to grow and so does urbanization; not only is more energy needed, but also more electricity. Even saving energy in developed countries relies on technologies using electricity, such as electric trains and cars, and automation. Economies continue to consume larger volumes of energy and electricity. Substantial energy expansions are planned in key large economies, such as China and India. Overall concerns about the environment and climate change continue, perhaps stronger than ever. At the same time, security of energy supply and energy independence are high on national agendas. With the current global economic problems, competitiveness and cost stability of energy plays an ever increasing role to national economies.

Therefore, it is no wonder that many countries are continuing their nuclear programmes as planned. It is a fair statement that world's reliance on nuclear power continues to grow, evidently slower than before Fukushima at least for some time to come, but the long term growth is there.

This also means many surfacing changes to the fuel cycle and waste technologies. Fukushima has impacted the whole fuel cycle starting from the price of raw uranium in strengthening spent fuel disposal considerations.

Major activities have taken place since our previous Newsletter. As you read, we have achieved important results on our long interesting journey. The nuclear world continues to change.

Tero Varjoranta, Director (T.Varjoranta@iaea.org)

The management of waste generated by clean-up is one of the major challenges taking into account the need for storing and disposing of large volumes of contaminated materials. Important considerations are related to criteria and options for handling, treatment, recycle and re-use, storage and disposal. Valuable lessons have been learned from past experience with handling of accidents in Chernobyl, Goiania and mining waste. These experiences and lessons learned are documented in a number of IAEA publications. Through its Technical Cooperation Programme, the IAEA is actively supporting continuing efforts of Ukraine, Belarus and Russian Federation in rehabilitation of the areas affected by the Chernobyl NPP accident.

Different technologies have been applied on a large scale in Ukraine, Belarus, the Russian Federation, the USA and Brazil. Various equipment for remotely handling decontamination was applied after the Chernobyl accident. Testing of various countermeasures is performed by emergency teams in different countries.

Most of these technologies were tested on a small scale in Denmark and the other Nordic countries to better understand their implications (doses, requirements, cost, effectiveness, secondary waste generation and social impacts). Mining companies also have experience in the management of large waste volumes and remediation of large areas. The IAEA has also developed material on the decontamination of rural settlements and a software tool to support decision making on the remediation of rural areas.

In summary, a great deal of information on dealing with clean-up of large contaminated inhabited areas affected by nuclear and radiological accidents exists. The decision making process to formulate and implement clean-up strategy can certainly benefit from the information and experience that is available.

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Decontaminating Radioactive Water Using Mobile Technologies

The treatment of radioactive liquid (mainly aqueous) waste streams generated from the operation of nuclear reactors and fuel cycle facilities is routinely carried out worldwide using a variety of well-established techniques. As result of treatment, liquid waste is usually partitioned into two separate streams: a bulk stream of decontaminated liquid that is suitable for either discharge or recycle, and a small liquid or wet solid stream in which the radioactivity gets concentrated and which can be conditioned, packaged, stored or disposed of.

Several treatment techniques are commonly used for the treatment of liquid waste: filtration, chemical treatment, ion exchange, reverse osmosis and evaporation. Usually, it is a combination rather than a single technique that helps to achieve the desired results. For any particular application, the appropriate treatment technique or combination of techniques is selected based on some key considerations that include the characteristics and volumes of the waste stream, target decontamination and volume reduction factors, management of secondary waste, etc.

There have been significant improvements in these techniques over the years. The development and availability of selective ion exchange media and high performance membranes can be cited as significant achievements. In many applications, ^{137}Cs is amongst the major radionuclides to be removed and caesium-selective sorbents are used for this purpose. Zeolites, transition metal hexacyanoferrates and silicotitanates are well-known examples. These inorganic sorbents have high radiation stability. They have higher selectivity for caesium compared to the conventional ion exchange resins and can efficiently remove caesium in the presence of much higher concentrations of competing sodium ions that are usually present in waste water streams.

In respect of mode of application, liquid waste treatment systems have been deployed as either fixed or mobile systems. Valuable experience has been acquired by using both options in over 30 years of application. In recent years there is an increasing tendency to use mobile and transportable skid mounted modular systems versus centralized fixed systems. This trend is driven by a variety of factors, for example:

- Avoiding off-site transport of liquid waste to a centralized treatment facility;
- The opportunity to manage waste in a campaign mode in case of multiple facilities that generate similar waste streams.

Mobile systems can be assembled and tested in the factory, easily installed on site and easily replaced with more advanced techniques/processes.

However, the decision to use mobile and transportable skid mounted modular systems versus centralized fixed systems requires careful evaluation of safety, design and operational limits, and cost. Possibilities for equipment sharing amongst multiple sites for processing campaigns that may vary in duration from very short periods to several years and fewer requirements on infrastructure and operating personnel favour mobile and transportable skid mounted modular systems in the selection process. However, limitations with respect to system processing capacity and shielding need to be taken into account.

On the other hand, there are cases where mobile and transportable skid mounted modular systems have clear advantages under specific circumstances involving:

- Non-routine problematic wastes with smaller volume that require case specific solutions using a combination of techniques;
- Accident/incident situations when the system needs to be deployed in an emergency;
- Decommissioning situations where building of new nuclear facilities, such as waste processing facilities, should be avoided.

The mobile and skid mounted systems are available from many commercial vendors or are custom designed to address specific needs. The following examples provide brief summary information on some such systems in use, optimized and configured in line with the specific requirements.

Figure 1: Aqua-Express
(Photo courtesy of MosNPO Radon, Russian Federation).

The mobile modular system Aqua-Express is designed by MosNPO Radon, Russian Federation for the treatment of liquid low level and intermediate level radioactive waste (LILW) and can be optimized to address different needs. This skid mounted system is intended for application in small to medium nuclear research centres and other organizations where the generation of waste is rather low. Treatment is achieved through a technological chain that includes filtration, sorption and ultrafiltration processes and is designed to release non-radioactive salts together with the cleaned water. The system consists of three autonomous modules and a sampling system. The system can be transported by road, rail or air. It can be installed in a standard ISO transport container. Basic capacity is 300—500 L/h. The mobile facility ECO-3 uses a similar process configured inside an ISO container.

A mobile nuclide removal system (NURES) has been constructed and operated by Fortum Nuclear Services Ltd, Finland. NURES can be tailored to different needs, either as a fixed or mobile system. Because of its flexibility the mobile units can differ from case to case. NURES can be used for treatment of different liquids, including liquids with high salt concentrations. The system has been used for liquids with total salt concentrations up to 300 g/L. The first step in the process is an efficient filtering unit, which removes suspended radioactive particles. The next step removes target radionuclides as ionic radioactivity by highly selective ion exchange materials. Basic capacity with a standard 12 litre column gives a processing flow rate from 120 to 240 L/h. Parallel use of columns or use of powdered material in cartridges can increase the capacity.

A mobile filtration and ion exchange treatment system is utilized in the Bhabha Atomic Research Centre, India for treatment of alkaline intermediate level waste streams from reprocessing plants. The process involves passing the aqueous waste through a disposable filter cartridge for removal of suspended solids and then through a series of selective ion exchange columns for removal of ^{137}Cs and ^{90}Sr. The ion exchange resins are used in cyclic loading-elution-regeneration mode. Basic capacity with 100 litre columns is 400 to 500 L/h. The system has been used to remove ^{137}Cs with a decontamination factor >10 000 from waste streams having salt concentrations up to 200 g/L.

Further technical details on the above three systems are included in an IAEA draft technical report on Considerations for the application of mobile processing systems for radioactive waste management, that is being finalized.

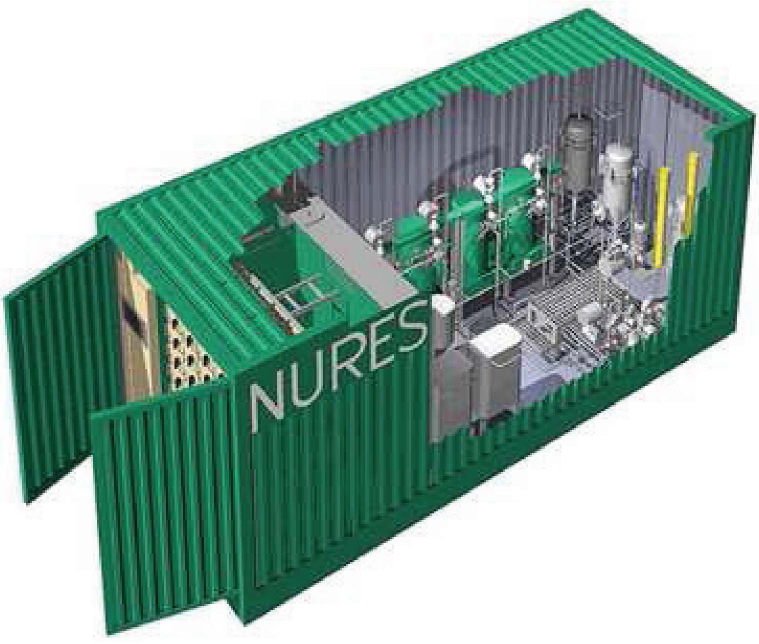

Figure 2: Nuclide Removal System (NURES) (Photo courtesy of Fortum Nuclear Services Ltd, Finland).

Figure 3: Transportable Ion Exchange (TRIX) plant, (Photo courtesy of Bhabha Atomic Research Centre, India).

The floating waste processing facility Landysh belongs to the Zvezda shipyard in the Russian Far East (near Vladivostok). It processes low level liquid waste from submarines. Its maximum capacity is 35 m^3 per day. The maximum salt content is 35 g/L. The facility was funded by the Japanese government, designed by the USA and built and commissioned in the Russian Federation in 2001.

Figure 4: Landysh floating waste processing facility, Zevezda Shipyard, Russian Federation.

Potok-2, is a membrane sorption skid mounted facility for processing low and intermediate level liquid waste with an activity up to 10^9 Bq/L, complex chemical composition and salt content up to 27 g/L. The capacity is 1 m^3 per hour. The facilities are provided by the Ecoatom Company located in Sosnovyi Bor (near St. Petersburg).

There is also good experience in processing of waste from nuclear submarines and navy bases. One such facility is located in the Russian Far East at the DalRAO Company.

A submerged demineraliser system (SDS) was used to process more than 5 000 m^3 of contaminated water resulting from the TMI-2 accident. The system was designed by Chem-Nuclear (now Energy Solutions) in collaboration with the US DOE (Savannah River and Oak Ridge National Laboratories). Zeolite sorbent columns were used in SDS to remove 12 580 TBq of ^{137}Cs and ^{90}Sr from the waste water.

Figure 5: Potok-2 facility (Photo courtesy of the Ecoatom Company, Russian Federation).

Pre-assembled transportable skid mounted systems have been deployed at the Fukushima Daiichi NPP in Japan to decontaminate very large volumes of highly radioactive wastewater. It is expected that, at a the later stage, pre-assembled skid mounted modular treatment systems will also be used at individual reactor units as part of a closed cooling loop. Since throughput will be low it should be possible to assemble the required combination of treatment techniques on a compact skid.

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Spent Fuel Management Post-Fukushima: Have the Risks Changed?

March 11, 2011 was one of those days when the world seemed to change. Most of us remember where we were and what we were doing when we first heard about the Great East Japan Earthquake and resulting tsunami.

Many of us working in the nuclear fuel cycle have a sense that the fuel cycle too has changed, particularly in the area of spent fuel management. Our perception of the nature of stored spent nuclear fuel and the associated risks seem to have changed.

Spent nuclear fuel no longer seems like a contented retiree, lounging comfortably in a private pool. Driven largely by speculation, some now see it more like a fiery-tempered Genie waiting to escape from its bottle and wreak havoc. Spent nuclear fuel is now scary.

The risk picture has changed.

We are used to risk being the product of consequence and probability. The worst theoretical consequence would be the destruction of the fuel accompanied by some physical or chemical processes that spread radiologically or chemically hazardous material over large areas. But we knew that there was really no probability of such consequences.

Now, the speculation and discussions about these theoretical consequences have changed our perception of the chances. Thus, they have changed our perception of the risk.

At the end of the day the stored spent nuclear fuel will likely show us that it survived the natural disaster relatively well in Fukushima. Faced with an earthquake ten times what was considered possible and an ensuing tsunami larger than the design base, the spent fuel came out surprisingly well. Its contribution to the resulting radioactive contamination seems to be small. And yet, the risks will never seem the same.

Many safety improvements for storing spent fuel are already on drawing boards. However, there is no credible technical way to avoid spent fuel being stored in water pools, like those in Fukushima, near the reactor for a few years after it has been discharged from the reactor. And that's the time period, when the heat load of the fuel is at its highest, as is the safety risk.

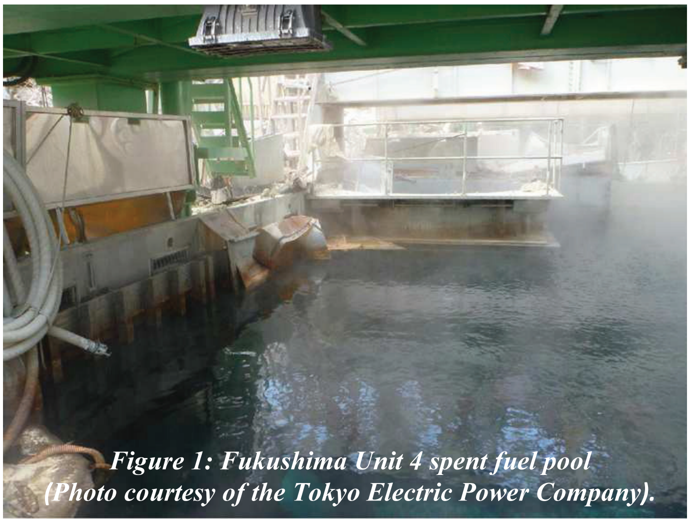

Figure 1: Fukushima Unit 4 spent fuel pool (Photo courtesy of the Tokyo Electric Power Company).

In the coming years, we will no doubt re-examine the nuclear fuel cycle quite carefully. We will re-consider the merits of closed, partially closed and open fuel cycles. We will look for ways to minimize the inventory of stored spent nuclear fuel. We will re-evaluate the relative merits of at-reactor storage and away-from-reactor storage and of wet storage and dry storage. We will re-think design-basis scenarios and we will design stress tests that go beyond the design basis.

All of this effort and expense will be driven by the day the spent fuel changed. And how has the spent fuel been changed by the Fukushima accident? It hasn't, of course. We have changed.

Gary Dyck (G.Dyck@iaea.org)

"Yes, it will be safe!"

The Swedish Nuclear Fuel and Waste Management Company (SKB) submitted – as the first one in the world – a construction permit application for a final disposal facility for spent fuel last spring. At the same time SKB applied for a permit to build a facility where the fuel will be encapsulated before being transported to the final repository.

SKB's application is now being reviewed by the Swedish Radiation Safety Authority and the Environmental Court. The application will subsequently be presented for a political decision in the relevant municipalities and by the government.

If SKB gets permission to build the facilities according to the plans and quality measures suggested in the application, then safety is guaranteed. This is *Claes Thegerström*´s, the CEO of SKB, firm conviction.

The application has been submitted to the Swedish authorities. What happens now?

"Now follows the review of our application. Of great importance will, of course, be the confirmation that The Swedish Radiation Safety Authority has checked that all necessary information is included the application. We expect to get that message within approximately one month. That will be our first indication that we are on track; that all information is there for execution of deep and thorough review."

What part has the division of responsibilities between industry, authorities and legislators played?

"I believe it has been a strength that industry has had a clear task to solve the problem. When we began, we had right from the beginning a mix of experienced people from the industry, among them some who had built reactors. We had outgoing academics and, don't forget, strong authorities, which allowed us – in contrast to the American way – to own the mission. This has been a crucial success factor, I am sure."

Opinion polls have shown that SKB has strong local support in both affected municipalities of Oskarshamn and Östhammar. How come?

"The main reason, I believe, is that we have been there for a long time, and we have acted in a fashion that

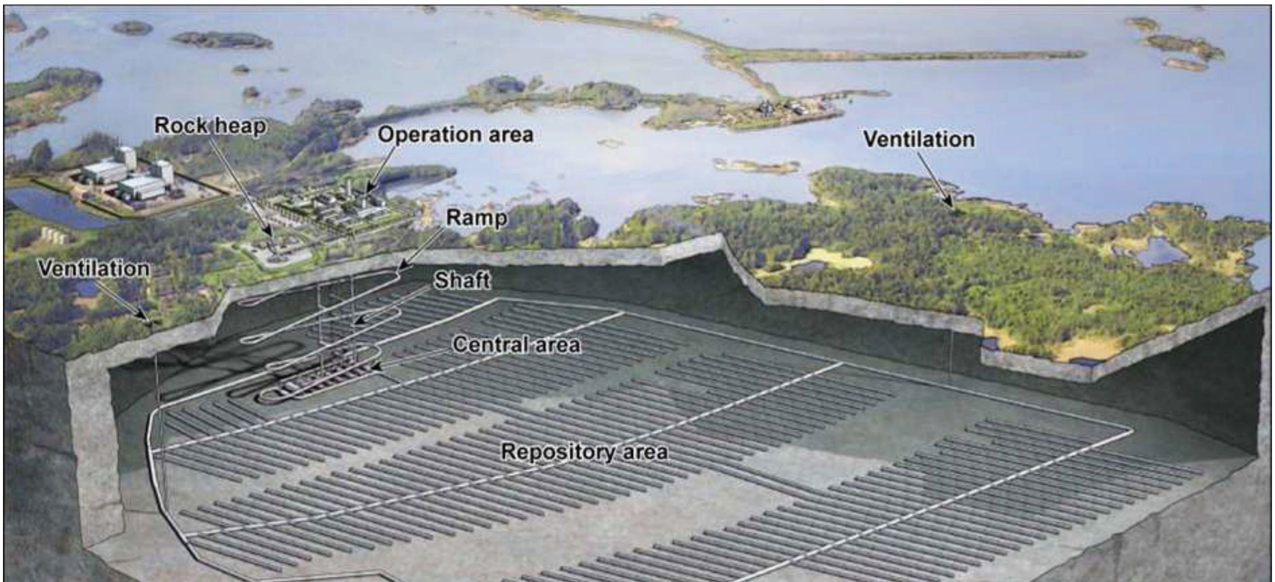

Figure 1: The illustration shows how the final repository for spent nuclear fuel may look in the future. With the encapsulation facility (built next to the Clab interim storage facility in Oskarshamn) and the final repository (built at a depth of almost 500 metres in the bedrock at Forsmark, Östhammar), the system for managing spent nuclear fuel from Swedish nuclear power plants will be complete (Photo courtesy of SKB).

renders us respect. Obviously we have focused on creating good relations at all levels, and tried to be open with information. We have met people in their homes, around their kitchen tables, and we have opened our facilities for visitors. It has been crucial to take people's questions and worries seriously."

The important question is, of course, will SKB's suggestion for final disposal be safe?

"Yes, it will be safe! It is a very robust system, with a great location and a thoroughly researched method. If we get our permissions, and we are allowed to build according to our plans and with our suggested safety measures in place, it will be safe."

During the years, the suggested methods for final disposal have been criticized. How have you reacted to that?

"We have nothing against critical questions or views. It is part of our job to accept, want to listen to, and to handle them. When conclusions are drawn on misleading and even false information, then of course we need to respond to that."

SKB has sometimes been the subject of international praise for its way of working. How has that affected your work?

"It is stimulating to get positive attention. It is also good for Sweden, along with a few other countries, to take the lead in such an important issue. We have partners around the world.

"There are some differences in the world, mainly in regards of the choice between direct disposal and reprocessing; however, we also have lots in common, and all major programs include geological disposal in some way."

What is your most important advice to programmes for final disposal around the world?

"Keep a clear division of responsibilities, and keep to the chosen roles in the process, and expect everything to take time. There are no quick-fixes in regards of nuclear fuel. Many parts have to mature – among them confidence in the process among politicians. In Sweden this has taken us 30 years. And we have had clear ´game rules´ with everything in order: legislation, funding, responsibilities, and an on-going review of research." (Source: SKB)

Hanna Kajander (H.Kajander@iaea.org)

Leading Spent Fuel Repository Project Reached Its Full Length

A few months after Swedish SKB had submitted the construction permit application for its deep repository, Posiva, the company responsible for the geological disposal of spent nuclear fuel of its owners in Finland, completed the excavation of the access tunnel to the underground rock characterisation facility *ONKALO,* which is designed, constructed and licensed to operate as an integral part of Posiva's spent fuel repository. The full length of the tunnel is now ready technically at a depth of 437 metres.

At the repository level of 420 metres Posiva has completed the excavation of the first demonstration tunnel.

The tunnel (approximately 50 metres long, 8.5 metres wide and 6 metres high) has been excavated following the requirements set to an actual deposition tunnel of the future repository. The excavation has been successful and after a short investigation period the second demonstration tunnel will be excavated. After the completion of tunnelling work, the test boring of deposition holes, similar to those planned for the real repository (approx. 8 m deep and , 1.8 m in diameter), will be initiated.

Completion of these demonstration tunnels will be a significant milestone for Posiva as the company will use them to assess the skills of excavating the deposition tunnels and of carrying out the necessary research in them. At the same time, Posiva will prove that safe final disposal can be implemented with the intended vertical placement option.

Excavation will continue at ONKALO during 2012 to finish the technical rooms necessary for the operation of the facility. Posiva is preparing to submit the construction licence application in 2012, the operating licence application in 2018 and final disposal is planned to begin in 2020.

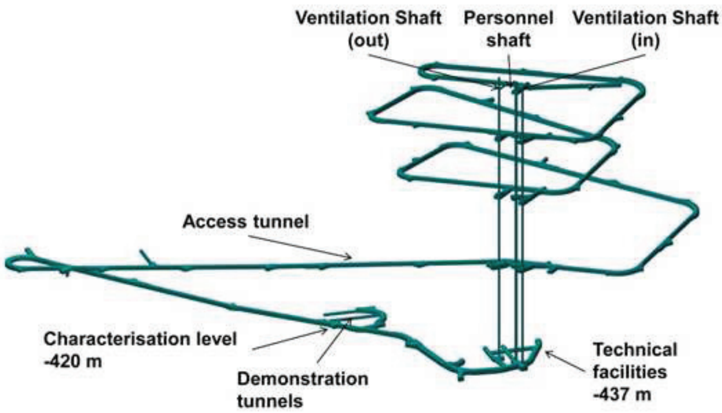

Figure 1: Layout of Posiva's research tunnel ONKALO, which will be a part of the spent fuel final disposal facility in the future (Photo courtesy of Posiva).

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Magnox Decommissioning: An IAEA Peer Review

In June of this year the IAEA organized an international peer review of Magnox Limited's decommissioning activities, using the Bradwell nuclear power plant (NPP) site as a reference site. This review meeting was a follow -up to an earlier meeting which took place, from June 29 to July 7, 2008 and facilitated the completion of the peer review exercise, which had begun with the first meeting.

Figure 1: Aerial view of the Bradwell power plant (Photo courtesy of Magnox Electric Ltd.).

The review team for the second meeting comprised Christopher Clement (International Commission on Radiological Protection, Team Lead), Håkan Sterner (EWN GmbH, Germany), John Rowat (IAEA), and Patrick O'Sullivan (IAEA). The peer review report will become publicly available later this year.

The Bradwell site is located on the east coast of England, about 100 km east of London, and Magnox intends that the decommissioning solutions developed here will be applied for the decommissioning of other Magnox plants. The objective of the peer review was to provide an independent assessment of the activities associated with the planning and implementation of the Magnox decommissioning programme. In particular, it was intended to:

- Inform Magnox whether its decommissioning programme is in accordance with international safety standards and reflects good practice from other national decommissioning programmes,
- Assist Magnox in identifying opportunities for improvement to their decommissioning project planning and execution;
- Facilitate the sharing of good practices identified during the review.

The review team was concerned mainly with the preparatory activities required for entry of the Bradwell site into a long term care and maintenance (C&M) phase. The scope of the peer review included strategic considerations and technical areas central to decommissioning. The technical areas considered included those being developed by Magnox project teams that are scheduled for implementation at Bradwell (e.g.

use of MiniStores (ductile cast iron containers) for storage of intermediate level waste (ILW) and the fuel element debris (FED) treatment programme). Off-site management of radioactive waste was considered only in so far as it has an impact on the decommissioning programme.

Figure 2: Bradwell water treatment tanks (Photo courtesy of Magnox Electric Ltd).

The review team noted several substantial changes between the July 2008 and June 2011 site visits. In particular, it was clear in 2008 that the level of funding available for decommissioning activities had been a significant barrier to progress. The review team observed then that this was resulting in inefficient use of the available workforce, a planned protracted C&M preparation phase, and associated increases in the total project cost. In 2011 the review team encountered an entirely different situation, with sufficient funding having been allocated by the Nuclear Decommissioning Authority (NDA) to facilitate an accelerated C&M preparation phase at both the Bradwell and Trawsfynydd sites. As a result of this and other initiatives the estimated total project cost had been substantially reduced, C&M preparations were proceeding rapidly, and the contractor workforce had been expanded considerably to support the work being undertaken.

Since the previous site visit there was significant progress in several dismantling areas. The fuel ponds are now in a state which will allow their inclusion in the structure that will remain during the C&M phase. Demolition of the turbine hall is progressing well. Detailed sampling has shown no contamination and the material can be conventionally recycled. Furthermore, one of the gas circulator halls had been completely dismantled and can now be used for temporary waste storage.

The review team found that Magnox had adopted a well-coordinated corporation-wide approach to decommissioning projects, using accelerated entry into C&M at Bradwell and Trawsfynydd as models for decommissioning of the remaining sites. Future major projects will be implemented by teams that move from site to site, making best use of experience gained at sites decommissioned earlier. Review of design changes and underpinning safety cases by an independent review committee, made up of Magnox and external experts, reflects good international practice. A systematic analysis of when and where skills will be needed across the fleet, and linking this with retraining and mobility programmes, demonstrates positive innovation in the management of human resources.

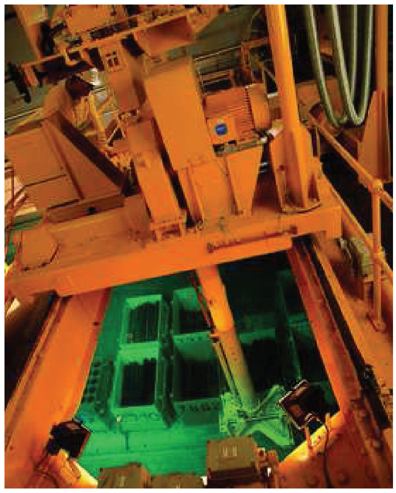

Figure 3: Bradwell cooling ponds (Photo courtesy of Magnox Electric Ltd).

The review team noted that issues such as the use of ductile cast iron containers for storage of ILW may have implications beyond Magnox's programme and therefore it was recommended that greater coordination in initiating and assessing such innovations should be established that would engage other waste generators, the NDA and the regulators. The team also recommended that efforts to develop disposal solutions for graphite waste, which represents an impediment to shortening the total duration of the C&M period (currently envisaged to be at least 70 years), should continue to be pursued vigorously.

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Mission to Malaysia: the Lynas Project

On 3 May 2011, the Malaysian Government approached the IAEA with a request to organize an independent expert review of the radiation safety aspects of a rare earths processing facility currently under construction in Malaysia. This facility forms part of the Advanced

Materials Project being developed by the Lynas Corporation Ltd. The IAEA's Director General, Mr Yukiya Amano agreed to offer the IAEA's support.

The Advanced Materials Project involves the mining and concentration of rare earth ore at Mt. Weld, Western Australia, followed by shipment of the concentrate to a rare earths processing facility at Gebeng, Pahang State, Malaysia, where further processing will take place to produce high purity rare earth compounds.

In Malaysia, the licensing of this type of facility is a sequential process involving the granting of five different types of licence: a siting licence, a construction licence, a pre-operational licence, an operational licence and a decommissioning licence. At the time of the review mission, Lynas had obtained a construction licence for the rare earths processing facility and about 40% of the construction had been completed.

Review mission looked at radiation safety aspects

The review mission was technical in nature. It did not engage in policy or other types of discussions as these were not within its mandate. As is the case with other IAEA review missions and stated in the mutually agreed terms of reference, the review mission was mandated only to deal with the radiation safety aspects of the proposed project. The objective was to review the project's radiation protection, waste management, decommissioning and environmental remediation, transport and safety assessment against relevant international safety standards and good practices.

Additionally, at the request of the Malaysian government, the mission participated in public communication activities. The review team benefited from the various public submission sessions during which several groups expressed their views, opinions and concerns.

Experienced review team from all over the world

The IAEA assembled a team of international experts using the mechanism established in terms of its technical cooperation programme. The review team was composed of experts from Canada, India, the Netherlands, South Africa, the United Kingdom and the IAEA. To preserve the international expert panel's impartiality, the review team did not include individuals whose participation could have led to a perceived conflict of interest.

The review is always more than just a mission

The review process consisted of the following main elements:

a) A review of the relevant documentation provided in advance to the review team by the Malaysian counterpart;

b) The review mission to Malaysia, 29 May – 3 June 2011, which included:

- Discussions with the relevant Malaysian officials, Lynas project staff and other stakeholders;
- A visit to the Lynas project site and the nearby harbour to which the feedstock will be shipped from Australia;

c) An evaluation of the observations and reporting of the results in a clear and concise manner.

The review team conducted and completed its review mission in a transparent, open and good working atmosphere and received good cooperation from all the parties involved in discussions throughout the mission. Many technical details during technical sessions as well as views, opinions and concerns during the public submission sessions were brought to the attention of the review team. The review team wishes to emphasize its appreciation of the good interactions and views shared with it.

Figure 1: The Lynas project, a rare earth processing facility under construction in Malaysia.

Main findings

The review team was not able to identify any non-compliance with international radiation safety standards. However, the review team identified 10 issues for which it felt that improvements were necessary before the next licensing phases of the Lynas project. Those recommendations are listed below and discussed in more detail in the report. The review team also added an 11th recommendation dealing with the manner in which recommendations 1–10 should be acted upon.

Technical recommendations covered issues like a long term waste management plan, updating radiation impact assessment, more specific criteria for residues, a funding mechanism for long term management of waste including decommissioning and remediation, strengthening the regulatory body (the Atomic Energy Licensing Board) further, and a programme for updating regulations in Malaysia.

Public communication recommendations covered issues like AELB enhancing the understanding, transparency and visibility of its regulatory actions in the eyes of the public, AELB intensifying its activities regarding public information and public involvement, and Lynas, as the party responsible for the safety of the proposed rare earths processing facility, being urged to intensify its communication with interested and affected parties in order to demonstrate how it will ensure the radiological safety of the public and the environment.

The full mission report can be found at http://www.iaea.org/newscenter/news/pdf/lynas-report2011.pdf

Good practices identified included the dedication, commitment and professionalism displayed by the Malaysian Atomic Energy Licensing Board in regulating the Lynas project. The review team appreciated the opportunities that were provided for meeting various groups of the public in sessions that were well organized and allowed individual views to be expressed to the review team.

The review team appreciated the Malaysian Government's commitment to improve radiation and nuclear safety in Malaysia and in the region.

The Malaysian rare earth plant is not unique

When viewing the proposed rare earth processing facility in a global context, the review team noted that there were some basic and widely shared misunderstandings among some stakeholder groups concerning a misbelief that the proposed Malaysian plant was somehow unique and an exception in bringing naturally occurring radioactive materials to the human environment. Therefore, the team clarified that:

a) Many similar plants producing rare earth compounds are operating in various parts of the world – the proposed Lynas plant is not unique in this regard;

b) The planned importation of feedstock from Australia and management of the process residues within Malaysia is in line with mineral processing practices worldwide, including those involving naturally occurring radioactive material (NORM).

c) Many of the mineral concentrates processed in other countries under similar arrangements are considerably more radioactive than those to be processed in the Lynas project. Most of the facilities involved are operated in compliance with the international safety standards.

Tero Varjoranta (T.Varjoranta@iaea.org)

The Internet Reactor

There are more than 250 operational research reactors in the world, and they come in every conceivable shape and size. But the IAEA is working with the USA's North Carolina State University (NCSU) and the Jordan University of Science and Technology (JUST) to pioneer a new type of reactor: one that isn't really there.

Figure 1: PULSTAR control room at North Carolina State University (Photo courtesy of NCSU).

In September 2010, NCSU and JUST commenced the first international Internet reactor programme, and continued their collaboration throughout the 2010-2011 academic year. The IAEA's Research Reactor Section assisted both universities with the programme's set-up, which was funded through an extrabudgetary contribution from the United States.

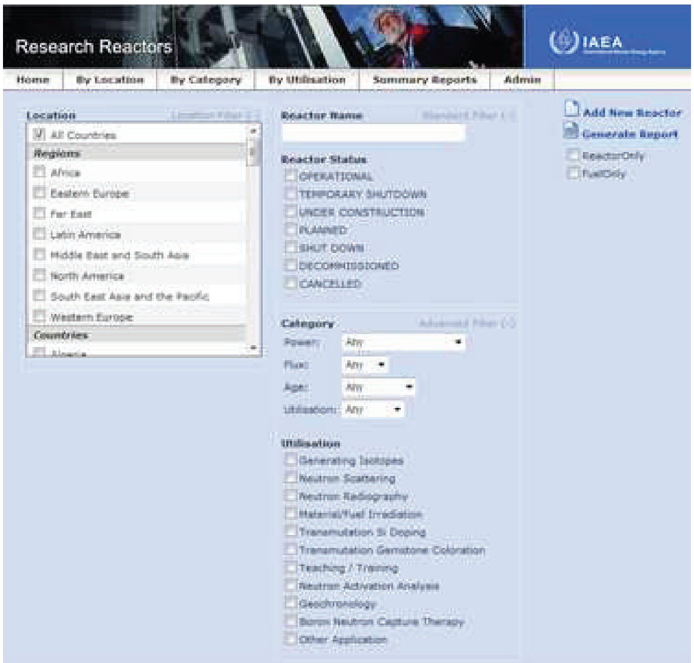
The Internet reactor is created through an internet link from a host reactor – in this case, NCSU's PULSTAR research reactor. Signals from the host reactor are sent to a remote site half way around the world – in this case, a laboratory at JUST - where students in a senior-level reactor course are able to see the same live displays that the PULSTAR's operators see. Using video conference equipment, the students at the remote site are able to interact with operators and instructors in the host reactor to learn about research reactor operations; they can also conduct experiments by asking the host reactor operators to change settings, and then seeing how the real-time reactor displays change accordingly.

Alex Burkart, the Deputy Director of the US State Department's Office of Nuclear Energy, Safety and Security and one of the project's originators, said that the launch of the Internet reactor, "is an important step in distance learning, one of the areas that [the 2010] IAEA General Conference requested the Director General to pursue in order to make nuclear knowledge more broadly available in an effective and efficient manner."

IAEA Research Reactor Section Head, Pablo Adelfang added, "The 'Internet reactor' programme is a cost-effective way to train groups of students in reactor operations, and can help states train and evaluate their human capital needs for ensuing reactor projects." The IAEA is currently exploring possibilities for expanding the Internet reactor programme into other regions beginning in early 2012. For more information about the programme, contact the RRS at research.reactors@iaea.org.

Alisa Carrigan (A.Carrigan@iaea.org)

New Research Reactor Database Interface



In an effort to make finding relevant information easier, a new search interface for the Research Reactor Database (RRDB) has been released. The database contains information on nearly 700 research reactor facilities in 70 states around the world. It is a joint project overseen by the IAEA's Physics Section (Department of Nuclear Sciences and Applications) and the Research Reactor Section of the Division of Nuclear Fuel Cycle and Waste Technology.

The new interface allows users to query the database in a number of new ways that make finding a specific reactor or subset of reactors easier. The interface now allows users to search for reactors by region, multiple countries, operational status, and by type of utilization.

"If a user needs information about research reactors around the world that have, for example, facilities for isotope generation, this information is now much easier to find through the RRDB," said Pablo Adelfang, who heads the IAEA's Research Reactor Section. "Also, there are fifteen new categories for formulating searches, which should help users find more specific information easily and quickly," Adelfang added.

The RRDB came out of the merging of two separate databases in 2005: one database catalogued technical and utilization information about research reactors around the world; the other contained information about the research reactor fuel cycle, for example fuel types used and amounts of stored spent fuel.

While both datasets are now part of the RRDB, only the first – on technical and utilization information of reactors – is publically available. Fuel cycle information is restricted to database administrators, though summary reports about fuel types are available. Both databases are populated and updated on-line by officially-nominated facility data providers from each research reactor.

The RRDB can be accessed via the IAEA's Nucleus portal, or navigating to http://nucleus.iaea.org/RRDB.

Alisa Carrigan (A.Carrigan@iaea.org)

Converting Research Reactors from High to Low Enriched Uranium

One of the Research Reactor Section's main objectives is to work with Member States toward reducing the amount of highly enriched uranium (HEU) in civilian nuclear complexes. Since research reactors often use HEU fuel, several of the RRS's projects revolve around helping states convert their research reactors from using HEU fuel to using fuel made from low enriched uranium (LEU).

The process is not always a straightforward one. In addition to finding the political will and the finances to carry out a reactor conversion, technical work must be done to prepare the reactor for running on a different type of fuel. In some cases, new LEU fuel must be qualified and manufactured for the conversion to take place. In the last several years, the IAEA has worked with Member States around the world to convert their reactor cores from HEU to LEU fuel: these include Poland, Romania, Portugal, Chile and the Libyan Arab Jamahiriya.

Most recently, important strides have been taken to convert Chinese-designed and built miniature neutron source reactors (MNSRs). MNSRs are a low power reactor that have a one kilogram HEU core; they are used primarily for neutron activation analysis, education and training. Currently there are four MNSRs in China and five abroad in the Islamic Republic of Iran, Ghana, Nigeria, Pakistan and the Syrian Arab Republic.

In 2006, the IAEA initiated a Coordinated Research Project (CRP) to assist states with the conversion of their MNSRs. That CRP is being wrapped up at present, and a final report on the work done is expected to be published at the end of 2011. Additionally, a Working Group consisting of MNSR operators, designers, and stakeholders has been established to coordinate information exchange and efforts for implementing the individual conversions and return of HEU spent fuel to China. The first meeting of the MNSR Conversion Working Group was held in February 2011. At that meeting, two critical path activities for the conversion were identified. The first one, the conduction of a zero-power critical test at China Institute of Atomic Energy has recently achieved a new milestone, with the approval of the test by the Chinese authority. The second critical path activity is the selection of a suitable transport cask and transportation means for the return of spent fuel to China. This selection process has been launched with the set-up of a web-based discussion and a consultants meeting in July 2011. Three options for transport were recommended at that meeting and are being evaluated at present.

The RRS encourages Member States to make contact with the IAEA to seek assistance and make suggestions for new activities in relation to RR conversion issues. More information about RRS conversion work can be found on the IAEA's website, at http://www.iaea.org/OurWork/ST/NE/NEFW/Technical_Areas/RRS/home.html.

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The IAEA Peaceful Uses Initiative

In 2010, the Peaceful Uses Initiative (PUI) was launched by the USA to provide extra budgetary support to IAEA activities in the peaceful uses of nuclear energy, largely directed toward developing countries. The USA has pledged US $50 million to the PUI over a five year period from 2010 to 2014. The PUI aims to reach a total of US $100 million with contributions from other potential donors over the five year period. These funds will be applied to IAEA projects relating to nuclear power infrastructure development, food security, water resource management and human health.

For the first year, over US $9 million was awarded by the USA. Japan and the Republic of Korea have also announced their intention to contribute to the PUI.

Of the US $9 million awarded for 2010, over US $3 million was awarded to projects related to nuclear energy, with about 40% of that for projects conducted by the Nuclear Energy Department and 60% for projects conducted through the Technical Cooperation Department. The Nuclear Energy Department's awards cover projects to develop networks for countries embarking on nuclear power, support infrastructure development in such countries, develop a 'roadmap for human resource development', help developing countries prepare for new uranium mining, and prepare a Coordinated Research Project (CRP) on spent fuel performance. The last two topics are the responsibility of the Division of Nuclear Fuel Cycle and Waste Technology (NEFW). A project was also approved, to be funded in 2011, to help developing countries with small electricity grids to assess reactor designs in the 'small and medium-sized' category, i.e. less than 700 MW(e).

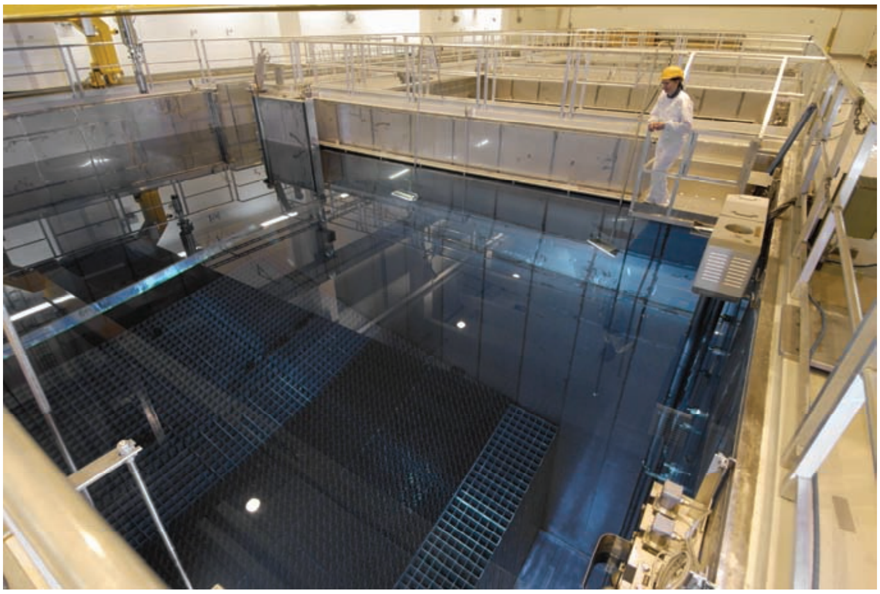


Figure 1: One of three pools for long term storage of spent fuel from Finland's Olkiluoto-1 and -2 reactors. The three pools can store all the spent fuel to be generated in 40 years of operation (Photo courtesy of Hannu Huovila/TVO).

Work on most of these projects only began in the second half of 2011, as the awards were announced late in 2010 and time was needed to bring necessary staff on board .

In late May 2011, a package of new project proposals for a multi-year round of awards were submitted by the IAEA to the USA, and other interested potential donors. Proposed projects related to nuclear energy totaled about US $40 million. Selected nuclear energy proposals would be carried out mainly through the Nuclear Energy Department and the Technical Cooperation Department although, for several of the projects, the Nuclear Safety and Security Department and the Office of Legal Affairs would have principal responsibility.

The May 2011 package of new proposals includes 15 projects for which NEFW would provide most of the technical expertise. For countries embarking upon nuclear energy, these include support for establishing radioactive waste and spent nuclear fuel infrastructure and for improving public knowledge about nuclear power including waste.

For uranium production, they include support to Asia-Pacific Region countries in applying good uranium production practices, and support for the Uranium Mining and Remediation Exchange Group (UMREG), through which operators and regulators exchange information to reduce poor environmental performance, increase the application of good practices, and improve skill levels for uranium mining and its regulation.

For research reactors, the May package proposes projects designed to provide assistance to new users for planning and managing their first research reactors most effectively; increased use of existing facilities for international training, non-fission Mo-99 production, automated neutron analyses, industrial applications of advanced neutron beam techniques, neutron transmutation doping and radiotracer production; assistance to African countries in developing strategies to manage spent fuel once current repatriation programmes conclude; and improved safety, availability and reliability through I&C upgrades and on-line monitoring and maintenance.

With respect to disused sealed radioactive sources (DSRSs), the May package proposes projects to provide assistance to Ghana, Philippines and Malaysia for borehole disposal; regional workshops on technologies for conditioning DSRSs for long term storage; and help in strengthening ‘cradle to grave’ control of radioactive sources in the Mediterranean region.

The May package also included a final proposal to better connect the five networks that the IAEA operates in the field of radioactive waste management.

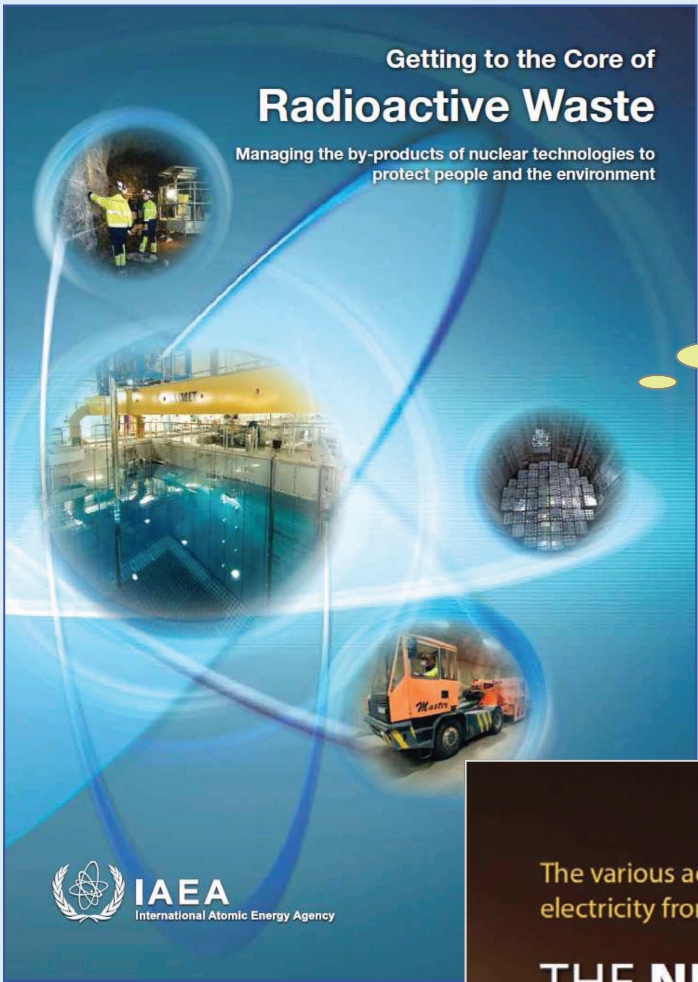
Alan McDonald (A.McDonald@iaea.org)

Figure 2: Uranium production at Caetité, State of Bahia, Brazil (Photo courtesy of Brazil / UPSAT).

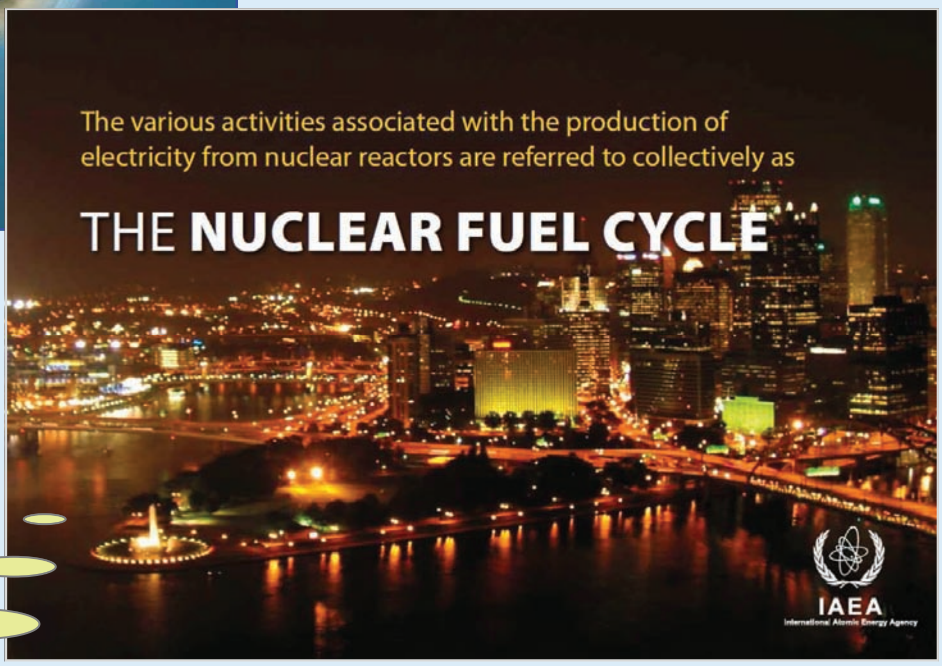
Two New Basic Brochures Available!

What is the nuclear fuel cycle? What is radioactive waste? Answers to these questions may seem straightforward to experts in the nuclear field, but not to the general public. Therefore – as a response to the growing demand for easily understandable information – we are finally able to provide two compact brochures: Both of the illustrated brochures are available electronically and in printed versions. To receive these, please see

http://www.iaea.org/OurWork/ST/NE/NEFW/home.html



Getting to the Core of Radioactive Waste



Nuclear Fuel Cycle

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Introduction of Authors

Susanta Kumar Samanta is Waste Predisposal Specialist in the Waste Technology Section. His work includes characterization, treatment, conditioning and storage of radioactive waste, to enhance waste predisposal operations.

Zoran Drace is the team leader of Predisposal Management of Radioactive Waste in the Waste Technology Section. His work includes characterization, pre-treatment, treatment, conditioning, storage and minimization of radioactive waste.

Gary Dyck is the head of the Nuclear Fuel Cycle and Materials Section, which covers: prospecting for, mining and processing of uranium; fuel engineering; spent fuel management; fuel recycling; and advanced fuel cycles.

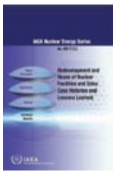
Hanna Kajander is a Communications Specialist in the Division of Nuclear Fuel Cycle and Waste Technology Section and is involved in activities that aim at improving public knowledge on radioactive waste.

Patrick O'Sullivan is a decommissioning specialist in the Waste Technology Section and is Scientific Secretary to the International Decommissioning Network. His work covers planning, costing, strategy selection, technologies, and implementation.

Alisa Carrigan is RRDB Administrator in the Research Reactor Section on human resource development projects. She also works on RRS projects involving conversion of medical isotope production from using HEU to LEU.

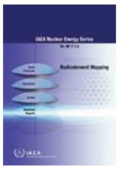
Alan McDonald is the Programme Coordinator for the Department of Nuclear Energy and involved in the Department's PUI proposals and activities.

Recent Publications

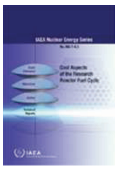


IAEA Nuclear Energy Series No. NF-T-2.2
Redevelopment and Reuse of Nuclear Facilities and Sites: Case Histories and Lessons Learned (2011) **NEW!**

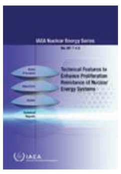
IAEA Nuclear Energy Series No. NF-T-3.8
Impact of High Burnup Uranium Oxide and Mixed Uranium-Plutonium Oxide Water Reactor Fuel on Spent Fuel Management (2011) **NEW!**



IAEA Nuclear Energy Series No. NF-T-1.3
Radioelement Mapping (2010)



IAEA Nuclear Energy Series No. NG-T-4.3
Cost Aspects of the Research Reactor Fuel Cycle (2010)



IAEA Nuclear Energy Series No. NG-T-4.5
Technical Features to Enhance Proliferation Resistance of Nuclear Energy Systems (2010)

IAEA-TECDOC-1625
Research Reactor Modernization and Refurbishment (2009)

IAEA-TECDOC-1630
Use of Reprocessed Uranium: Proceedings of a Technical Meeting held in Vienna, 29-31 August 2007(2010)

IAEA-TECDOC-1645
High Temperature Gas Cooled Reactor Fuels and Materials (2010)

IAEA-TECDOC-1647
Progress in Radioactive Graphite Waste Management (2010)

IAEA-TECDOC-1648
Assessment of Partitioning Processes for Transmutation of Actinides

IAEA-TECDOC-1649
Delayed Hydride Cracking of Zirconium Alloy Fuel Cladding

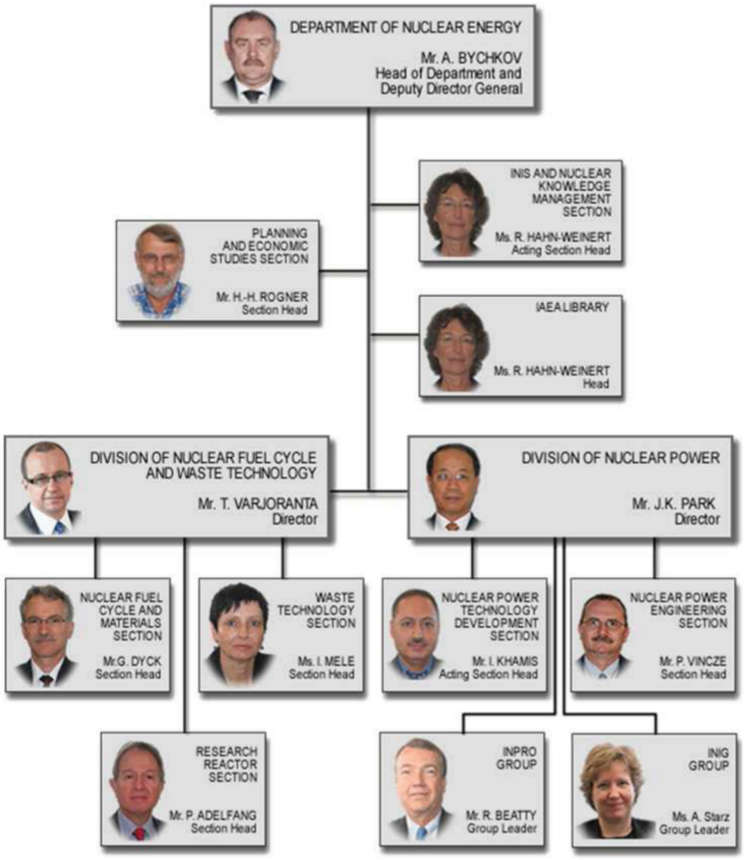
IAEA-TECDOC-1654
Advanced Fuel Pellet Materials and Fuel Rod Design for Water Cooled Reactors

Upcoming Meetings in 2011

Date	Title	Place	Contact
4—6 Oct	TM on the Network of centres of excellence in low level waste disposal (DISPONET)	Stockholm Sweden	L.Nachmilner@iaea.org
10—14 Oct	TM on research reactor ageing management, modernization and refurbishment - including new research reactor projects	Vienna Austria	E.Bradley@iaea.org
12—14 Oct	TM on fuel and fuel cycle options for small and medium size reactors	Vienna Austria	U.Basak@iaea.org
17—21 Oct	Training Workshop for new NEWMDB Country Coordinators	Vienna Austria	J.Kinker@iaea.org
17—21 Oct	TM on operation of radioactive waste disposal facilities	Vienna Austria	P.Ormai@iaea.org
17—21 Oct	TM on world thorium resources (ThDEPO)	Thiruvanantha-puram India	H.Tulsidas@iaea.org
18—21 Oct	TM on fuel behaviour and modelling under severe transient and LOCA conditions	Ibaraki Japan	V.Inozemtsev@iaea.org
25—28 Oct	TR/workshop on burnup credit applications and criticality safety calculations	Beijing China	X.Zou@iaea.org
31 Oct— 4 Nov	TR on uranium recovery from phosphates and phosphoric acid	Marrakech Morocco	H.Tulsidas@iaea.org
1—3 Nov	Annual forum for regulators and operators in the field of decommissioning: the IDN and other major decommissioning initiatives	Vienna Austria	P.Osullivan@iaea.org
2—4 Nov	Joint OECD/NEA-IAEA Uranium Group Meeting (47th meeting)	Paris France	N,Fairclough@iaea.org
8—11 Nov	TM on developing strategies for assisting Member States in the management of disused sealed radioactive sources	Vienna Austria	R.Heard@iaea.org
8—11 Nov	Plenary meeting of Network of Centres of Excellence in Environmental Remediation (ENVIRONET)	Vienna Austria	H.Monken-Fernandes@iaea.org
14—16 Nov	TM on spent fuel management from fast reactors	Vienna Austria	Z.Lovasic@iaea.org
14—18 Nov	TR/Workshop on radiation damage in nuclear materials	Trieste Italy	V.Inozemtsev@iaea.org
16— 8 Nov	TM on network of training and demonstration of waste disposal technologies in underground research facilities (URF Network)	Vienna Austria	P.Degnan@iaea.org
28 Nov— 1 Dec	First RCM on treatment of irradiated graphite to meet acceptance criteria for waste disposal	Vienna Austria	Z.Drace@iaea.org
5—9 Dec	Third RCM on improvement of computer codes used for fuel behaviour simulation FUMEX-III	Vienna Austria	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
- Integrated Nuclear Fuel Cycle Information System (iNFCIS)
  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 Section (RRS)

- 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://nucleus.iaea.org/RRDB/RR/ReactorSearch.aspx?rf=1
- Research Reactor Ageing Database
  http://www.iaea.org/OurWork/ST/NE/NEFW/AD/index.html

Impressum

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