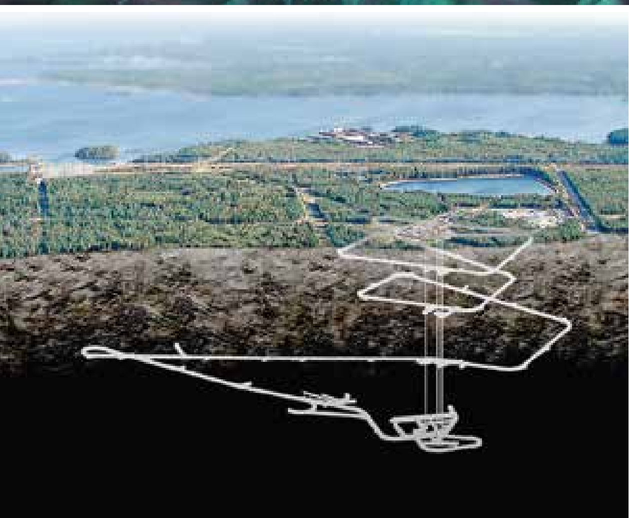
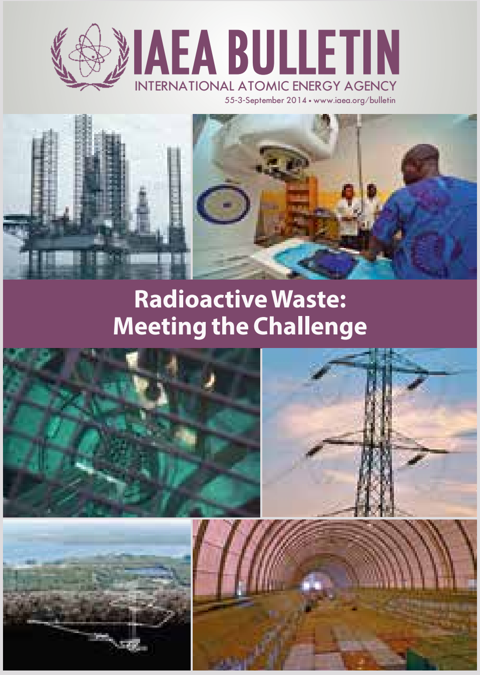
IAEA BULLETIN
INTERNATIONAL ATOMIC ENERGY AGENCY
55-3-September 2014 • www.iaea.org/bulletin

Radioactive Waste: Meeting the Challenge





IAEA BULLETIN
is produced by the
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Cover:
Nuclear technology is used in many areas such as human health, agriculture and electricity generation. Storage and disposal technologies are available to manage the radioactive waste generated from these activities.
(Photos: IAEA; ANDRA; Posiva Oy; Photodisc)

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IAEA

The International Atomic Energy Agency's mission is to prevent the spread of nuclear weapons and to help all countries — especially in the developing world — benefit from the peaceful, safe and secure use of nuclear science and technology.

Established as an autonomous organization under the United Nations in 1957, the IAEA is the only organization within the UN system with expertise in nuclear technologies. The IAEA's unique specialist laboratories help transfer knowledge and expertise to IAEA Member States in areas such as human health, food, water and the environment.

The IAEA also serves as the global platform for strengthening nuclear security. The IAEA has established the Nuclear Security Series of international consensus guidance publications on nuclear security. The IAEA's work also focuses on helping to minimize the risk of nuclear and other radioactive material falling into the hands of terrorists, or of nuclear facilities being subjected to malicious acts.

The IAEA safety standards provide a system of fundamental safety principles and reflect an international consensus on what constitutes a high level of safety for protecting people and the environment from the harmful effects of ionizing radiation. The IAEA safety standards have been developed for all types of nuclear facilities and activities that serve peaceful purposes, as well as for protective actions to reduce existing radiation risks.

The IAEA also verifies through its inspection system that Member States comply with their commitments under the Nuclear Non-Proliferation Treaty and other non-proliferation agreements to use nuclear material and facilities only for peaceful purposes.

The IAEA's work is multi-faceted and engages a wide variety of partners at the national, regional and international levels. IAEA programmes and budgets are set through decisions of its policymaking bodies — the 35-member Board of Governors and the General Conference of all Member States.

The IAEA is headquartered at the Vienna International Centre. Field and liaison offices are located in Geneva, New York, Tokyo and Toronto. The IAEA operates scientific laboratories in Monaco, Seibersdorf and Vienna. In addition, the IAEA supports and provides funding to the Abdus Salam International Centre for Theoretical Physics, in Trieste, Italy.

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IAEA Bulletin 55-3-September 2014

THE SCIENCE AND TECHNOLOGY BEHIND SAFE AND SUSTAINABLE RADIOACTIVE WASTE MANAGEMENT

Nuclear technology provides enormous benefits in many areas, including human health, agriculture and electricity generation. Management of the radioactive waste generated from activities in these and other areas is often seen as a problem. In fact, storage technologies have a long and successful performance record and disposal technologies are also available.

Sound science and technology are prerequisites for safe and sustainable waste management.

Sound science and technology are pre-requisites for safe and sustainable waste management. The technology continues to develop, including in areas such as the geological disposal of high level waste and spent nuclear fuel.

Appropriate legal, governmental and regulatory frameworks need to be in place.

But it is also essential that the public are kept fully informed. It is no coincidence that the countries with the lowest levels of public anxiety about the safety of nuclear technology are those which demonstrate the highest degree of openness and transparency.

I decided to devote the 2014 IAEA Scientific Forum to technologies for the management of radioactive waste because I wanted to provide a platform for experts from all over the world to consider the challenges and solutions and to explain the technology to a wider public audience.

It is up to each country using nuclear technology to ensure the safe management and disposal of waste. But countries can benefit greatly from each other's experiences. Providing a forum for exchanges of experience and best practice is one of the key roles of the IAEA.

The IAEA has, from the beginning, been actively involved in helping Member States to safely manage radioactive waste with a view to protecting people and the environment from the harmful effects of ionizing radiation. We develop safety standards and guidance. We publish technical reports. And we organize training courses, workshops and technical meetings to assist with safe and sustainable implementation of national radioactive waste management programmes.

The Scientific Forum, entitled *Radioactive Waste: Meeting the Challenge*, will take stock of technological developments related to the management of all types of radioactive waste. Existing solutions and emerging technologies will be considered. Renowned experts and organizations in waste management will share their expertise.

This edition of the IAEA Bulletin is intended to give readers a clear understanding of the different types of radioactive waste and the measures needed to ensure its safe management and disposal, as well as the role of the IAEA in supporting Member States.

I hope you will find it helpful and informative.

Yukiya Amano, IAEA Director General

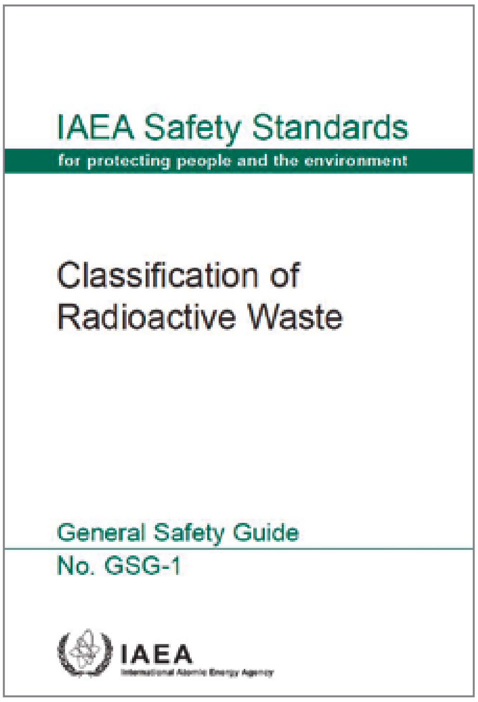
WHAT IS RADIOACTIVE WASTE?

Radiation and radioactive substances are found naturally in the environment and can also be man-made. They have a range of beneficial applications, from generating power to uses in medicine, industry and agriculture. These activities lead to radioactive waste in various gaseous, liquid and solid forms. The waste is radioactive because the atoms in the waste are unstable and spontaneously release ionizing radiation during the transformation process towards becoming stable. This ionizing radiation can have potentially harmful effects. Therefore, it is important to safely manage the waste in order to protect people and the environment, and help prevent waste from becoming a burden on future generations.

Radioactive waste arises from the generation of electricity in nuclear power plants, as well as from nuclear fuel cycle operations such as fuel manufacture and other activities in the nuclear fuel cycle, like mining and processing of uranium and thorium ores. In some countries, spent nuclear fuel is declared as radioactive waste, as no further use is foreseen. In other countries, spent nuclear fuel is a resource intended for reprocessing. Reprocessing will itself generate highly radioactive, heat-generating waste, which is typically conditioned in a glass matrix, in addition to other types of radioactive waste such as the metal cladding that is removed from the fuel elements before treatment.

Radioactive waste also comes from a wide range of activities in industry, medicine, research and development, and agriculture. The majority of this type of waste consists of disused sealed radioactive sources. Sealed sources are used in various applications, for example high activity cobalt sources used in cancer treatment. They contain radioactive material permanently sealed in a capsule. Sources are declared as radioactive waste if they are no longer used or no longer fit for their original purpose. Radioactive waste also comes from activities and processes where naturally occurring radioactive material becomes concentrated in waste material. One such example is depleted uranium, a by-product of fuel fabrication, which can also be declared waste when no further use is foreseen.

The decommissioning of nuclear facilities and the cleanup of contaminated sites also generates radioactive waste which has to be managed and ultimately disposed of. These activities use many different techniques to minimize the volume of radioactive waste but still generate varying quantities of structural materials like concrete and metal items. Site remediation inevitably leads to the removal of contaminated soil.

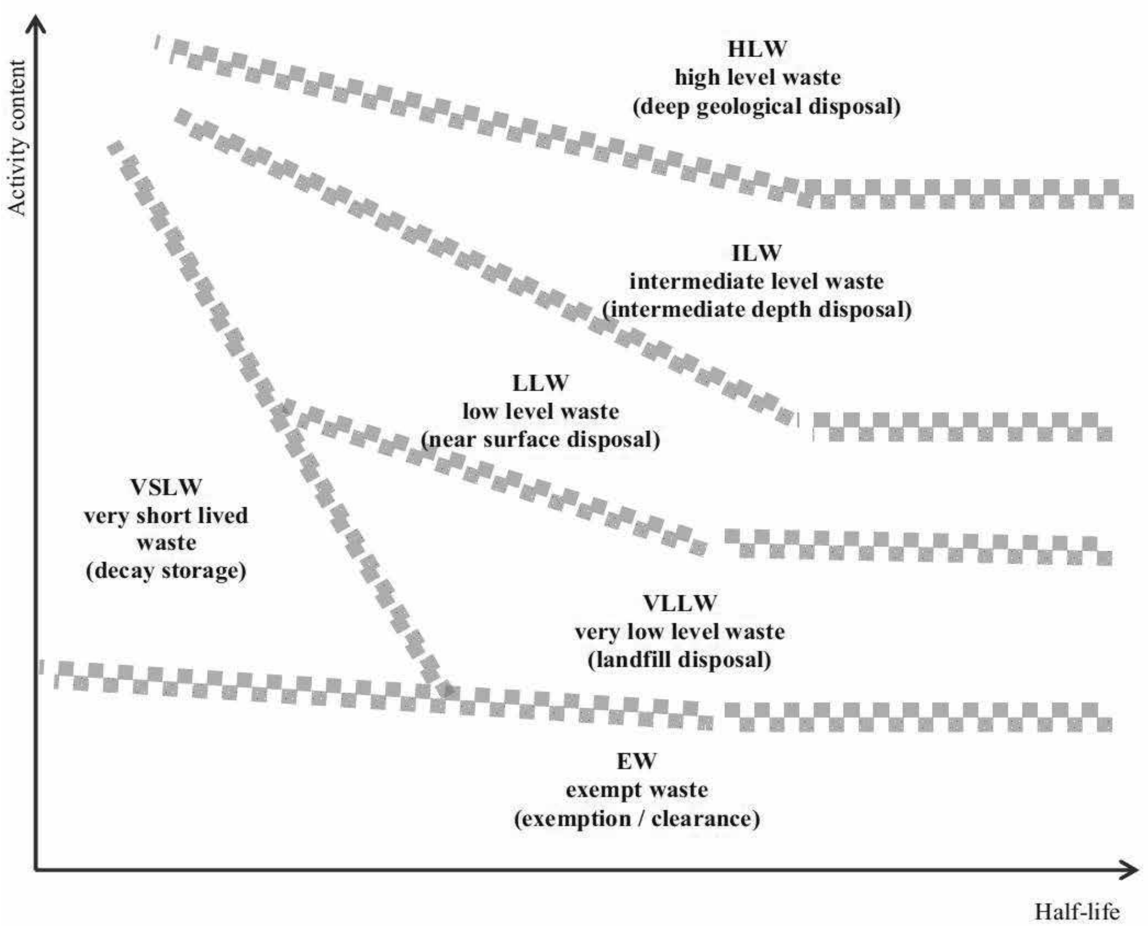


The IAEA establishes safety standards with the aim of facilitating the appropriate management of radioactive waste. Among these is a Safety Guide with general standards for classifying radioactive waste: *Classification of Radioactive Waste*.

The radiation risks to workers, to the public and to the environment that may arise from radioactive waste have to be assessed and, if necessary, controlled. The properties of radioactive waste vary, not only in terms of radioactive content and activity concentration but also in terms of physical and chemical properties. A common characteristic of all radioactive waste is its potential to present a hazard to people and to the environment. The potential hazards can range from trivial to significant.

To reduce any associated risks of these hazards to acceptable levels, radioactive waste management and disposal options must account for the varying characteristics and properties of radioactive waste, as well as the range of potential hazards. It must also account for the entire chain of radioactive waste handling, from the point of waste generation to disposal. This includes processing waste streams to produce stable and solid waste forms that are reduced in volume and immobilized as far as practicable, and placing them in containers in order to facilitate storage, transport and disposal. In some cases, radioactive waste may also present a security

IAEA Waste Classification System, 2009



threat, which must be accounted for and mitigated appropriately in managing the waste.

To ensure appropriate handling, the IAEA establishes safety standards for radioactive waste management that include guides for classifying radioactive waste according to physical, chemical and radiological properties. These standards facilitate the use of appropriate management approaches and the selection of safe radioactive waste disposal facilities.

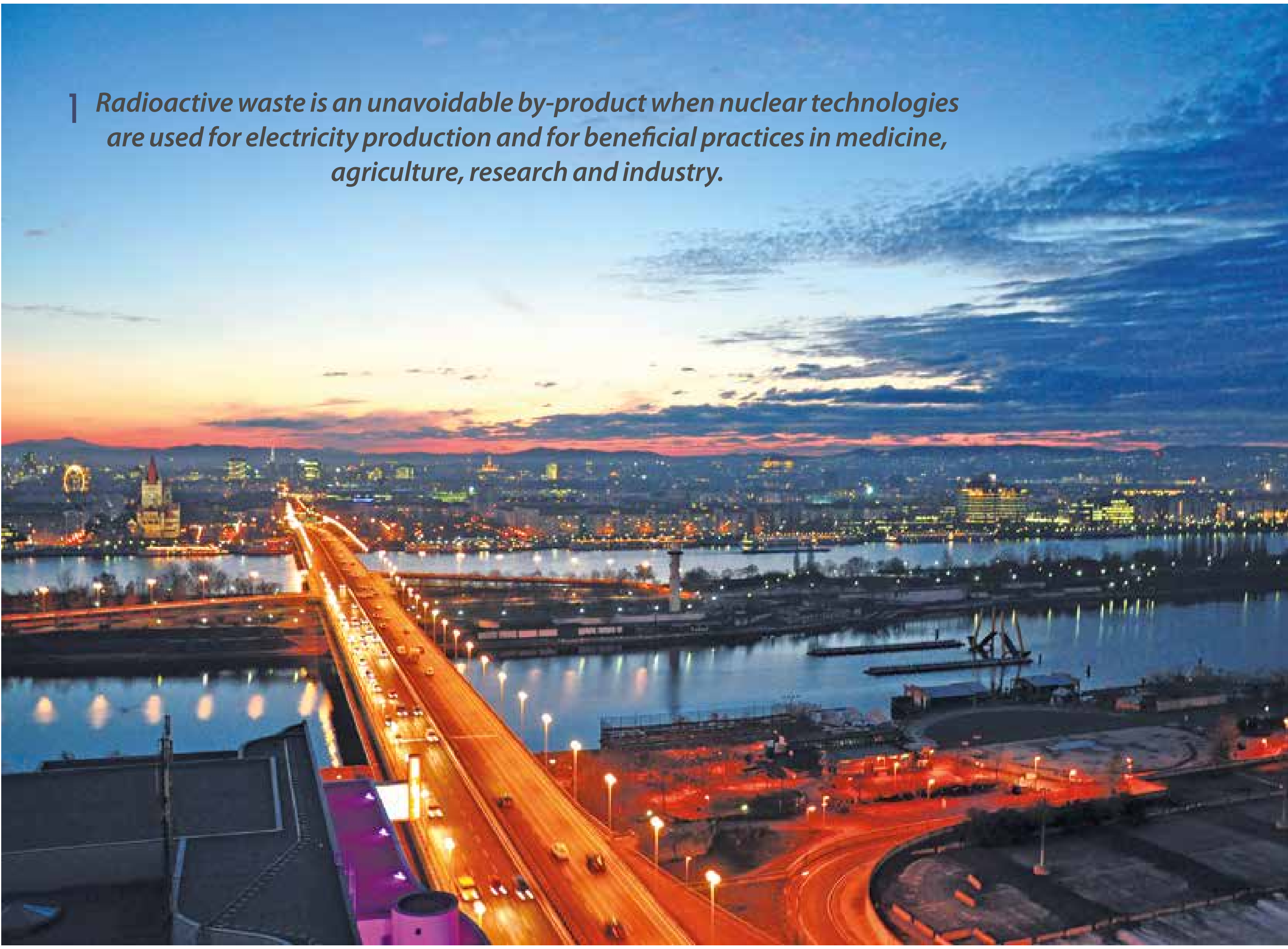
The IAEA establishes safety standards with the aim of facilitating the appropriate management of radioactive waste. Among these is a Safety Guide with general standards for classifying radioactive waste: *Classification of Radioactive Waste* (Safety Standards Series No. GSG-1). This classification system primarily focuses on long term safety, which requires appropriate disposal and management approaches that address different types of waste. It defines six classes of waste: exempt waste (EW), very short lived waste (VSLW), very low level waste (VLLW), low level waste (LLW), intermediate level waste (ILW) and high level waste (HLW).

The VLLW, LLW, ILW and HLW classes are safely and sustainably managed through disposal. These classifications link the different classes of waste to disposal options that are, in principle, suitable. It must be demonstrated that the disposal of a specific type of waste in a particular disposal facility is suitable.

IAEA Division of Radiation, Transport and Waste Safety and IAEA Division of Nuclear Fuel Cycle and Waste Technology

STEP-BY-STEP: LIFE CYCLE RADIOACTIVE WASTE MANAGEMENT

1 *Radioactive waste is an unavoidable by-product when nuclear technologies are used for electricity production and for beneficial practices in medicine, agriculture, research and industry.*



(Photo: Magdalena Ablanedo Alcala)

When the radioactivity of the waste is above a certain threshold, the waste requires special disposal methods. Through extensive research, standards and approaches have been developed for safely and securely preparing for and managing radioactive waste disposal.

In the course of its journey from the point of generation to disposal, radioactive waste undergoes a number of predisposal management treatment steps to transform it into a safe, stable and manageable form suitable for transport, storage and disposal.

Passive Active Neutron Differential Die-Away System (PANDDA™), a drum-monitoring high resolution gamma spectroscopy system

(Photo: Pajarito Scientific Corporation, USA)

2 Characterization

Characterization is a technique that provides information on the physical, chemical and radiological properties of the waste in order to identify appropriate safety requirements and potential treatment options, and to ensure compliance with accepted storage and disposal criteria. X-ray and other tomographic methods are also used to confirm the presence of or look for hazardous materials or prohibited items.

Sorting box for waste segregation

(Photo: Dounreay Site Restoration Ltd and Nuclear Decommissioning Authority (NDA), UK)

3 Pretreatment

Pretreatment activities prepare the waste for processing and may include sorting and separating different types of waste, as well as size reduction or shredding to optimize treatment and disposal. Decontamination techniques reduce the volume of waste requiring treatment thereby minimizing the disposal costs.

Supercompactor for solid waste drums

(Photo: Teollisuuden Voima Oyj (TVO), Finland)

4 Treatment

Treatment activities focus on waste volume reduction, radionuclide removal from the waste, and often changing its physical and chemical composition. There are technologies to treat both liquid waste and solid waste.

Cement-encapsulated Magnox fuel-cladding at Sellafield

(Photo: Sellafield Ltd., UK)

5 Conditioning

Conditioning puts the waste in a safe, stable and manageable form for transport, storage and disposal. Common forms of conditioned waste for disposal are encapsulated or solidified waste in cement, bitumen or glass. Conditioning techniques are designed to slow the release of radionuclides from the disposed waste package into the environment.

Long term storage facility for low level waste

(Photo: Central Organization for Radioactive Waste (COVRA), Netherlands)

Low level waste disposal at the Centre de l'Aube facility

(Photo: National Radioactive Waste Management Agency (Andra), France)

Underground exploration to demonstrate feasibility of deep geological disposal for high level waste

(Photo: Posiva Oy, Finland)

6 **Storage**

Storage of untreated and treated waste must be safe, retrievable and secure. The storage requirements depend on the type of waste and may be short term to allow for radioactive decay or long term until the waste can be safely transferred to a suitable disposal site.

All waste storage facilities are required to have a regime to monitor the integrity of waste packaging to ensure the safety and protection of the environment.

7 **Disposal**

The appropriate disposal option and the extent of isolation and containment needed depend on the properties of the waste and the length of time the waste remains radioactive.

The suitability of waste for disposal in a particular facility must be demonstrated by the safety case and supporting safety assessment of the facility.

Text: IAEA Division of Nuclear Fuel Cycle and Waste Technology

THE IAEA PROMOTES THE APPLICATION OF SAFETY STANDARDS AND BEST PRACTICES FOR THE MANAGEMENT OF RADIOACTIVE WASTE

The IAEA works to promote a high level of safety as it facilitates peaceful uses of nuclear energy worldwide. The IAEA's Statute authorizes it to establish or adopt standards of safety for protection of health and minimization of danger to life and property, and to provide for the application of these standards. The Statute also mandates the IAEA to foster the exchange of scientific and technical information to facilitate the peaceful uses of atomic energy.

To this end, the IAEA develops safety standards on different topics, including on the safety of radioactive waste management. These standards, issued in the IAEA Safety Standards Series, reflect an international consensus on what constitutes a high level of safety for protecting people from harmful effects of ionizing radiation and protecting the environment.

The IAEA also launched the IAEA Nuclear Energy Series, which is aimed at promoting best practices in the peaceful uses of nuclear technology, and, in particular, in the management of radioactive waste. These two series are designed to complement each other.

The IAEA Safety Standards Series

The IAEA Safety Standards Series sets out fundamental safety principles, requirements and measures to control radiation exposure of people and radioactive releases to the environment. The standards address the prevention of incidents that might lead to the loss of control over a nuclear reactor core, nuclear chain reaction, radioactive source or any other source of radiation, and how to mitigate the consequences of such events if they do occur. The safety standards are designed for use in relation to facilities and activities that generate radiation risks, such as nuclear installations, the uses of radiation and radioactive materials, the transport of radioactive material and the management of radioactive waste. The standards are issued in three categories:

Safety Fundamentals (Fundamental Safety Principles) present the fundamental safety objective and principles and concepts of protection and safety, and provide the basis for the Safety Requirements.

Safety Requirements establish the conditions that must be met to ensure the protection of people and of the environment, both now and in the future. The requirements are governed by the objective and principles of the Safety Fundamentals. The requirements must be met; if they are not met, measures must be taken to reach or restore the required level of safety.

Safety Guides provide recommendations and guidance on how to comply with the Safety Requirements. The Guides present international good practices, and they increasingly reflect best practices to help users striving to achieve high levels of safety.

The IAEA safety standards form the basis for the IAEA's safety review services for Member States. Additionally, the standards are used by the IAEA to support competence building, including developing educational curricula and training courses.

The IAEA's Statute binds the IAEA's operations to these safety standards and requires that Member States are also bound to these standards in IAEA assisted operations. The IAEA safety standards also support States in meeting their obligations under international conventions, which establish requirements that are binding on the contracting parties.

The IAEA Nuclear Energy Series

The IAEA Nuclear Energy Series provides guidance and information related to nuclear power, the nuclear fuel cycle, radioactive waste management and decommissioning of facilities, including general topics relevant to all of these areas. The information in this series builds on the expertise of Member States' representatives participating in technical working groups. The series is designed to assist Member States that are either implementing or planning nuclear activities, and it is structured according to the following levels:

The Nuclear Energy Basic Principles publication describes the rationale and vision for the peaceful uses of nuclear energy.

Nuclear Energy Series Objectives explain the expectations to be met in various areas at different stages of implementation.

Nuclear Energy Series Guides provide high level guidance on how to achieve the various objectives related to the peaceful uses of nuclear energy.

Nuclear Energy Series Technical Reports offer more detailed additional information to supplement topics dealt with elsewhere in the IAEA Nuclear Energy Series.

The IAEA Nuclear Energy Series also assists Member States with research and development as well as practical applications of nuclear energy for peaceful purposes. This includes practical examples and lessons learned that can be used by, among others, utilities, owners and operators of facilities, technical support organizations, researchers and government officials.

IAEA Series: Elements of a Whole

These two IAEA series are elements of an international framework of legal instruments, international standards and guidance, national requirements and industry standards which, as a whole, provide a comprehensive system for effectively managing nuclear energy and managing radioactive waste so as to protect people from harmful effects of ionizing radiation and to protect the environment.

Prominent among the legal instruments related to radioactive waste management is the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (the Joint Convention). The Joint Convention is the only legally binding international instrument between Contracting Parties in the field of safety of spent fuel management and radioactive waste management. The IAEA is the depository for the Joint Convention and provides its scientific secretariat. The objectives of this Convention are:

(i) To achieve and maintain a high level of safety worldwide in spent fuel management and radioactive waste management, through the enhancement of national measures and international cooperation, including, where appropriate, safety related technical cooperation;

(ii) To ensure that, during all stages of spent fuel management and radioactive waste management, there are effective defences against potential hazards, so that individuals, society and the environment are protected from harmful effects of ionizing radiation; and in such a way that the needs of the present generation are met without compromising the ability of future generations to meet their needs;

(iii) To prevent accidents with radiological consequences and to mitigate the consequences of such accidents if they do occur in any stage of spent fuel management or radioactive waste management.

IAEA Division of Radiation, Transport and Waste Safety and IAEA Division of Nuclear Fuel Cycle and Waste Technology

PREDISPOSAL RADIOACTIVE WASTE MANAGEMENT

Recognition of the importance of the safe management of radioactive waste means that, over the years, many well-established and effective techniques have been developed, and the nuclear industry and governments have gained considerable experience in this field.

Minimization of waste is a fundamental principle underpinning the design and operation of all nuclear operations, together with waste reuse and recycling. For the remaining radioactive waste that will be produced, it is essential that there is a well-defined plan (called a waste treatment path) to ensure the safe management and ultimately the safe disposal of radioactive waste so as to guarantee the sustainable long term deployment of nuclear technologies.

A State's nuclear waste management policy and national regulations will influence the chosen treatment option, but the general strategy is to concentrate and contain radioactive waste and isolate it from people and the environment. To implement this strategy, the waste generator (nuclear power plant operator, mining company, medical facility, etc.) needs to carry out a number of predisposal activities that may include characterization, pretreatment, treatment, conditioning and storage.

All of these activities are carried out by trained personnel following established guidelines for radiation protection, safety and security. The IAEA has established tight regulations for radioactive waste management to ensure that all operations meet strict standards with regard to safety and security.

Before selecting a waste management strategy or technology, it is essential to know and understand the waste source and rate of waste generation, as well as the amounts and characteristics of the waste. This allows for the selection of an appropriate treatment strategy to ensure that the final waste form will be compatible with the chosen disposition path.

Once the characteristics are understood, the waste needs to be transformed into a form suitable for disposal. The first stage is preparation of the waste for treatment. This may include segregation to separate contaminated from non-contaminated items, size reduction, or the adjustment of chemical properties like pH to aid later processing.

Pretreatment activities may also utilize a decontamination process where radionuclides are removed from the surfaces of buildings or components using physical (e.g. sand blasting) or chemical means (e.g. washing with a special solution that is able to selectively remove the radionuclides from surfaces).

Left: 200-litre drums are often used to collect radioactive waste

(Photo: Advanced Mixed Waste Treatment Project, Department of Energy, USA)

Right: High-force supercompaction can reduce a 200-litre drum to a height of less than 10 cm

(Photo: Dounreay Site Restoration Ltd and Nuclear Decommissioning Authority (NDA), UK)

Vitrification is a practical and effective option for conditioning radioactive and hazardous chemical wastes.

(Photos: Pacific Northwest National Laboratory, USA)

Decontamination techniques are especially useful when the radioactive contamination is spread unevenly over a large surface area, such as floors or pipework, as the application of these techniques will substantially reduce the volume of waste requiring treatment.

Once the waste is suitably prepared, the next step is treatment. In general, treatment processes tend to reduce the volume of radioactive waste to enhance the safety or reduce the costs of further management phases such as storage or disposal.

Treatment usually results in the production of two streams: a small volume stream containing the majority of the radionuclides, which will be further conditioned for storage and disposal, and a larger volume decontaminated stream, which can be routed to discharge or disposal as non-radioactive waste.

A variety of waste treatment processing techniques are available for use depending on the nature of the waste and the waste form requirements of the chosen disposal site.

Two common examples are incineration of solid waste and evaporation of liquid waste. While incineration reduces solid waste volumes by concentrating the radioactivity in a small volume of ash, evaporation of the liquid waste results in a small volume of radioactive liquid concentrate. In a subsequent conditioning step, the ash or liquid concentrate is further processed to convert it into a form in which the radioactivity is effectively immobilized. This step is known as conditioning.

Conditioning reduces the risk associated with the waste and prepares the waste for later handling, transportation, storage and disposal. Most commonly, this is accomplished by mixing the waste with cement powder and water, and allowing the mixture to set to a solid block in a suitable container.

Alternative conditioning techniques include radionuclide immobilization in glass, bitumen, a polymer or a mineral matrix. All of these techniques have the effect of reducing the potential for migration or dispersion of radionuclides to the environment. The radioactive waste package consisting of immobilized waste in a container is the final product from such processing.

IAEA Division of Nuclear Fuel Cycle and Waste Technology

MAJOR CONSIDERATIONS: THE ISSUE OF WASTE STORAGE AND DISPOSAL

HABOG storage facility, Central Organization for Radioactive Waste (COVRA), Netherlands
(Photo: COVRA, Netherlands)

When people talk about the adoption of nuclear technology and use of radioactive material, one of the most contentious issues is its ultimate disposal.

The length of time needed for radioactive waste and spent nuclear fuel declared as waste to no longer present a potential hazard to human health or the environment varies significantly. This can range from a few months or years for some types of radioactive waste, to millennia for high level waste, and hundreds of thousands of years for spent fuel. As such, governments and citizens have legitimate concerns about safety in the near and long term.

Long term safety is provided by disposal, and until a suitable disposal facility has been implemented, safe management is provided by storage. While safe and sustainable solutions have been implemented or are under development around the world, it is never enough to simply reproduce the same solution in a different location. For every facility, safety has to be assessed and a license application based on a safety case has to be reviewed by a competent authority. This ensures that such legitimate concerns from governments and citizens are fully addressed and that the protection of people and the environment is provided for. Licensing a disposal facility is often a lengthy process and therefore there is a need in the near term to safely store the waste pending disposal.

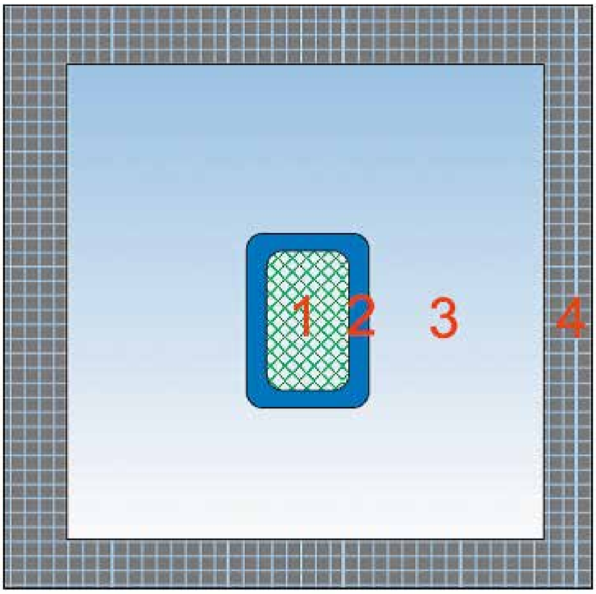
Waste Storage

Storage may be required at any stage of the waste management process and may serve several purposes, such as to allow for the decay of short-lived radionuclides, dissipation of heat, time to accumulate sufficient waste to enable efficient processing, or to provide for waste containment and isolation until a suitable path towards disposal has been implemented.

Storage is defined as the holding of radioactive sources, spent fuel or radioactive waste in a facility that provides for their/its containment, with the intention of retrieval. Storage is consequently, by definition, an interim measure.

To provide safe, retrievable, monitorable and secure storage of waste that ensures protection for workers, the public and the environment,

Schematic Representation of a Storage System



Packaged waste storage — physical and environmental layers of protection

1. The conditioned waste form is the primary barrier.
2. The waste container is the secondary barrier.
3. Control of the store environment is important in maintaining integrity of the waste form and waste container.
4. The store structure is the final layer of weather/atmosphere protection for the waste package and is also an important element in the physical security of the waste.

Image: *November 2012 Industry Guidance: Interim Storage of Higher Activity Waste Packages — Integrated Approach*, NDA, UK

a storage system composed of two primary components — the waste package and the storage facility itself — is required. These two components are closely linked as the properties and behaviour of one strongly influences the design of the other. Both need to be properly addressed to ensure the system meets the necessary safety and regulatory requirements. The figure above provides a schematic illustration of the storage system.

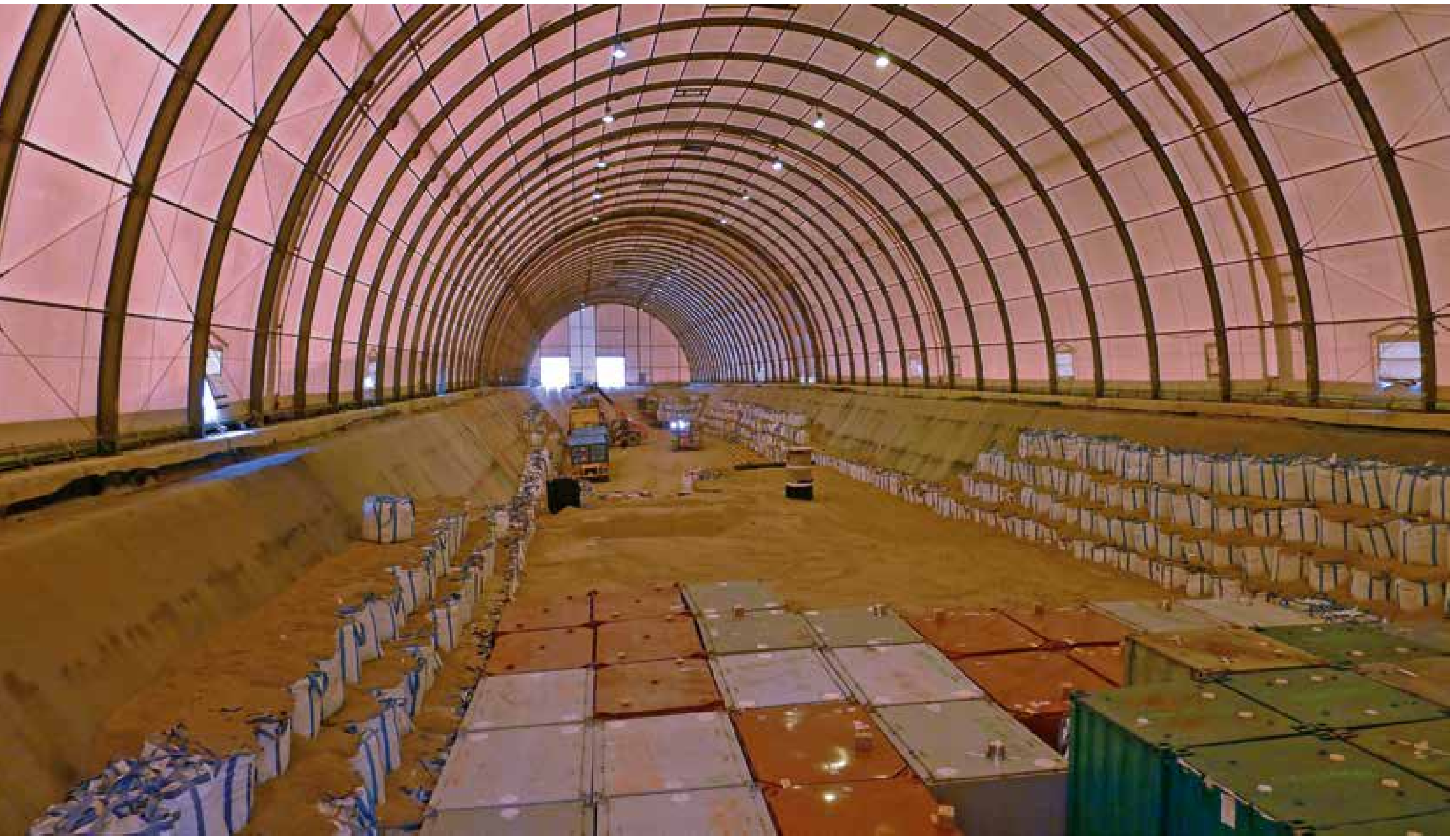
The waste package includes the waste form and the container. The preferred waste form is a stable solid product, which may be produced using a suitable conditioning technique such as cementation or vitrification. The container ensures secure containment of the radioactive material for the required storage period and for disposal, and will include features for handling and stacking in the store. Some containers in common use are illustrated on the right.

The storage facility provides an environment such that the waste packages do not degrade during the period of storage and are safe to retrieve and transfer to the disposal facility. The type of store building and its internal storage arrangement are therefore linked to the type and classification of waste being stored.

Low level waste, commonly stored in 200 litre steel drums or metal containers and likely to be routed to disposal within a short time, requires simple storage arrangements as shielding is not required. A suitable structure can be an industrial-type building able to provide protection from the local climate, with a firm concrete slab, and vehicle and personnel access doors, together with monitoring and

From top left: 200 litre steel drum, concrete boxes and stainless steel container for high level waste (HLW)

(Photos, from top left: IAEA; Magnox Limited, UK; and Sellafield Ltd, UK)



Very low level waste disposal trench at the CIRES disposal facility in France.

(Photo: National Radioactive Waste Management Agency (Andra), France)

inspection provisions; humidity control may also be necessary.

Storage of long lived vitrified high level waste or spent nuclear fuel requires a carefully designed, highly engineered facility to provide remote handling, shielding, cooling and an assured environment for the required storage period. Such a facility must also provide adequate security and, in the case of spent nuclear fuel, safeguard the fissile material.

In recent years, mainly because of the absence of permitted disposal facilities, long term storage (e.g. up to 100 years) is being considered by a number of Member States as a risk mitigation measure should there be delays in the availability of a final disposal facility. Such long term storage entails taking additional measures to ensure continuing satisfactory control and protection of the waste packages and the facility itself and to demonstrate, including by taking into account ageing of materials and structure, that the safety and security of the facility is ensured for the planned period and that a corresponding licence is given.

The HABOG facility in the Netherlands is an example of a modern long term storage facility for vitrified high level waste from reprocessing and spent fuel from research reactors. Even in this example, storage can only be considered a temporary solution, implemented with the intention and need to eventually retrieve waste for further management. Disposal is the only permanent management solution for radioactive waste capable of providing for passive, long term safety.

Waste Disposal

Different disposal solutions exist, which may broadly be classified into:

- Near surface disposal facilities, suitable for very low level waste and low level waste; and
- Geological disposal facilities, suitable for intermediate level waste, high level waste and spent nuclear fuel declared as waste.

Very low level waste (VLLW) and low level waste (LLW) present a potential hazard for durations not exceeding a few centuries. They can safely be contained in a near surface facility. Some 140 near surface disposal facilities have been successfully sited worldwide, and are in operation, or even already closed. Efficient disposal solutions for VLLW are landfill-type surface trenches utilizing a limited barrier system. Disposal solutions for LLW rely on a combination of site properties and engineered barriers such as liners, concrete disposal vaults and covers of alternating impermeable and water diverting features, to provide the required protection.

Intermediate level waste (ILW), high level waste (HLW) and spent fuel (SF) declared as waste may present a hazard for durations exceeding hundreds of thousands of years. They therefore require disposal in a stable, geological environment, capable of ensuring long term safety without human intervention for several thousands (in the case of ILW) or several hundreds of thousands of years (in the case of HLW and SF).

Disposal of LLW and ILW is well established and several geological disposal facilities for LLW and ILW are in operation worldwide.

A few countries (Sweden, Finland and France) are well advanced in the development of geological disposal facilities for HLW including spent fuel and such facilities are expected to be operational by 2025.

Despite these success stories, the implementation of disposal strategies remains one of the greatest ongoing challenge in the management of spent fuel and radioactive waste in many Member States.

From the technical and safety perspective, geological disposal is feasible. Different types of host rock have been found to be suitable for safe geological disposal and safety cases have been developed for disposal in crystalline rock (e.g. in Finland, Sweden), in sedimentary (i.e. clay) rock (e.g. in France) and in evaporite (i.e. salt) rock (e.g. in Germany).

Initially, the suitability of a site is assessed, for example, by evaluating whether the risk of seismic activity, volcanic activity, or the presence of natural resources prevent it from hosting a geological disposal facility. With further investigation a site is characterized to a stage where the relevant natural features and processes are understood with confidence, especially regarding how they contribute to containing and isolating the radionuclides in the waste and spent fuel — and thus how they contribute to long term safety.

In addition to these natural site properties, engineered features such as the waste form, the waste package, and any buffers and seals that may be emplaced also contribute to the containment, and thus to long term safety are also analyzed and taken into consideration. Indeed, waste is processed into waste forms limiting its long term release (e.g. from a glass matrix for HLW). It is further conditioned into disposal packages preventing any contact with water for specified durations (e.g. several hundred thousand years for the copper containers in the Swedish and Finnish geological disposal design).

IAEA Division of Radiation, Transport and Waste Safety and IAEA Division of Nuclear Fuel Cycle and Waste Technology

Top: The SFR geological disposal facility for operational nuclear power plant waste in Sweden

(Photo: Swedish Nuclear Fuel and Waste Management Company (SKB), Sweden)

Bottom: Host formation for deep geological disposal of the Finnish spent nuclear fuel inventory

(Photo: Posiva Oy, Finland)

CRADLE TO GRAVE: MANAGING DISUSED SEALED RA

1 Some countries in the Mediterranean region lack appropriate facilities for the safe management or disposal of radioactive waste such as disused radioactive sources. Disused radioactive sources could be lost, stolen or abandoned and thus fall outside the regulatory control.

2 Such loss of control over disused sources presents a significant risk to the public and the environment.

3 At their request, the IAEA's Department of Technical Cooperation is helping countries in the Mediterranean region manage the problem, and reduce the risk of harm, through a four-year project that began in 2012. The European Commission, Spain and the USA have also supported the project with expertise and funding.

4 Sealed radioactive sources or "sealed sources" are radioactive materials that have been isolated/sealed in metal capsules like this one. Sealed sources are used in many fields, such as medical diagnostics and treatment, to control industrial processes, and to sterilize food and medical products.

DIOACTIVE SOURCES IN THE MEDITERRANEAN REGION

5 Radioactive sources that are no longer in use are still harmful because of the radiation they emit. Finding solutions for the safe and secure long term management of disused sources is, therefore, one of the most important steps in eliminating radiation hazards to the public.

6 Using workshops, one-on-one training, and demonstrations with actual sources, the IAEA interregional technical cooperation project has helped 15 countries around the Mediterranean to develop and implement strategies for the control of sealed sources from distribution to installation, use, disuse, and through to disposal, including storage and transport. This is referred to as cradle to grave management.

7 The project also addresses the governmental and regulatory aspects of source management, helping the countries formulate national policies, regulations, and guidance in line with the IAEA's safety standards and contribute to ensuring overall nuclear and radiation safety.

8 When the project ends in 2016, it will have contributed to strengthening the control of disused sealed radioactive sources on the shores of the Mediterranean, thereby protecting people and the environment.

Text: Sasha Henriques, IAEA Office of Public Information and Communication

Photos: Mohamed Maalami, National Centre for Nuclear Energy, Sciences and Technology (CNESTEN), Morocco

Project INT/9/176, 'Strengthening Cradle to Grave Control of Radioactive Sources in the Mediterranean Region', is carried out with funding by the European Union and the IAEA.

CONDITIONING OF RADIOACTIVE SOURCES IN MONTENEGRO: AN IAEA INTERREGIONAL TRAINING COURSE

1 From 24 to 26 June 2014, 26 participants from 15 countries were given an overview on options for the safe management of disused sealed radioactive sources of categories 3 to 5 at an interregional training course held in Podgorica, Montenegro. Topics included the life cycle of sources, categorization and technical procedures for conditioning.

2 On the second day of the training participants were able to observe a real-life conditioning operation at Montenegro's national radioactive waste storage facility. Devices containing disused sealed radioactive sources, collected from all over the country, are stored here awaiting further management.

3 At the facility, Croatian radioactive waste management experts contracted by the IAEA demonstrated the conditioning process to the participants, who are involved in their national radioactive waste management programmes.

4 The training course also provided the participants with the opportunity to ask the experts questions and share their experiences. The IAEA regularly organizes training courses of this kind in its Member States through its technical cooperation programme.

Photos and text: Louise Potterton, IAEA Office of Public Information and Communication and Vilmos Friedrich, International Consultant and Lecturer at the Interregional Training Course

THE IAEA ENGAGES THE INTERNATIONAL COMMUNITY ON RADIOACTIVE WASTE MANAGEMENT

The importance of the safe management of radioactive waste for the protection of people and the environment has long been recognized, and considerable experience has been gained in defining objectives, establishing safety standards and developing technology and mechanisms for meeting safety requirements. This is of fundamental relevance to the global nuclear industry as well as for the increasing use of nuclear energy.

The IAEA safety standards reflect an international consensus on what constitutes a high level of safety for protecting people from the harmful effects of ionizing radiation and protecting the environment. This consensus serves to identify and give prominence to common safety concerns and also helps to give Member States an agreed basis for the harmonized application of the standards.

The development of safety standards is based on pooling expert knowledge and experience from organizations in Member States. This process is part of the IAEA's ongoing international collaboration in establishing "standards of safety for protection of health and minimization of danger to life and property" in accordance with the IAEA's Statute.

To ensure the safety of radioactive waste management, the international nuclear community is supported by a global nuclear safety framework comprising several elements that include reinforcing nuclear safety, facilitating the global application of safety standards, and implementing international instruments such as conventions and codes of conduct.

In 1995, the IAEA set up four topical Safety Standards Committees and the Commission on Safety Standards that oversee the development of the safety standards and exchange experience for strengthening the global nuclear safety framework.

Safety Standards Committees

As one of the four Safety Standards Committees, the Waste Safety Standards Committee (WASSC) is a standing international advisory body of senior representatives in the areas of waste safety. It reviews and approves proposals for the development of standards to be published in the IAEA Safety Standards Series and it is invited to comment on relevant proposals for the development of publications in the IAEA Nuclear Security Series.

The IAEA safety standards reflect an international consensus on what constitutes a high level of safety for protecting people from harmful effects of ionizing radiation and protecting the environment.

WASSC is responsible for reviewing and approving draft waste safety standards that are submitted to Member States for comment before their approval for publication. Waste safety is supported by a comprehensive set of internationally agreed safety standards, established with the active involvement of Member States and under the supervision of WASSC and the other Committees as necessary and appropriate, which also advise on the provision of guidance and assistance to Member States on the implementation of these standards.

The Commission on Safety Standards (CSS), a standing body of senior government officials, endorses the texts of the Safety Fundamentals and Safety Requirements for submission to the IAEA Board of Governors for approval, and also advises on the suitability of Safety Guides, which are issued under the authority of the IAEA Director General.

With the assistance of the CSS, the IAEA works to promote the global acceptance and use of its safety standards. In accordance with the mandate of the IAEA, the CSS assists in articulating a vision for the future application of the safety standards, policies and strategies, and corresponding functions and responsibilities.

Participants discussing a case study on stakeholder involvement in radioactive waste disposal at an IAEA training workshop in Warsaw, Poland, November 2012

(Photo: A. Izumo, IAEA)

The International Radioactive Waste Technical Committee, a working group of senior international experts, provides advice to the IAEA on activities and directions for the radioactive waste management programme, and supports its implementation. It develops and reviews selected publications for the IAEA Nuclear Energy Series, assesses gaps and advises on the preparation of new publications that fall within its scope of responsibilities.

Networks — Cooperation in the Nuclear Field

The IAEA is the world´s centre of cooperation in the nuclear field. Since 2001, the IAEA has championed the concept and use of professional networks (communities of practice) to advance best practices in nuclear knowledge management, implementation of nuclear technology, radioactive waste management, decommissioning and environmental remediation. The communities of practice aim to enhance the safety and sustainability of practices and facilities related to nuclear science and technology, and to serve as international forums for learning and growth of competence in the application of nuclear knowledge management, as well as for networking nuclear education. The IAEA has developed tools and services to provide better sharing and access to existing knowledge for scientists and experts in the nuclear field.

Currently, five such networks focus on these specific nuclear related areas of specialization.

1. Network on Environmental Management and Remediation (ENVIRONET)

The scope of ENVIRONET covers the enhanced implementation of remediation actions as well as of public and environmental protection and site monitoring. The basis for this network has been built over the past decade as a number of remediation methods have been developed to deal with environmental cleanup of sites with radioactive contamination.

2. International Decommissioning Network (IDN)

The IDN is intended to bring together existing decommissioning initiatives both inside and outside the IAEA to augment cooperation and coordination. It was launched in 2007 to provide a continuing forum for the sharing of practical decommissioning experience among Member States, in response to the needs expressed at the International Conference on Lessons Learned from Decommissioning of Nuclear Facilities and the Safe Termination of Nuclear Activities held in Athens, Greece, in 2006.

3. International Network of Laboratories for Nuclear Waste Characterization (LABONET)

LABONET is a network of laboratory-based centres that aims to improve the sharing of international experience in the application of proven, quality assured practices for the characterization of low and intermediate level radioactive waste and waste packages and to facilitate risk reduction and cleanup of the environmental legacy.

4. International Low Level Waste Disposal Network (DISPONET)

DISPONET brings together planners, developers and operators of disposal facilities who wish to improve international practices and approaches in managing low level waste.

5. Underground Research Facilities (URF) Network

The URF Network provides a platform for learning about the geological disposal of radioactive waste. Under the auspices of the IAEA, nationally developed underground research facilities and associated laboratories concerned with the geological disposal of radioactive waste are being offered by various Member States for training in and demonstration of disposal technologies.

These networks in different areas of radioactive waste management are beneficial for Member States. The networks provide a forum for information exchange and dissemination and also enhance cooperation between experts in developed and less developed programmes. Through this exchange, the IAEA is able to help those Member States seeking assistance in the area of spent fuel management and radioactive waste management.

International Projects Examine the Application and Use of Waste Safety Standards

The IAEA has developed intercomparison and harmonization projects that examine the application and use of its waste safety standards, with a view to enhancing their effectiveness as well as seeking to harmonize methods in respect to the safe management of radioactive waste.

International Project on Demonstration of the Operational and Long-Term Safety of Geological Disposal Facilities for Radioactive Waste (GEOSAF Part II)

This project provides a forum to exchange ideas and experience in developing and reviewing the safety case — defined as a collection of arguments to demonstrate the safety of facilities and activities — for geological disposal facilities. It also aims at providing a platform for knowledge sharing. With more countries contemplating embarking on nuclear power, and countries with nuclear power programmes seeking to define national policies and strategies aimed at covering all elements of the fuel cycle, such a platform is considered not only relevant, but appropriate. There is also a need to maintain existing knowledge bases.

The initial project (2008–2011) focused on the development by the operator and the review by the regulators of the safety case for geological disposal facilities, a concept that has recently gained considerable prominence in the waste management area and is addressed in several waste safety standards.

GEOSAF Part II was initiated in 2012 with the objective of reaching a joint understanding and working towards harmonization of views and expectations regarding the safety of the operational phase for geological disposal of radioactive waste and of post-closure safety.

Practical Illustration and Use of the Safety Case Concept in the Management of Near-Surface Disposal (PRISM)

The PRISM project focuses on the nature and use of the safety case over the lifetime of a near surface radioactive waste disposal facility. The objective of this project is to share experience and expertise in facilitating good practices in the safe disposal of radioactive waste.

This project provides guidance in the demonstration of safety, through the development of a safety case, for taking decisions, as part of the licensing process, regarding the development of near surface disposal facilities. The follow up Application of the Practical Illustration and Use of the Safety Case Concept in the Management of Near-Surface Disposal Project (PRISMA) will develop a model safety case based on the tools and methodology established under the PRISM project.

International Project on Human Intrusion in the Context of Disposal of Radioactive Waste (HIDRA)

The HIDRA project is a two-year project that commenced in 2012. The objective of this project is to provide guidance on how to take into account potential human intrusion aspects in the demonstration of safety for radioactive waste disposal facilities. The outcomes of the project will contribute, as part of the development of radioactive waste disposal facilities, to optimizing siting, design and waste acceptance criteria.

The IAEA organizes and administers networks and international working groups to assist Member States in the use and application of safety standards, technical guidance and best practices for the safe management of all types of radioactive waste. Such assistance is complemented by other tools such as peer review missions, seminars and workshops, and education and training.

IAEA Department of Nuclear Safety and Security and IAEA Division of Nuclear Fuel Cycle and Waste Technology

THE FUTURE: INNOVATIVE TECHNOLOGIES FOR RADIOACTIVE WASTE PROCESSING AND DISPOSAL

Safe, proliferation resistant and economically efficient nuclear fuel cycles that minimize waste generation and environmental impacts are key to sustainable nuclear energy. Innovative approaches and technologies could significantly reduce the radiotoxicity, or the hazard posed by radioactive substances to humans, as well as the waste generated. Decreasing the waste volume, the heat load and the duration that the waste needs to be isolated from the biosphere will greatly simplify waste disposal concepts.

Recycling and reusing minimizes the waste volume. This concept, together with the optimal use of natural resources, forms the basis of the 'closed fuel cycle', where the reusable parts of the spent fuel are recycled and not considered as waste.

Spent nuclear fuel could be processed to separate and/or convert the long lived radioactive elements into shorter lived, less hazardous forms. Known as 'partitioning and transmutation', or P&T, this process results in a smaller volume of waste with considerably less radiotoxicity.

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Partitioning and Transmutation

Spent nuclear fuel discharged from a nuclear reactor is highly radiotoxic due to three groups of elements it contains: major actinides, which are uranium and plutonium; minor actinides including neptunium, americium and curium; and fission products. Due to the long lived actinides and heat generating fission products, the spent fuel is considered high level waste and must be contained and isolated from the biosphere in a deep geological facility for hundreds of thousands of years.

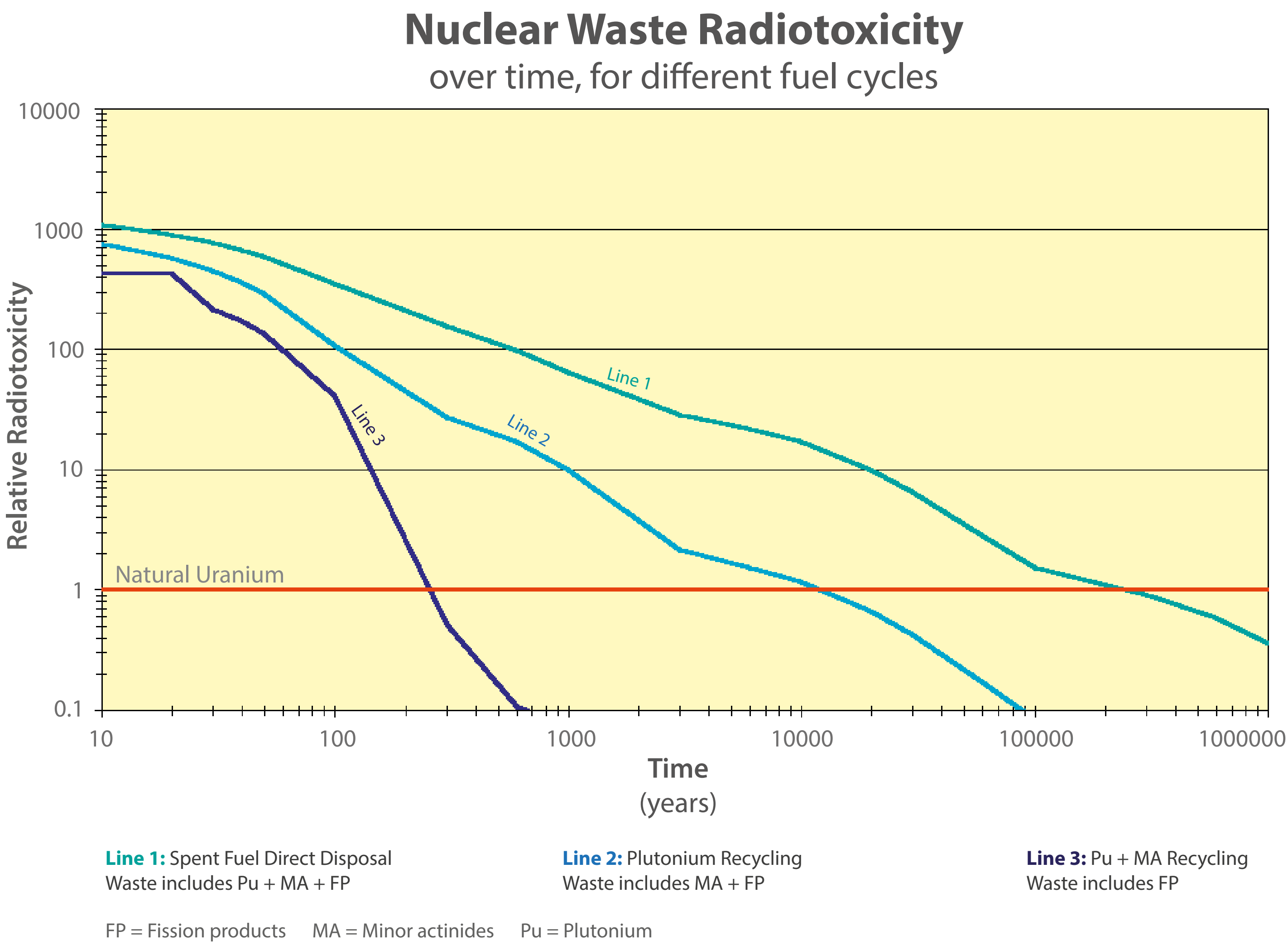
Long lived actinide elements are the highest contributor to long term radiotoxicity. Fission products, although they generate heat, are short lived and contribute to radiotoxicity only during the first 100 years.

In P&T, the plutonium and minor actinides are extracted from spent fuel by chemical separation. This is followed by transmutation where the transuranic elements (neptunium, plutonium, americium and curium) are destroyed by fission in a specially designed nuclear reactor. Utilizing a P&T approach can improve the efficiency of radioactive waste management because of the reduction in the volume of waste which results in more cost effective management schemes.

Today, fast neutron systems are the most studied transmutation technology to destroy the long lived actinide elements. Transmutation is possible in other reactors such as pressurized water reactors but fission is less efficient in them.

A distinct advantage is that when fast reactors are used in combination with new fuel cycle technologies, it is possible to recycle major and minor actinides without the need for high purification schemes, as is the case with existing reprocessing plants in France, India, Japan and the Russian Federation. This system is highly proliferation resistant, as there is no need to separate the plutonium from the other actinides. The combination of fast reactors (or utilization of the fast spectrum) with advanced pyroprocessing of the spent fuel is currently under development and being demonstrated in India, the Russian Federation and the European Union.

Recycling the actinides in fast reactors provides a significant reduction in waste volume, heat load and time required for radiotoxicity levels to decrease to that of the natural uranium ore used for the light water reactor fuel. Current research and development (R&D) demonstrates that the concept of 'natural equivalent disposal'



Fast neutron technology can reduce the radiotoxicity of the waste to the level of natural uranium in about 400 years instead of hundreds of thousands of years.

is viable. In other words, it is technically possible to generate radioactive waste that would decay to such natural levels over the course of 300 to 400 years, instead of the 250 000 years needed if you would directly dispose of spent fuel. Or simply, the development of a modern nuclear power plant would drastically reduce the waste burden on future generations.

Nevertheless, this is a complex task and it is necessary to enhance reprocessing and recycling technologies: to improve the efficiency of actinide separations, to reduce the volume of secondary wastes, and to avoid proliferation problems. IAEA studies in the area of fast reactor development and innovative fuel cycles demonstrate that these issues could be solved and the nuclear industry could advance to a more sustainable new fuel cycle.

There are also serious R&D efforts focusing on using thorium instead of uranium, and on the increased use of reactor systems with higher fuel burnup, such as high temperature gas-cooled and molten salt reactors. The goal of these efforts is to reduce the amounts of transuranic elements while producing the same amount of electricity.

Alexander V. Bychkov, IAEA Deputy Director General and Head of the Department of Nuclear Energy

LEGAL ASPECTS OF RADIOACTIVE WASTE MANAGEMENT: RELEVANT INTERNATIONAL LEGAL INSTRUMENTS*

The responsible use of nuclear technology requires the safe and environmentally sound management of radioactive waste, for which countries need to have stringent technical, administrative and legal measures in place.

The legal aspects of radioactive waste management can be found in a wide variety of legally binding and non-binding international instruments. This overview focuses on the most relevant ones, in particular those on nuclear safety, security, safeguards and civil liability for nuclear damage. It also identifies relevant regional instruments concerning environmental matters, in particular, with regard to strategic environmental assessments (SEAs), environmental impact assessments (EIAs), public access to information and participation in decision-making, as well as access to justice.

In the field of radioactive waste management, the most pertinent treaty is the 1997 Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (Joint Convention). The Joint Convention is applicable to the safety of radioactive waste management when such waste arises from civilian applications,

The legal aspects of radioactive waste management can be found in a wide variety of legally binding and non-binding international instruments. This overview focuses on the most relevant ones, in particular those on nuclear safety, security, safeguards and civil liability for nuclear damage.

including disused sealed sources, uranium mining, milling wastes and discharges from regulated activities. As an example, according to the Joint Convention, Contracting Parties involved in the transboundary movement of radioactive waste are to take appropriate steps to ensure that such movement is undertaken in a manner consistent with its provisions and other relevant binding international instruments. It is also noted that radioactive waste resulting from the operation of nuclear power plants is covered by both the Joint Convention and the 1994 Convention on Nuclear Safety.

In the field of nuclear safety, the provisions of the legally non-binding 2003 IAEA Code of Conduct on the Safety and Security of Radioactive Sources are also relevant in respect of those disused sealed radioactive sources managed as radioactive waste.

Underpinning these legal instruments are relevant IAEA safety standards, notably the Safety Fundamentals, as well as the Safety Requirements and Safety Guides dealing with the governmental, legal and regulatory framework; predisposal management of radioactive waste; disposal of radioactive waste; the safe transport of radioactive material; and the control of orphan sources and other radioactive material in the metal recycling and production industries.

In the field of nuclear security, the 1980 Convention on the Physical Protection of Nuclear Material (CPPNM), as amended in 2005, addresses the physical protection of nuclear material (including radioactive waste) used for peaceful purposes while it is in international nuclear transport and domestic use, storage and transport. The CPPNM is the only international, legally binding instrument in the area of physical protection of nuclear material.

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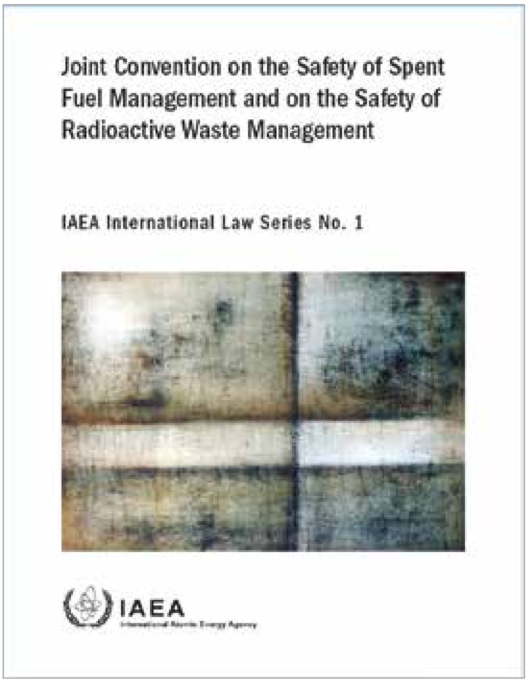
*Reference should also be made to the article entitled *An Expanding International Legal Regime: Environmental Protection & Radioactive Waste Management* by Wolfram Tonhauser (Head, IAEA Nuclear and Treaty Law Section, IAEA Office of Legal Affairs) and Gordon Linsley (former Head, IAEA Waste Safety Section), published in Volume 42, Number 3, 2000, IAEA Bulletin.



Furthermore, IAEA safeguards under comprehensive safeguards agreements (CSAs) are applied to all nuclear material[**] within the territory of States with a CSA in force, under their jurisdiction or carried out under their control anywhere. This includes nuclear material contained in retained waste for the exclusive purpose of verifying that such material is not diverted to nuclear weapons or other nuclear explosive devices. Furthermore, under additional protocols concluded by CSA States, the IAEA verifies the information provided by States regarding the location or further processing of intermediate or high level waste containing plutonium, high enriched uranium or uranium-233.

Regarding nuclear liability, international legal instruments include the 1963 Vienna Convention on Civil Liability for Nuclear Damage, the 1997 Protocol to Amend the Vienna Convention on Civil Liability for Nuclear Damage and the 1997 Convention on Supplementary Compensation for Nuclear Damage. These instruments provide a basis for third-party compensation in respect of nuclear damage arising from a nuclear incident during the transport of radioactive waste or from a nuclear incident at a nuclear installation, such as a radioactive waste storage facility, a shutdown reactor, an installation being decommissioned or a radioactive waste disposal facility.

[**]Nuclear material subject to safeguards under comprehensive safeguards agreements consists of uranium, plutonium and thorium.

Regarding nuclear liability, international legal instruments include the 1963 Vienna Convention on Civil Liability for Nuclear Damage, the 1997 Protocol to Amend the Vienna Convention on Civil Liability for Nuclear Damage and the 1997 Convention on Supplementary Compensation for Nuclear Damage.

Finally, of particular relevance to installations designed for the processing, storage, and disposal of radioactive waste are regional instruments concerning environmental matters. These treaties, adopted under the auspices of the United Nations Economic Commission for Europe (UNECE), address EIAs, SEAs, public access to information, public participation in decision-making and public access to justice. They include the 1991 Convention on Environmental Impact Assessment in a Transboundary Context (Espoo Convention), the 2003 Protocol on Strategic Environmental Assessment to the Convention on Environmental Impact Assessment in a Transboundary Context (Kyiv SEA Protocol) and the 1998 Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters (Aarhus Convention).

Anthony Christian Wetherall and Isabelle Robin, IAEA Office of Legal Affairs

REGULATING RADIOACTIVE WASTE MANAGEMENT AT THE NATIONAL LEVEL

National and local governments design and enforce rules concerning the safe transport, treatment, storage, disposal, and classification of radioactive waste. These rules are intended to protect people and the environment, and to provide a legal and regulatory framework within which radioactive waste management can be planned and safely carried out.

Radioactive waste regulations also cover "who" is responsible for "what" at each stage of the waste management process, and define the optimal decision making process over the different stages in the lifetime of the waste facility, including development, operation, and closure or decommissioning.

Regulations, which are created and enforced by an independent national/local government entity, also address how the waste facility is allowed to secure funding, how to hire staff, how and to what extent outside parties can become involved, where waste facilities can be built, and the measures that must be taken to protect workers at these facilities.

The role of the IAEA is primarily to provide advice and guidance when asked.

Many of the IAEA's 162 Member States use the IAEA safety standards on radioactive waste as a template to create their own, legally binding regulations. These standards are vetted by experts and based on global best practices.

Radioactive waste management regulations are different in each country, depending on the national legal structure of the Member State, and on the complexity and extent of radioactive waste management facilities, activities, and inventories. For example, radioactive waste management regulations for countries with comprehensive fuel cycle programmes that include reactors would differ from those for countries with limited inventories of disused radioactive sources.

IAEA Division of Radiation, Transport and Waste Safety and Sasha Henriques, IAEA Office of Public Information and Communication

DEVELOPING CAPACITIES IN RADIOACTIVE WASTE MANAGEMENT

As the Agency's main service-delivery mechanism, the IAEA's technical cooperation (TC) programme plays a large part in supporting radioactive waste management around the world, helping to share information on the topic, and training personnel in the proper treatment and disposal of radioactive waste. The TC programme supports the development of policies and strategies, the assessment and upgrading (if necessary) of existing facilities, and the implementation of new management facilities, especially for near surface disposal. The programme also helps to develop competence in geological disposal for Member States operating nuclear power plants. This article presents just a few project examples to illustrate the scope of the programme.

In Africa, the main radioactive waste challenges that Member States face are related to the lack of adequate national infrastructure and properly trained personnel. Through the TC programme, the IAEA is helping African Member States improve their capabilities in radioactive waste management, and acquire experience through comprehensive, tailored capacity-building programmes that support the transfer of knowledge and technology.

For example, the Tanzania Atomic Energy Commission operates a central radioactive waste management facility, which was established with the assistance of the IAEA's TC programme. Disused radioactive sources are collected from various places around the country and are placed in the facility for safe, long term storage. The United Republic of Tanzania has also received assistance on the technical and safety aspects of radioactive waste interim storage, management, monitoring, control and handling. As a result, public exposure control measures are in place, together with a radioactive waste management strategy and a radioactive waste legal framework for the country. Today, radioactive waste of all types in the United Republic of Tanzania is properly managed, using appropriate technology, and in line with international safety standards.

The United Republic of Tanzania is also currently participating in a regional TC project on improving waste management infrastructure in Africa. Among other topics, this project focuses on improving the inventory of radioactive sources, cradle to grave management of radioactive sources, and the application of waste management and remediation technologies in naturally occurring radioactive material (NORM) industries.

Tanzania Waste Storage Centre.

(Photo: Tanzania Atomic Energy Commission, Tanzania)

In another project in Asia and the Pacific, more than 90 experts from 22 Member States are taking part in a regional TC project to establish radioactive waste management infrastructure. The project focuses on the modular design of processing and storage facilities for small volumes of low and intermediate level radioactive wastes, including disused sealed sources, and supports training in the management of disused sealed radioactive sources (DSRSs) using the IAEA borehole disposal concept and cradle to grave management of sources, and on NORM waste management.

Radioactive waste management is guided by national policies and strategies, for which the IAEA also provides important support. Under the same project, Bangladesh, Oman, Thailand and Viet Nam have received support in the preparation of national policies and strategies for the management of radioactive waste and disused sources. Indonesia has received assistance on the characterization of solid radioactive waste and the selection of disposal options for radioactive waste and DSRSs. The

The IAEA's technical cooperation programme provides Member States with essential skills and capacities in radioactive waste management.

Here are some statistics on assistance over the past decade.

Technical cooperation projects	122
Fellows	130
Scientific visitors	397
Non-local training course participants	740
Meeting participants	1567

Islamic Republic of Iran has been helped to assess its national inventory and national capabilities, and to draft an action plan for the management of DSRSs.

An example from Europe is the help provided through the TC programme in the assessment of Romania's policy and strategy for radioactive waste management, which included reviewing documents and providing advice on IAEA guidelines, international best practices and regulatory guidance on radioactive management. This project has facilitated national dialogue and greatly strengthened the capacity of Romania's Nuclear and Radioactive Waste Agency to address nuclear fuel and radioactive waste management issues.

Interactions between countries with different levels of experience in nuclear science and technology support better waste management practices.

Finally, in Latin America, regional projects have strengthened national infrastructure and regulatory frameworks for the control of public exposure and safe management of radioactive waste in the region. Countries have received assistance in building national policies on the management of radioactive waste, in line with international recommendations, and training was provided for the staff responsible for regulatory activities and for managers of radioactive waste.

Interactions between countries with different levels of experience in nuclear science and technology support better waste management practices. The IAEA has established several knowledge networks in different areas of radioactive waste management. The Network on Environmental Management and Remediation hosts documents related to environmental remediation, while the International Low Level Waste Disposal Network offers information on near surface waste disposal, and the International Network of Laboratories for Nuclear Waste Characterization provides assistance for accurate and quality assured characterization of the radionuclide inventory, which is essential for decisions about waste management options. Such networks provide a forum for information exchange and dissemination among the IAEA's Member States, strengthening their ability to safely manage any radioactive waste.

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International Atomic Energy Agency Scientific Forum

RADIOACTIVE WASTE: MEETING THE CHALLENGE

Science and Technology for Safe and Sustainable Solutions

23–24 September 2014, Vienna, Austria

Boardroom D, C Building, 4th Floor

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