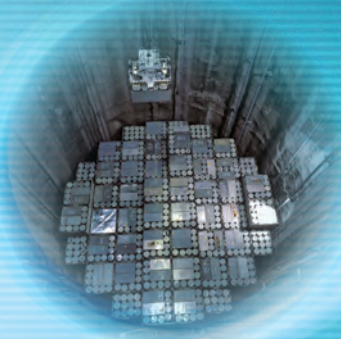
Getting to the Core of
Radioactive Waste

Managing the by-products of nuclear technologies to protect people and the environment



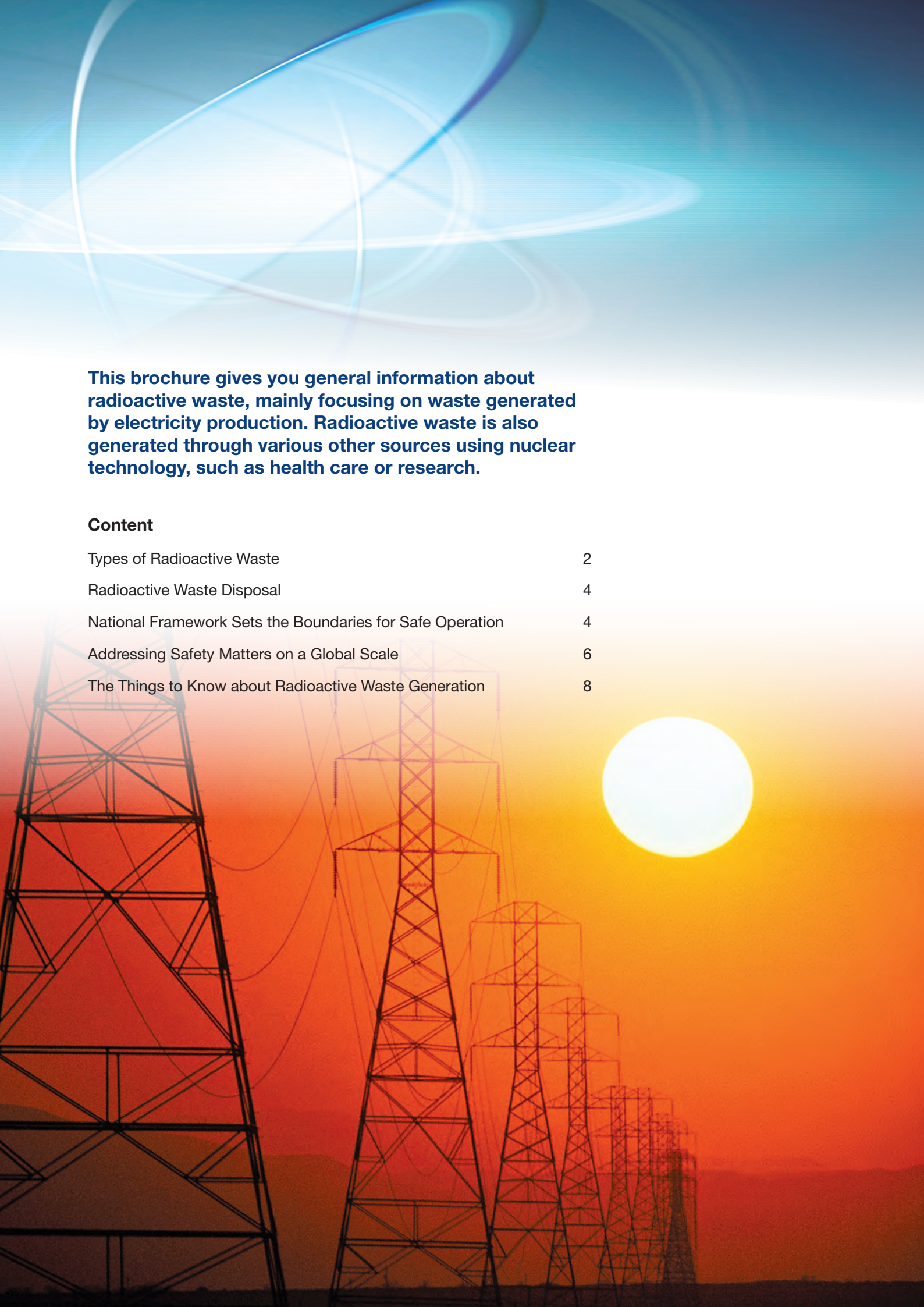
IAEA
International Atomic Energy Agency

Getting to the Core of Radioactive Waste

The world has over half a century's knowledge and experience on how to deal with nuclear waste. When the characteristics of the waste are known, it can be managed.

This brochure gives you general information about radioactive waste, mainly focusing on waste generated by electricity production. Radioactive waste is also generated through various other sources using nuclear technology, such as health care or research.

Content



Getting to the Core of Radioactive Waste

Modern life is filled with technology whose production or use generates radioactive waste. Radioactive waste is an unavoidable by-product of the use of radioactive material and nuclear technology.

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Most radioactive waste comes from nuclear electricity production and military activities. However, it is also generated in hospitals from the use of radioactive material to diagnose and treat the sick and sterilize medical products, in universities in conducting vital research in biology, chemistry and engineering, and in agriculture, where nuclear applications have helped produce crops that are more drought and disease resistant, as well as crops with shorter growing periods or increased yield – a practice that has been especially beneficial for some developing countries.

As with all radioactive sources, radioactive waste is potentially hazardous to health. Therefore, it must be managed in a safe way to protect people and the environment. Good waste management begins before the waste is generated: the starting point for all activities that produce radioactive waste is to avoid or reduce waste generation at its source. Minimizing primary waste generation also minimizes the quantity of waste requiring disposal.

Various types of radioactive waste exist and proper disposal will depend on the properties of the waste.

Types of Radioactive Waste

The main consideration for defining and categorizing waste is long term safety of disposal. Waste is classified according to its potential hazard and this determines the containment and isolation required.

Within the nuclear energy sector, a rough categorization divides nuclear waste into low level, intermediate level and high level wastes. This categorization varies slightly from country to country, but in principle the main criteria for determining the type of waste are derived from radioactive content and half-life, i.e. the time taken for the waste to lose half of its radioactivity.

Low and intermediate level wastes arise mainly from routine facility maintenance and operations. Low level waste can be contaminated clothing such as protective shoe covers, floor sweepings, paper and

plastic. Intermediate level waste can be, for example, reactor water treatment residues and filters used for purifying a reactor's cooling water. The radioactivity ranges from just above nature's background level to more elevated radioactivity in certain cases, such as parts from inside the reactor vessel in a nuclear power plant. Low and intermediate level wastes comprise 97% of the volume but only 8% of the radioactivity of all radioactive waste.

High level waste consists mostly of spent fuel from reactors. Some countries also reprocess spent fuel, which gives rise to additional types of high level waste. All of this high level waste and spent fuel, when declared as waste, poses a sufficiently high enough radiological risk that a high degree of isolation from the biosphere is required for a long period of time. Because of the radioactivity and heat generated, this waste has to be shielded and cooled.

Whatever the type of the radioactive waste, all of it has to be disposed of in a safe manner.

Radiation is a fact of life. Light and heat radiations are produced by the sun. Earth itself is radioactive. Even our bodies contain radioactive material.

It is a common misbelief that radioactive waste takes up a lot of space. However, all the spent fuel generated by two 860 MW reactors during their 40 years of operation would fit into three 10 metre by ten metre pools as in the picture.
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Getting to the Core of Radioactive Waste

Radioactive Waste Disposal

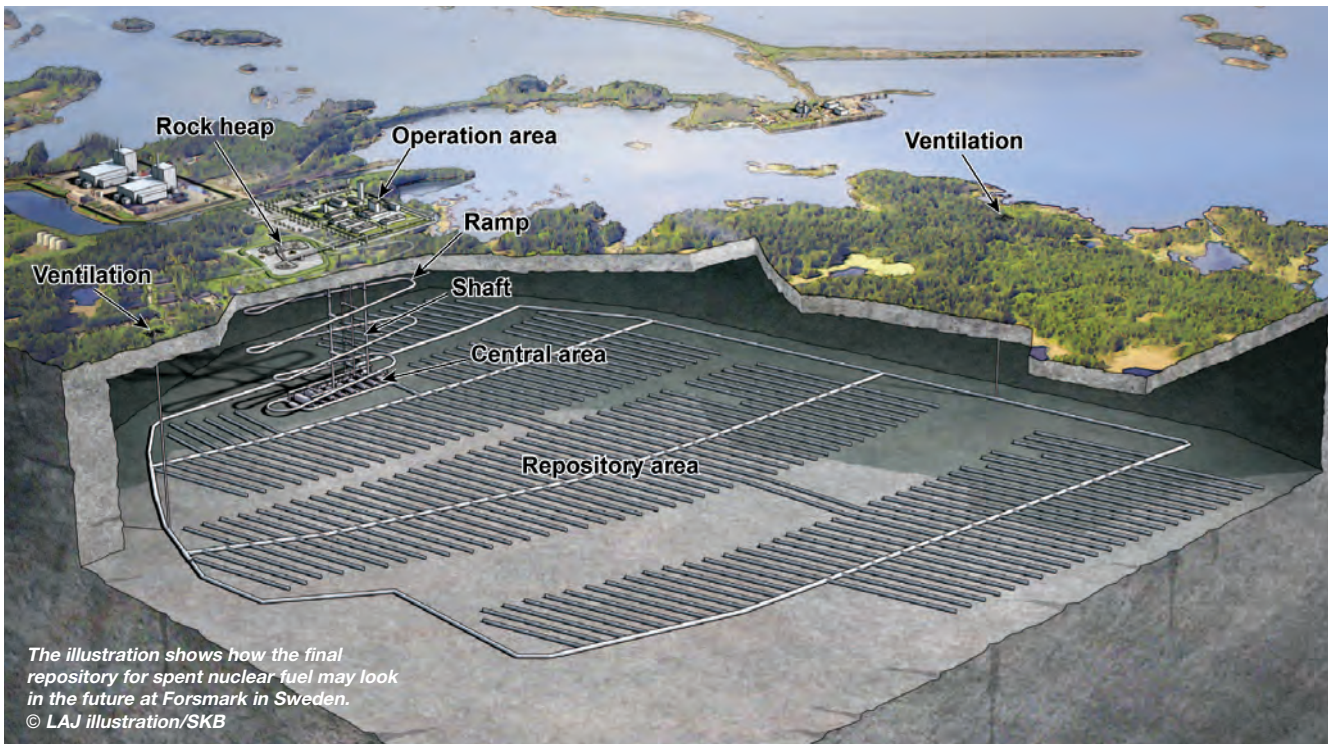
Radioactive waste is very diverse in terms of its radioactivity as well as its chemical and physical forms.

The world has over half a century's knowledge and experience on how to deal with nuclear waste. Good practices developed over the years are being used throughout the whole cycle of electricity production to help ensure the safety of people and the environment from possible effects of harmful radiation.

The characteristics of nuclear waste are well known; a prerequisite for safe and secure disposal. The appropriate disposal option and the extent of safety measures depend on the length of time the waste remains hazardous – some waste remains radioactive for hundreds of thousands of years and other waste for tens of years or less.

Disposal of low and intermediate level radioactive wastes is already implemented in several countries. Usually these facilities are at, or near, the surface, but some intermediate level waste that contains long lived radioactivity requires disposal at greater depths, of the order of tens of metres to a few hundred metres.

High level radioactive waste is presently temporarily stored in storage facilities. Several options are being examined and research for implementing disposal is being conducted in many countries with nuclear



The illustration shows how the final repository for spent nuclear fuel may look in the future at Forsmark in Sweden.
© LAJ illustration/SKB

power. In every option, deep geological disposal is the preferred final end point. The principle of geological disposal is to isolate the waste deep inside a suitable host formation, e.g. granite, salt or clay. The waste is placed in an underground facility or disposal facility, designed to ensure that a system of natural and multiple artificial barriers work together to prevent radioactivity from escaping.

In the nuclear energy sector, good waste management, resulting in safe disposal, also considers financial implications. The objective is to have enough funds to execute activities (waste disposal, decommissioning, human resources, etc.) required once electricity production of a facility has ceased. There are mechanisms for collecting money to cover all nuclear power production expenses. In terms of good practices of radioactive waste management, responsibility covers all the steps from 'cradle to grave', i.e. from uranium mining up to the disposal of the waste.

National Frameworks Set the Boundaries for Safe Operation

In principle, the operators of the facilities which generate radioactive waste have prime responsibility for the safe management of the radioactive waste that they produce. Each operator has to ensure safety throughout the whole life cycle of the production chain: siting, design, construction, commissioning, operation, decommissioning, close-out or closure of its facilities, including remediation of any contaminated areas; and for activities in which radioactive material is used, transported or handled.

However, the safety of nuclear facilities and sources of harmful radiation, radiation protection, the safe management of radioactive waste and the safe transport of radioactive material are of great importance to individuals, society and the environment. Therefore, each operator needs to demonstrate to the satisfaction of the national regulator that its responsibility has been, and will continue to be, fulfilled.

The sole purpose of the regulator is to protect the health and safety of people. The regulator carries out its function within the national legal framework, and the regulatory process continues throughout the life cycle of the facility or for the duration of an activity that produces radioactive waste. The day to day activities of a national regulator are related to authorization, review, assessment, inspection and enforcement.

The safety of facilities and activities is also of international concern. Several international conventions are in force, where various aspects of safety related information are exchanged to fulfil safety obligations and to promote cooperation.

A reactor core.
© Fortum

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Addressing Safety Matters on a Global Scale

All activities using nuclear technologies are systematically supervised. This also includes monitoring the environment for the possible effects of such activities.

Among the many international organizations, the IAEA is the global focal point for nuclear cooperation. It is an independent, intergovernmental, science and technology based organization that works with its over 150 Member States and multiple partners worldwide to promote safe, secure and peaceful nuclear technologies. The mission of the IAEA is to:

- Assist its Member States, in the context of social and economic goals, in planning for and using nuclear science and technology for various peaceful purposes, including the generation of electricity, and facilitate the transfer of such technology and knowledge in a sustainable manner to developing Member States;
- Develop nuclear safety standards and, based on these standards, promote the achievement and maintenance of high levels of safety in applications of nuclear energy, as well as the protection of human health and the environment against ionizing radiation;
- Verify, through its inspection system, that Member States comply with their commitments, under the Non-Proliferation Treaty and other non-proliferation agreements, to use nuclear material and facilities only for peaceful purposes.

Seaweed sampling near the AREVA La Hague reprocessing plant.
© AREVA

The only legal instrument to address the safety of spent fuel and radioactive waste management on a global scale is the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management.

The Contracting Parties of the Joint Convention are committed to apply the Joint Convention's safety measures, and to demonstrate this, they prepare a National Report on the applied measures and submit this report for peer review by other Contracting Parties. The Review Meetings of the National Reports for the Joint Convention are held every three years and are organized by its Secretariat, the IAEA.

The Joint Convention contributes to enhancing the safety of radioactive waste and spent fuel management in many ways, for example, by:

- Fostering an international approach to these areas and sharing expertise;
- Assuring the public that national arrangements for spent fuel and radioactive waste management conform to safety measures agreed internationally; and
- Highlighting the opportunities to receive assistance, in the case of a country having limited resources, to improve its infrastructure.

The Joint Convention is open for accession, not only to those States with nuclear power programmes, but also to those using radiation sources in medicine and industry.

Getting to the Core of Radioactive Waste

The Things to Know about Radioactive Waste Generation

- All electricity generation forms produce waste. The most important waste from a nuclear power plant is radioactive nuclear waste.
- Radioactive waste is also produced by military activities and beneficial practices in medicine, research and industry.
- The world has over half a century's experience in managing radioactive waste – the characteristics of the waste are well known and therefore it can be safely managed.
- The main objective of waste management is to protect people and the environment, now and in the future.
- As a term, nuclear waste management refers to practices and techniques used for all activities (administrative and operational) involving the handling, pretreatment, treatment, conditioning, transport, storage and disposal of radioactive waste.
- Only trained personnel are allowed to manage radioactive waste.
- There are over 440 nuclear power plant units in the world today producing three types of waste that are roughly categorized as low, intermediate and high level wastes.
- The criteria defining these three main types of waste are derived from the waste's radioactive content and half-life, i.e. the time taken to lose half of the radioactivity.
- The disposal of low and intermediate level wastes is well established in several countries. Long term safety determines the measures needed to protect people and environment.
- A number of countries have made good progress towards implementing geological disposal of spent fuel, in particular Finland, France and Sweden.
- The mechanisms for collecting money in advance to cover waste management costs exist and have been successfully implemented.

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