Ministry of Industry and Trade of the Czech Republic
Na Františku 32
110 00 Prague 1

The Concept of Radioactive Waste and Spent Nuclear Fuel Management in the Czech Republic

- Prague, May 2002 -

TABLE OF CONTENTS

1 INTRODUCTION

1.1 Determination of the Concept

Radioactive waste and spent nuclear fuel are generated in the Czech Republic as a consequence of the peaceful use of nuclear energy and ionising radiation in many industries, particularly in the generation of nuclear energy, health care (therapy, diagnostics), research, and agriculture. The current extent of utilisation of nuclear energy and ionising radiation in the Czech Republic is comparable with that of other developed countries.

Compared to other hazardous waste generated by human activity, the amount of radioactive waste and spent nuclear fuel is relatively small; it makes up hundredths of one percent of the mass of all hazardous waste generated. Certain radioactive waste and, above all, spent nuclear fuel contains a high risk potential, which is why strict management requirements are set out in terms of the technical, professional and financial provision of services. This is one of the reasons why the utilisation of nuclear energy and ionising radiation, as well as radioactive waste management, are subject to state supervision and approval by the State Office for Nuclear Safety.

The Concept of Radioactive Waste and Spent Nuclear Fuel Management (Concept hereinafter) is a fundamental document formulating government and state authority strategy for the period up to approximately 2025 (affecting policy up to the end of the 21st century), concerning the organizations which generate radioactive waste and spent nuclear fuel. The Concept puts forward solutions to provide for the disposal of waste in compliance with requirements for the protection of human health and the environment without excessively transferring any of the current impacts of nuclear energy and ionising radiation utilisation to future generations.

The Concept has been prepared in compliance with energy policy approved by Government Decree No. 50 of 12th January 2000; preparation of the Concept is required, amongst other reasons in connection with preparations for the Czech Republic's accession to the European Union and in connection with the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management adopted under the auspices of the International Atomic Energy Agency, which was signed by the Czech Republic in 1997.

The objectives of the Concept are as follows:

- To determine strategically justified, scientifically, technically, environmentally, financially and socially acceptable principles for radioactive waste and spent nuclear fuel management in the Czech Republic;
- To develop a basic system framework for the decision-making of those authorities and organizations responsible for radioactive waste or spent nuclear fuel management in the Czech Republic;
- To communicate in straightforward way information concerning the long-term management of radioactive waste and spent nuclear fuel to organizations involved in this field and to the general public.

The Concept proposed here is based on an analysis of current developments and professional forecasts of future trends in the peaceful employment of nuclear energy and ionising radiation. It is based on fifty years of experience of Czech organisations involved in the disposal of radioactive waste and on proven practice, as well as on a modern and complex system of legal regulations that make it possible to perform individual activities in a safe way and which contain sufficient control mechanisms relevant to present–day conditions and into the future. The Concept also takes into account experience and best practice in radioactive waste management in other countries.

The Concept respects strategic government policy including:

- *Energy Policy*[1]
  The Concept allows for the possible further development of nuclear energy. It proposes sufficiently flexible solutions, in terms of both technology and time for the back end of the fuel cycle, and the continuous disposal of operational radioactive waste from the energy sector.
- *State Policy for the Environment*[2]
  The Concept respects the principles of sustainable development (e.g. it employs mechanisms to minimize the quantity of radioactive waste and addresses the security of radioactive waste up to the point when it becomes harmless).
- *Former Government resolutions*
  Government resolutions recommended the construction of spent fuel storage facilities at nuclear power plants, in the area of waste management, recommended the disposal of radioactive waste in operational repositories and in the area of spent fuel management, the construction of a deep geological repository was recommended.

The Concept applies to the activities of numerous interest groups and organisations, including:

- *The Czech Government and state authorities in general*
  By adopting the Concept the government declares the principles, objectives and priorities for achieving optimum radioactive waste and spent nuclear fuel management, to be implemented by individual ministries, including the Ministries of Industry and Trade, the Environment and Finance.
- *The State Office for Nuclear Safety*
  The Concept sets out the specific content of those activities subject to legal regulation, thereby providing support for the state supervision of radioactive waste and spent nuclear fuel management.
- *The Radioactive Waste Repository Authority and its supervisory Board (RAWRA)*
  The Concept is a fundamental, strategic document, which will be used as a basis for the preparation of annual, three-yearly and long-term action plans to be presented on an annual basis, together with RAWRA's budget, to the government for approval. These plans will allow RAWRA's Board to evaluate the performance of RAWRA and the fulfilment of targets, and ensure the efficient use of funds from the nuclear account.
- *Generators of Radioactive Waste and Spent Nuclear Fuel*
  The Concept provides a decision-making framework for generators of radioactive waste and spent nuclear fuel concerning their business or production strategies.

[1] Energy Policy was approved by Government Decree No. 50 of 12th January 2000.
[2] The State Policy for the Environment was adopted by the Government's Decree No. 323/99 of 14th April 1999.

- *Institutions Involved in the Development of Methods for the Disposal of Radioactive Waste and Spent Nuclear Fuel*
  Using the Concept, research and scientific institutions, universities and other organisations can allocate capacity and systematically prepare for the fulfilment of any requirements arising from the implementation of the concept.
- *The General Public*
  The Concept contains basic information about future intentions and priorities concerning radioactive waste and spent nuclear fuel management in the Czech Republic.

1.2 Recapitulation of Current Developments in Radioactive Waste and Spent Nuclear Fuel Management

Radioactive waste management in the Czech Republic has a relatively long history. Radioactive waste was generated in the Czech Republic as early as the beginning of the 20th century in connection with the use of uranium and radium. As early as 1959 a nation-wide system was established for the transportation and disposal of radioactive waste generated in the research, medicine, industry and other non-energy fields. Operation of the system was the responsibility of the Institute for the Research, Use and Production of Radioisotopes (ÚVVVR). The system included the radioactive waste repository at Hostim (now closed), the Richard repository near the town of Litoměřice from 1964, and from 1974 the Bratrství repository near the town of Jáchymov. Operation of the Hostim repository began in 1959 and ended in 1963. Operation of the Richard repository started in 1964 and currently 5096 m^3 of conditioned waste (approximately 61% of total capacity) having a total activity level of 778 TBq is disposed of at this facility. The Bratrství repository was commissioned in 1974 and 910 m^3 of conditioned waste (approximately 69 % of total capacity) is disposed of here. Permanent disposal of the institutional radioactive waste was financed by the government until 1990. From 1991 waste generators paid only for the cost of radioactive waste processing for disposal. With the Atomic Act, came the obligation for radioactive waste generators to pay the cost of permanent disposal, such payments commencing after radioactive waste repositories were taken over by the state. Currently, the largest amount of non-energy radioactive waste is generated by the Nuclear Research Institute at Řež, which also maintains a storage facility for spent nuclear fuel from research reactors.

In 1981 the government approved the concept for the disposal of radioactive waste from the operation of nuclear reactors, which included the construction of a regional surface repository in the Czech Republic. Radioactive waste from the operation of the Dukovany nuclear power plant (four reactors built successively 1985-87) has been disposed of at the regional repository sited at the nuclear power plant since 1994. This repository is also designed for radioactive waste from the Temelín nuclear power plant and for radioactive waste of certain categories which will be created during decommissioning of the nuclear power plants. A storage facility for nuclear fuel from the Dukovany nuclear power plant was put into operation in 1995 at the nuclear power site; an updated government concept for spent nuclear fuel storage (Government Decree No. 121/97) recommended that more such facilities be constructed on the premises of nuclear power plants. Site permits for a new storage facility for spent nuclear fuel at the Dukovany nuclear power plant and at the „Skalka“ site near Dolní Rožínka (central storage facility) have been granted. The use of the Skalka“ site is dependent on the outcome of discussions on and the subsequent preparation of a spent nuclear fuel storage facility at the Temelín nuclear power plant which will begin after the commencement of commercial

operation of this power plant. Between 1985 and 2001 the Dukovany nuclear power plant generated 575 tonnes of spent nuclear fuel. By 2015 both nuclear power plants will have generated approximately 1831 tonnes of spent nuclear fuel. Mass is made up of so-called „heavy metal“, which means the uranium and plutonium isotope content in the spent nuclear fuel. This fuel contains about 94% uranium isotopes, about 1% plutonium isotopes, 1% transuranes and the rest is made up of fission products. Their content is dependant on so-called spent fuel burn-up, which indicates the energy usage of the fuel (given in MWd per ton of uranium).

An independent supervisory body was established in 1971 – the Czechoslovak Commission for Atomic Energy, which was responsible for adherence to nuclear safety principles and for the system of guarantees of non-proliferation of nuclear materials; simultaneously, the Commission oversaw technical and building development in the peaceful utilisation of radioisotopes and ionising radiation. The Commission became, in 1993, the State Office for Nuclear Safety, which took over control of radiation protection from the Ministry of Health in addition to maintaining responsibility for the system of guarantees of non-proliferation of nuclear materials and nuclear safety. Research and development in the field of radioactive waste management was originally the responsibility of the Ministry of the Economy, later becoming that of the Ministry of Industry and Trade.

Upon adoption of the Atomic Act, the Radioactive Waste Repository Authority was established to provide for activities pertaining to the disposal of radioactive waste and spent nuclear fuel. In compliance with the Atomic Act, existing radioactive waste repositories became, as of 1st January 2000 the responsibility of the Radioactive Waste Repository Authority. As a result, the state has taken over responsibility for the disposal of radioactive waste. The processing of radioactive waste into a form suitable for disposal, except for the processing of spent nuclear fuel to be carried out by the Radioactive Waste Repository Authority after the owner of such spent nuclear fuel declares it as waste, will be the responsibility of entities licensed to process radioactive waste, which will provide this service for other radioactive waste generators.

1.3 Classification of Radioactive Waste

Radioactive waste is defined by the Atomic Act as material for which no further use is foreseen and of which radionuclide content exceeds limit for release into the environment. Radioactive waste is usually classified according to the concentration of radionuclides and by the period of time during which the waste will remain radioactive. Depending on the concentration of radionuclides and intensity of emitting radiation, radioactive waste is classified as low, intermediate or high-level waste; depending on the period of time required for decay, as short-term and long-term. This document refers to those categories of radioactive waste complying with Czech legislation, which itself complies with the four main categories as per the recommendations of the IAEA[3]. These categories of radioactive waste correspond to three main ways of disposal – storage until the time of natural decay, surface and sub-surface disposal of short-lived radioactive waste, and the geological disposal of long-lived radioactive waste:

a) Radioactive waste the radioactivity of which will decrease to values allowing its release into the environment in less than five years (after that period, such waste is

[3] IAEA Safety Series No. 111-G-1.1 Classification of Radioactive Waste, Vienna 1994

excluded from the competence of the Atomic Act), generally called transient radioactive waste;

b) Short-lived radioactive waste, which can be accepted at near-surface (surface or sub-surface) repositories, generally called low-level and intermediate-level, short-lived waste (LILW-SL);

c) Radioactive waste which contains excessive amounts of long-lived radionuclides and which should be disposed of in geological repositories, generally called low-level and intermediate-level, long-lived waste (LILW-LL);

d) Radioactive waste which generates a non-negligible quantity of heat (e.g. waste arising from the re-processing of spent nuclear fuel and spent nuclear fuel after it is declared as waste), and which should be deposited in geological repositories, generally called high-level waste (HLW).

According to the Atomic Act, spent nuclear fuel is not waste unless it is declared as such by its owner; in certain cases the State Office for Nuclear Safety can decide on this issue. It is in hypothetical cases when the owner would not be able to comply with legislation requirements. Storage of spent nuclear fuel is subject to the same requirements as those for radioactive waste management before disposal and should be managed in such a way that options for its further processing be not impeded.

Natural materials generated in the mining and processing of uranium ore are managed in compliance with Act No. 44/1988 Coll. on the protection and use of mineral resources (Mining Act hereinafter), therefore the Concept is not required to address this issue. These materials are collected in dumps and mud pits, where, because of radioactive substances present, they are subject to all the radiation protection criteria.

Materials with a very low contamination of natural radionuclides can be found in various industrial processes. Currently they occur in water treatment processes and oil and natural gas transport and treatment. The content of contaminants in such materials is lower than, sometimes, at most, close to the limits for introduction into the environment. Similar materials can be found in metallurgic processes. The presence of such materials could evoke risks due to unsuitable concentrations at dumps or due to the non-application of the principle of protection against ionising radiation at these facilities. In the case of metallurgic processes the low contaminant presence is used also as an advantage commercially. Studies indicate that the occurrence of such materials in the Czech Republic is low. Management of these materials is carried out on an ad-hoc basis. In the Czech Republic a national system for the detection and treatment of most of these materials has been proposed. Reliable detection methods already exist in the metallurgic industry.

1.4 Major Issues in the Radioactive Waste and Spent Nuclear Fuel Management System

The radioactive waste and spent nuclear fuel management system in the Czech Republic is on a level comparable with that in EU countries. Nevertheless, there are certain areas that need to be addressed further:

a) Legal and Organizational Aspects

The Atomic Act has provided a basic legal framework in the Czech Republic compatible with those of EU countries, and set out the fundamental principles of the organisational system which is able to provide for all the aspects concerned with the safe management of radioactive waste and spent nuclear fuel in the Czech Republic. A new amendment to the Atomic Act should remove any remaining differences between Czech and EU legislation. This amendment should come into force in 2002; no significant changes in radioactive waste management are expected.

Both the recording and forecasting of the creation of radioactive waste and spent nuclear fuel from nuclear-energy operations are at the required level; concerning institutional waste, forecasts of the radioactive waste creation will have to be updated because the validity of licences issued according to former legislation ends in the middle of 2002 and it is expected that some former workplaces will not have their licences renewed.

b) Low/Intermediate-level Waste Management

The technical equipment necessary for the management of radioactive waste generated in the Czech Republic is available. Technologies for radioactive waste processing are operated commercially. Because RAWRA is obliged to manage radioactive waste of unknown generators, it is considered implementation of processing technologies by RAWRA or support of some commercial organisations for technological innovation equipment in the form of lease of this technology from RAWRA.

Radioactive waste repositories are operated in compliance with current legislation (requirements take the form of limits and conditions); as per international practice, the performance of disposal systems is periodically assessed.

c) High-Level Waste and Spent Nuclear Fuel Management

Global opinion suggests that a deep geological repository be utilized for the permanent disposal of this category of waste. The development of such a repository has begun in the Czech Republic; however, since the project is very complex, it will continue for several decades. Amongst other things, the project should determine a method for the processing for disposal of high-level waste and spent nuclear fuel currently being generated. Currently, high-level waste and spent nuclear fuel are stored by the generator. Only if the storage of high-level waste is not provided for by the generator, RAWRA will provide for its storage as paid service.

Simultaneously, research is being carried out into so-called partitioning and transmutation methods which could result in the transformation of long-lived radionuclides contained in spent nuclear fuel into short-lived ones which have considerably less risk.

d) Economic Aspects

All the costs involved in the disposal of radioactive waste and spent nuclear fuel are borne by generators. Disposal of radioactive waste is financially demanding; the optimum relationship between technical requirements and financial resources should be sought. In the case of institutional waste, some of it was disposed of at existing repositories before the Atomic Act came into force, therefore the state should participate financially in the operation and closure of these repositories.

e) Support

The development and operation of the radioactive waste and spent nuclear fuel management system depends on the support of research institutes, engineering organizations and universities; in addition, the system is also observed by the general public. Both areas may be crucial for radioactive waste management and should be adequately covered.

1.5 Main Principles of the Concept

Radioactive waste and spent nuclear fuel management in the Czech Republic is provided by licensed private entities (collection, processing, storage and transportation of radioactive waste and spent nuclear fuel, processing of radioactive waste) and by the state-owned organisation RAWRA (disposal of radioactive waste, future processing and disposal of spent nuclear fuel). If necessary, RAWRA can also provide extended services to generators.

Low-level and intermediate-level, short-lived radioactive waste will be safely disposed of in the Czech Republic in existing near-surface repositories; their operation will be assessed and optimised on a continual basis.

One possible method for the disposal of low-level and intermediate-level, long-lived radioactive waste and high-level waste involves disposal in a deep geological repository; before such a repository is put into operation, such materials will be stored at the generators' own site or by RAWRA.

The technical procedures for the disposal of radioactive waste and the preparation of deep geological disposal will be carried out in the Czech Republic in compliance with the outcome of foreign research and technical development. In addition options for spent nuclear fuel reprocessing and the employment of new techniques which will result in lower volumes or reduced toxicity of spent nuclear fuel will be pursued.

Costs pertaining to the disposal of radioactive waste and spent nuclear fuel will be paid from the nuclear account, which is a financial resource created specifically by radioactive waste and spent nuclear fuel generators in compliance with the Atomic Act and Government Decree. This approach ensures that the cost of disposal of waste generated today will not be carried forward to future generations.

The public will be kept informed about the Concept of Radioactive Waste and Spent Nuclear Fuel Management and progress made in achieving its aims.

2 LEGAL AND ORGANIZATIONAL ASPECTS OF RADIOACTIVE WASTE AND SPENT NUCLEAR FUEL MANAGEMENT

The efficient functioning of the radioactive waste and spent nuclear fuel management system depends not only on technical equipment and expertise but also on the existence of an efficient legal system and other supporting activities. Above all, the following is crucial for radioactive waste and spent nuclear fuel management:

- Adherence to a legal framework which does not permit any developments in radioactive waste management which would be inconsistent with the requirements for the protection of people and the environment.
- Guaranteed compliance with and enforceability of legal regulations.
- Clear specification of the basic responsibilities of all legal entities and persons involved in radioactive waste management.
- Comprehensive coverage of all activities that might give rise to radioactive waste or spent nuclear fuel and the maintaining of a survey of such materials.

Such a system has already been created to a large extent in the Czech Republic and will be further developed in compliance with the basic principles of radioactive waste management as defined by the IAEA (Annex 1) and with the requirements of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management[4]. In addition, other generally accepted principles contained in international documents are respected. Current trends in the field of radioactive waste and spent nuclear fuel management are also considered and taken over by modification of legislation according to the recommendations of international institutions (e.g. the International Commission for Radiation Protection - ICRP).

2.1 Legal System

The Czech Republic is preparing for accession to the European Union; a priority of both the Government and the legislative body is the harmonization of Czech legislation with EC law. The current legal environment in the field of radioactive waste and spent nuclear fuel management is based on recently updated legal standards. The Atomic Act and its revision in preparation specifies the inclusion of the Government agencies and the regulatory authority, creates a radioactive waste disposal system guaranteed by the state, and stipulates responsibility for potential nuclear damage. Upon adoption of the Atomic Act and eighteen related decrees, the Czech Republic became one of a group of countries which apply modern principles and standards to radiation protection, nuclear safety, emergency preparedness and physical protection of nuclear materials and facilities.

Radioactive waste and spent nuclear fuel management is also regulated by legislation relating to protection of the environment, building and mining (in case of underground repositories), etc. The effectiveness of legislation depends on the efficient interconnection and compatibility of the system. This element will therefore be considered when amending mutually related legislation.

2.2 Control and Inspection Functions, Responsibilities

The efficiency of legal requirements depends on the ability to enforce them. In the field of radiation protection and nuclear safety, this task is entrusted to the State Office for Nuclear Safety, which constitutes the central supervisory authority. Approval and supervision activities fall under the SÚJB's competence, as well as the power to impose sanctions, where the system of radioactive waste management belongs under the mining law (e.g. sub-surface repositories) and the State Mining Authority carries out its own inspection.

Since Atomic Act came into force, generators have provided financial means for radioactive

[4] Adopted on 5th September 1997 by the Diplomatic Conference organised by the IAEA and signed by the Czech Government in 1999.

waste disposal. Both the processing and disposal of radioactive waste and spent nuclear fuel will be fully covered by generators even if they are unable to do it themselves, in which case these activities will be carried out by a third party at the generator's expense. The state will perform of certain activities related to the disposal of waste from non-energy sources (institutional radioactive waste), which was accepted for disposal under regulations in force prior to the Atomic Act. In addition the state will pay the cost of disposal of radioactive waste created by unknown generators (i.e. found radioactive waste).

The institutional framework for radioactive waste management is stipulated in the Atomic Act which defines the duties and rights of, and links between, individual entities, above all, generators, SÚJB and RAWRA. The existing system of independent supervision and institutional links complies with present requirements.

2.3 System of Recording Radioactive Waste and Spent Nuclear Fuel

The system for recording radioactive waste and spent nuclear fuel is sufficiently covered by existing regulations. It consists of three basic parts, registering radioactive waste as early as at the stage of its potential origin up to its permanent disposal:

- SÚJB provides the recording of those entities licensed to dispose of sources of ionising radiation as well as the recording of sources of ionising radiation;
- RAWRA provides the recording of radioactive waste generators as well as the recording of radioactive waste deposited in the Czech Republic;
- Radioactive waste generators provide the recording of radioactive waste from its origin up to its handing over to RAWRA.

The current situation in the recording of radioactive waste and spent nuclear fuel can be characterized as follows:

- Records of radioactive waste and spent nuclear fuel from the nuclear power engineering sector have existed for many years and are checked on a regular basis by SÚJB; in addition, records of spent nuclear fuel are subject to periodical checks by the IAEA as part of international guarantees and, after the Czech Republic's accession to the European Union and EURATOM, such record keeping will be carried out by EURATOM.
- The recording of institutional radioactive waste is carried out by most generators in compliance with the requirements of Czech legislation; the transition period during which the legal position of all generators is to be adapted to the requirements of the Atomic Act will last until 2002.

3 LOW/INTERMEDIATE-LEVEL WASTE MANAGEMENT

Short-lived, low-level and intermediate-level waste represents the highest volume of radioactive waste. This waste arises in liquid or solid form during the operation and decommissioning of nuclear reactors and when handling ionising radiation sources. This radioactive waste ceases to be radioactive after a couple of centuries; hence this waste can be deposited in near-surface repositories. Techniques for the processing and treatment of such radioactive waste before disposal are well-developed and implemented in the Czech Republic.

Transient radioactive waste is processed, treated and stored in the same way as low-level waste; after its activity decreases to below the stipulated level the waste is released for recycling or disposal at secured non-radioactive waste sites.

Very low-level waste and waste contaminated with naturally occurring radioactive material (NORM) form a specific sub-category. This waste is created in the processing of certain non-uranium ores or phosphate materials, during the shipment and processing of crude oil and in the water-treatment industry. Both types contain an amount of radionuclides below or near the limit permitting their release into the environment. Production of this waste occurs at specific facilities and management of this waste could potentially endanger the local area and hence attention has also been paid to these materials. The collection, sorting and processing of NORM is currently carried out on an ad-hoc basis, a system for its collection and assessment has been partially implemented. A legal framework for the management of such materials has not yet been established in the Czech Republic, nor for that matter in the EU. Currently an option is being discussed concerning the commercial management of waste contaminated with naturally occurring radionuclides in uranium industry desludging tanks.

Long-lived low-level and intermediate-level waste appears to a lesser extent; such waste cannot be accepted by currently operated near-surface repositories. Requirements for the method and quality of processing for storage and subsequent disposal in a deep geological repository will be stipulated for this waste at a later date. The method of processing and treatment of such radioactive waste is well-known and used commercially; hence the issue of implementation is more a time and financial rather than a technical issue. For the time being, waste of this kind is mainly stored unprocessed at the generators, and small amount is being stored by RAWRA.

The results of a survey of the amount of existing and expected short-lived LILW are given in Table 1.

Table 1: Survey of the Amount of LILW-SL

Source	RW–Operation (m^3)	RW Decommissioning (m^3)	Average Annual Production (m^3)
EDU (1985-2025)	10,250	--	256
EDU (2025-2035)	--	3,640	364
EDU (2085-2094)	--	2,385	239
ETE (2000-2042)	12,000	--	285
ETE (2040-2047)	--	620	78
ETE (2090-2095)	--	4,012	669
Total NPP	**32,907**		
Instit. (1958-2000)	2,800		67
Instit. (2000-2095)	5,700		60
Total institutions	**8,500**		

Note: An increase in the use of radionuclides with a shorter half-life which can be released into the environment after short-term storage as per section 8 of Act No. 18/1997 Coll.

Institution – an organization operating outside the nuclear power engineering sector

3.1 Low/Intermediate-level Waste Management Prior to Disposal

Before acceptance at a repository, radioactive waste is processed and conditioned to comply with the acceptance criteria for disposal. This radioactive waste is sorted, usually at the place of origin, and its volume is reduced. Equipment for processing radioactive waste includes, for example, evaporators, presses, filters, ion-exchange columns, incinerating plants or remelting devices. Radioactive waste processing includes the transformation of its physical or chemical properties so as to enable safe shipment, storage and disposal; for this reason waste is subjected to cementation, bituminisation or vitrification.

Radioactive waste management prior to disposal is the responsibility of the radioactive waste generator. Currently, only a small number of organizations in the Czech Republic are licensed and have the technical facilities required to process and to treat radioactive waste. Some of them provide this service to other radioactive waste generators. The formation of a viable market in the field of radioactive waste processing and treatment, however, is complicated and profitable to a limited extent only, due especially to the following reasons:

- Minor generators create only small amounts of radioactive waste at irregular intervals;
- The processing and treatment of radioactive waste is very demanding in terms of technology and licensing requirements and the necessary equipment is very expensive.

The method of checking radioactive waste parameters, important in radioactive waste disposal, is approved and subsequently inspected by the SÚJB. The SÚJB also audits quality assurance programs concerning processes (i.e. radioactive waste conditioning for disposal) and products (processed radioactive waste), such audits including inspections of processes employed at processing plants. RAWRA provides for the acceptance of processed radioactive waste for disposal on taking over the waste.

Experience shows that in order to provide for the guaranteed high standard of treatment of radioactive waste for disposal, it would be preferable to coordinate the employment of relevant techniques so making them available to all radioactive waste generators, thereby facilitating the centralised processing and conditioning of radioactive waste for generators outside the energy production sector (small generators) using various methods depending on the character of the radioactive waste (decontamination, fragmentation, concentration, cementation, bituminisation, vitrification). Establishment of such a system would involve commercial interests and the extension of legislation, with the Radioactive Waste Repository Authority providing the coordination role in this system.

The following objectives will be pursued in the medium-term, i. e. 10 – 15 years:

- Coordination and implementation of a research program of radioactive waste management according to stipulated priorities which will focus on advanced techniques for the minimization of the volume of radioactive waste for disposal and on advanced methods of radioactive waste processing and treatment.
- Providing for the safe storage of radioactive waste which cannot be deposited at existing repositories, for the period of time up to its final disposal, including a specification of processing requirements.

3.2 Low/Intermediate-level Waste Disposal

Only waste complying with the relevant acceptability conditions may be disposed of at a repository. The following near-surface repositories have been designed in the Czech Republic

for low/intermediate-level waste: Dukovany, Richard and Bratrství; waste of this type is also disposed of at the closed down repository at Hostim.

3.2.1 Dukovany Repository

The repository at Dukovany was built on the premises of the Dukovany nuclear power plant to accept operating radioactive waste from the power engineering sector. It is the largest and most modern radioactive waste repository in the Czech Republic. Its structure and safety levels are comparable with similar constructions in Western European countries. Leakage of radionuclides into the biosphere is prevented by a complex system of barriers. The repository has been in permanent operation since 1995. The repository's total volume of 55,000 cubic meters (approx. 180,000 drums) is sufficient to accept all the waste from the Dukovany and Temelín nuclear power plants, complying with disposal acceptability conditions, even if their operation is prolonged up to 40 years.

3.2.2 Richard – Litoměřice Repository

The Richard repository was built in a former limestone mine, Richard II (beneath the hill Bídnice). The repository has been used since 1964 to store institutional waste. The total volume of adapted underground chambers exceeds 16,000 cubic meters, waste repository capacity making up about half this volume (the rest being service corridors). Based on knowledge acquired from hydro-geological, engineering-geological, geotechnical and seismic research, building experts' reports and the condition of the packages already disposed of it can be stated that the entire location complies in the long-term with all the requirements for radiation protection and nuclear safety.

3.2.3 Bratrství – Jáchymov Repository

This repository is designed only for waste containing naturally occurring radioactive material. It was adapted from a mining adit in a former uranium mine where five repository chambers with a total volume of almost one thousand cubic meters were built. The repository was put into operation in 1974. The mine is situated in water-bearing crystalline rock hence a drainage system with run-through retention pits was built around the mine. Drainage water is monitored. Detailed safety analysis is being carried out to decide on the future operation of this repository.

3.2.4 Hostim – Beroun Repository

Hostim repository was built in 1959 in the Alcazar limestone mine near the village of Hostim. It was adapted from two chambers driven in 1942-44 for an unknown purpose. The total volume of the two chambers is about 1,600 cubic meters. The repository was used for institutional, low-level and intermediate-level waste generated at the Nuclear Research Institute at Řež and ÚVVVR Prague. The operation of the repository was discontinued in 1965. To provide for the safety of waste deposited there (an additional barrier, prevention of access of unauthorized persons); both repository chambers were filled in 1997 using a special cement mixture. Prior to closure, stocktaking was carried out and all long-lived radiators and chemical waste (Spironovan), which had been provisionally stored there, removed. The total activity of short-lived radionuclides deposited there does not exceed $8x10^{11}$ Bq. A hydrogeological monitoring system was built in 1990-91, which is currently operated by RAWRA, and a network of geodynamic points created to measure movement of the rock massif. Monitoring results demonstrate that the repository is leak-proof and safe.

All repositories, including the closed-down Hostim repository, are operated and monitored by RAWRA in compliance with the relevant permits issued by the SÚJB and in case of mines in compliance with licenses and permits as per mining regulations. Based on the current production of radioactive waste, the capacity of existing repositories is sufficient for several decades (Dukovany repository up to 2100, Richard repository up to 2070, Bratrství repository up to 2030). No new repositories for low/intermediate-level waste are planned; existing repository capacity will be used to the optimum and their enlargement will be considered, if necessary.

3.3 Conceptual Recommendations for Low/Intermediate-level Waste Management

Low/intermediate-level waste complying with acceptability criteria will be deposited in existing repositories with the aim of maximising available capacity. Simultaneously, repository safety documentation will be updated.

For low/intermediate-level waste which cannot be deposited in existing repositories, conditions will be stipulated for its treatment and adequate storage capacity will be reserved or built so that such radioactive waste can be accepted from generators.

To provide for the systemic management of low/intermediate-level waste, the establishment of a collection and processing centre will be supported. Methodology will be determined to assist in decision-making concerning the release of waste into the environment and waste sites will be selected at which waste no longer subject to the Atomic Act can be accepted.

Depending on the results of ongoing safety analysis, a time schedule and technical specifications will be prepared for the final disposal of radioactive waste accepted at the Bratrství and Richard repositories before the Atomic Act was passed.

4 HIGH-LEVEL WASTE AND SPENT NUCLEAR FUEL MANAGEMENT

Intermediate-level long lived waste (and spent nuclear fuel after it is declared as waste) is the most risky category of radioactive waste. The volume of this waste is not high; it makes up less than a tenth of all radioactive waste generated in the Czech Republic. It originates mainly from the operation of energy and research reactors. Because of the higher activity and considerable long-lived radionuclide content this kind of waste is currently expected to be deposited in a deep geological formation. Techniques for the processing of that waste are available and used industrially especially in spent nuclear fuel reprocessing plants (the vitrification technique was developed in the Czech Republic). Repository containers are being designed for the direct disposal of spent nuclear fuel or processed high-level waste and suitable structures and insulation materials are being analysed. The techniques for spent nuclear fuel and high-level waste processing and the production of repository containers and insulation materials will be further developed and final selection made when the geological and hydro-geological conditions at the site of permanent disposal are known.

Currently, spent nuclear fuel from the Dukovany nuclear power plant is stored on the premises of the nuclear power plant itself, fuel from research reactors is stored at the Nuclear Research Institute at Řež. Spent nuclear fuel from the Temelín nuclear power plant will be

stored at a storage facility to be put into operation around 2010, therefore, the location of this storage facility has not yet been decided. Production of the long lived ILW and spent nuclear fuel is summarized in Table 2.

Table 2: Survey of the Production of LILW-LL (post-processing volume) and Spent Nuclear Fuel

Source	LILW-LL Operation (m^3)	LILW-LL Decommissioning (m^3)	SNF (t)
EDU (1985-2025)	50	--	1,937
EDU (2085-2094)	--	2,000	--
ETE (2000-2042)	50	--	1,787
ETE (2090-2095)	--	624	--
Total NPP	**2,724**		**3,724**
Instit. (1958-2000)	80	5	0.2
Instit. (2000-2050)	150	50	0.3
Total institutions	**285**		**0.5**

Note: Data in the table excludes new nuclear sources, if any, and waste generated in case spent nuclear fuel should be reprocessed. Spent nuclear fuel from the FJFI ČVUT university reactor is included under "institutions".

4.1 High-Level Waste and Spent Nuclear Fuel Management Prior to Disposal

4.1.1 Storage and Shipment

According to the Atomic Act, the storage and shipment of spent nuclear fuel and high-level waste is the responsibility of generators. After being removed from the reactor, nuclear fuel is stored for a minimum of five years in the main reactor unit pool in the reactor hall after which it is placed in dry storage and kept in specially designed storage containers, at the Nuclear Research Institute at Řež in pool storage. Such storage techniques are straight forward and well-known. Spent nuclear fuel storage with a capacity of 600 tonnes has been in operation at the Dukovany nuclear power plant since 1995. This storage capacity will be exhausted by 2005, hence preparation for the construction of a new storage facility with a capacity adequate for the forecasted production of spent nuclear fuel at the Dukovany NPP has begun. In compliance with Czech Government Decree No. 121/97, preparation consists of two variants; the recommended variant involves the construction of separate storage at the NPP itself, the reserve variant involves the construction of a central underground storage facility at Skalka. Following the Ministry of the Environment's positive reaction to EIA documentation and the SÚJB's decision on the construction location, permission was granted for the construction of storage facilities at the Dukovany NPP site. Operation of a storage facility for spent nuclear fuel from the Temelín NPP will commence around 2010.

Currently, high-level waste is stored at the place of origin. In other parts of the world where large volumes of high-level waste are generated, similar storage techniques are used to those used for the storage of spent nuclear fuel. Storage of this type is not planned in the Czech Republic.

Storage is a preliminary step towards further follow-up operations. The usual time period for spent nuclear fuel storage prior to disposal is several decades and current developments suggest a further prolongation of that time period. The condition of storage containers is

continuously checked and assessed. The behaviour of spent nuclear fuel during storage has been verified by long-term experiments.

Thick-wall transport containers are used for the shipment of spent nuclear fuel and high-level waste. These containers can dissipate decay heat and reduce emissions of radiation to below permitted levels. Dual-purpose, transport-storage containers are used in the Czech Republic.

All Czech nuclear reactor operators are familiar with and have long experience in both the storage and shipment of high-level waste and spent nuclear fuel.

4.1.2 High-Level Waste and Spent Nuclear Fuel Processing for Direct Disposal

Liquid high-level waste is fixed by vitrification, whereas solid waste is fragmented and fixed by cement, although waste might be deposited without processing. These techniques are used throughout the industry.

In compliance with international practice, spent nuclear fuel is expected to be placed in repository containers made probably of high-grade steel, other stainless materials or a combination of such materials, before such waste is deposited in a deep geological repository either in the original form or with disassembled structural components not containing fuel material. The structural design of repository containers differs from that of transport-storage containers since repository containers must provide for the long-term nature of radionuclides contained in spent nuclear fuel. Repository containers have already been designed and manufactured as prototypes in certain foreign countries, in the Czech Republic the specific design of the container is under development.

4.1.3 Spent Nuclear Fuel Reprocessing and Transmutation

Before disposal, spent nuclear fuel can be reprocessed with the aim of reclaiming the fissile materials contained in it (Pu and U) or obtaining certain valuable radionuclides. Such uranium and plutonium can be recycled and used in the production of new fuel – either uranium fuel or fuel mixture (so-called MOX) containing uranium and plutonium oxides. Since Czech energy reactors operate on the so-called one through fuel cycle, fuel containing recycled materials is not used. The use of MOX fuel involves a complex approval process, and due to various physical reasons, the number of recycling processes is usually limited to three. The reprocessing technique is widely used in industry and available on the world market (Russia, France, and the United Kingdom). When spent nuclear fuel is reprocessed abroad, the resulting high-level waste is returned to the generator in a vitrified form in thin-wall containers made of high-grade metal (low-level and intermediate-level waste resulting from reprocessing is not necessarily returned to the generator).

Spent nuclear fuel reprocessing techniques are continually being improved with the aim of separating and subsequently disposing of higher transuranics (Am, Cm) and long-lived fission products. Consequently the transmutation (nuclear transformation) of isolated nuclides is the subject of extensive research which could ultimately lead to the further generation of energy. The ideal objective of transmutation is to achieve the nuclear transformation of all the long-lived radionuclides contained in spent nuclear fuel. Transmutation is currently at the basic or semi-operational research stage. The eventual outcome of this research is still unclear. On the

other hand, the safe storage of spent nuclear fuel provides enough time for both the development of a deep geological repository and transmutation. In any case, in view of the various forms of high-level waste, a deep geological repository has to be considered, although requirements in terms of location, the environment and technology will be considerably simplified should transmutation be successfully developed.

Czech research institutions are involved in the development of transmutation.

4.2 High-level Waste and Spent Nuclear Fuel Disposal

International opinion considers the disposal of high-level waste and spent nuclear fuel in a deep geological repository as the most realistic option for disposal. The objective of the deep geological disposal of high-level waste or spent nuclear fuel is to provide for the permanent isolation of such materials from the environment without the intention of later removal. The principle of the deep geological repository is based on passive safety (i.e. no further human supervision). The repository system consists of a number of barriers, i.e. a combination of engineering (artificial) and natural (geological) barriers.

Several factors support the use of deep geological repositories:

- Feasibility – a deep geological repository can be built using existing or modified technology;
- Safety – after decades of intensive research, detailed assessment methods are available (deterministic and probability models, study of natural analogues);
- Demonstrability – research programs using results obtained in underground laboratories confirm the suitability of the technology to be used and the feasibility of calculations and safety assessments;
- The putting into operation of WIPP, USA – a deep geological repository designed for long-lived low/intermediate-level waste; licensing authorities accepted the safety evidence of the repository for a period of 10,000 years; this is practically an intermediate stage for the disposal of high-level waste and spent nuclear fuel.

Internationally, magmatites (especially granitoids and basaltoids, as well as ultra basics have been studied), clay formations, salts (layered salt formations) and tuffitic rocks have been examined as host environments for a deep geological repository. The potential construction of a deep geological repository as well as its safety has been verified in all these rock environments.

It is expected that a deep geological repository in the Czech Republic will be built in granitic rocks. About thirty areas have been selected in the Czech Republic based on pre-existing geological data.

It is expected that the repository will accept all the radioactive waste that cannot be deposited in near-surface repositories, spent nuclear fuel after it is declared as waste, high-level waste from the decommissioning of nuclear power plants, alternatively high-level waste from the reprocessing of spent nuclear fuel from the Dukovany and Temelín NPPs, or high-level waste or spent nuclear fuel from other nuclear sources.

The preparation phase for the construction of a deep geological repository in the Czech Republic will be divided into four stages:

- The selection of candidate sites and the structure of engineered barriers for the deep geological repository;
- Development of relevant documentation, analysis and approval of the proposed sites by authorities
- Selection of the final site and a corresponding choice of engineered barriers;
- Confirmation of the deep geological repository's safety using safety analysis.

The project for the building and operation of a deep geological repository will be carried out in modules, i.e. consideration of the potential construction of new nuclear sources, the need for the continual construction of repositories for spent nuclear fuel and high-level waste as well as a location for the disposal of other than high-level waste will be taken into account. It is expected that the deep geological repository will be put into operation after 2065.

4.3 Options for High-level Waste and Spent Nuclear Fuel Management

The options proposed for the management of high-level waste and spent nuclear fuel are based on international experience and developments and on practical knowledge acquired over the past few decades during the development of a deep geological repository in the Czech Republic and are set out as a basis for SEA. Projects for disposing of high-level waste and spent nuclear fuel beneath the sea bed or in space are unrealistic, therefore, not included in the option for high-level waste and spent nuclear fuel management.

a) Permanent Storage (Zero Option)

The permanent storage of high-level waste and spent nuclear fuel would require permanent supervision at storage facilities and the continual replacement of basic storage and supporting systems components. The only advantage lies in the availability of spent nuclear fuel for future energy use, on the other hand, however, such availability considerably increases the risk of the misuse of fissile materials. The potential misuse of fissile materials considerably increases with storage time, as the radiation risk associated with spent nuclear fuel handling considerably decreases. The cost of permanent storage cannot be estimated, it can only be expected that it considerably exceed the cost of permanent disposal or any of the other disposal methods considered here. Storage could also become the subject of various forms of political blackmail.

Certain countries support the idea of the retrievability of disposed of high-level waste and spent nuclear fuel for a limited period of time (usually hundreds of years). This solution is based on the assumption of a future general lack of energy sources and considerably simplified spent nuclear fuel handling due, as already mentioned, to the considerable decrease in radioactivity and residual heat associated with prolonged storage.

The permanent storage of high-level waste and spent nuclear fuel is rejected as unrealistic.

b) Spent Nuclear Fuel Reprocessing/Transmutation and Disposal of Waste in a Deep

Geological Repository

The use of recycling techniques is justified if the economic return and safety issues can be proven. Current prices relating to the fuel cycle front end, especially the price of natural uranium, make spent nuclear fuel reprocessing un-economical. From the safety point of view, reprocessing does not considerably increase radiation risk, but from the point of view of final disposal, reprocessing or the treatment of radioactive waste from reprocessing allow the separation of long-lived and dangerous radionuclides and, consequently, provide the optimum conditions for final disposal. Current technology does not remove certain resulting uranium and plutonium isotopes and provides for only three reprocessing cycles; consequently, spent nuclear fuel has to be disposed of directly in a deep geological repository. If the isolated fissile materials are not then used for the production of nuclear fuel, they have to be stored and, in the case of plutonium, cleaned after about ten years of storage before re-use. The cleaning process is technically identical to the plutonium section in a reprocessing plant. Countries operating reprocessing plants promote their advantage; on the other hand the great nuclear powers demand that reprocessing be stopped because of the considerable risk of misuse of separated plutonium. Generally, the global trend is to abandon reprocessing; European countries that have reprocessing contracts with France or the United Kingdom are looking at ways of terminating such contracts.

Transmutation techniques have not yet been perfected and development remains at the theoretical and experimental level. However, transmutation is receiving widespread international support, being included, for example in the fifth general EU program for science and research.

The implementation of the thorium nuclear fuel cycle is being considered on the same level as transmutation. The advantage of the thorium fuel cycle is that the resulting spent nuclear fuel does not contain plutonium or other transuranics.

c) International Repositories

Recently, the idea of building an international (regional) repository has been put forward; this option, however, presents numerous technical, economic and, above all, legislative and political problems (most countries prohibit the disposal of foreign radioactive waste within their borders). This option would most probably not provide for the disposal of long-lived, intermediate-level and high-level waste generated other than from the reprocessing of spent nuclear fuel. The establishment of an international deep geological repository is dependent on international consent, a functioning system of guarantees, and state and local consent; whether such consent, even though contractually agreed, would be valid in the long-term is questionable.

Radiation risks associated with the transportation of spent nuclear fuel are not significant; the issue of spent nuclear fuel processing for disposal has not been solved (though it would probably be carried out in the country of origin).

Several associations have been established internationally to study the option of building an international repository, the idea is supported to a certain extent by international organizations (IAEA, EC).

d) National Deep Geological Repository

High-level waste and spent nuclear fuel disposal not involving reprocessing is the easiest solution and can be utilised by any country without having to master the special techniques of spent nuclear fuel reprocessing. The disadvantage of the direct disposal of spent nuclear fuel is the loss of materials that might be used for the further generation of energy.

The feasibility operation and long-term safety of a deep geological repository have been demonstrated for several rock environments (salt, clay, granite). The development of a deep geological repository is still subject to intensive scientific research and development, frequently as part of extensive supranational projects. The first deep geological repositories are expected to be put into operation between 2010 and 2020 (the USA, Finland, Sweden, Germany).

4.4 Conceptual Recommendations for High-level Waste and Spent Nuclear Fuel Management

Any final decision concerning the options for high-level waste and spent nuclear fuel management depends on the feasibility of establishing a deep geological repository in the Czech Republic. Hence, the program for the development of a deep geological repository will continue with the selection and confirmation of the suitability of the final location and the design of the whole repository system. Therefore, storage of spent nuclear fuel and high-level waste should be provided for until the deep geological repository is put into operation.

The option of high-level waste and spent nuclear fuel disposal in an international regional repository has not been excluded, although, for the time being it remains unrealistic. However, should such a project became feasible at a future date, the knowledge acquired in the development of a deep geological repository in the Czech Republic would prove invaluable in the construction of a regional repository.

Advanced separation methods of spent nuclear fuel processing make it possible to dispose of or utilise minority actinides (e.g. by their transformation in new types of reactors). By so doing, usable energy can be generated, thereby realising the energy potential of spent nuclear fuel. Studies of such methods will be financially and scientifically supported.

5 ECONOMIC ASPECTS

In compliance with internationally acknowledged principles, the Atomic Act states that the radioactive waste generator shall bear all the costs of radioactive waste management from the production to disposal of such waste, including the cost of monitoring repositories after their closure and the cost of the required research and development. The processing of radioactive waste for disposal is paid for by the generator in the form of direct payments to specialist organizations which carry out such activities on the generator’s behalf. Radioactive waste disposal and spent nuclear fuel processing and disposal are the responsibility of RAWRA; the generator pays for these services in the form of payments to the nuclear account.

5.1 Nuclear Account

The nuclear account is controlled by the government and nuclear account funds may only be used through RAWRA for tasks specified in the Atomic Act. Nuclear account funds come from several different sources, including:

- One-off payments or payments in instalments made by radioactive waste generators based on an assessment of services provided for radioactive waste disposal or spent nuclear fuel processing and disposal;
- Revenue from the investment of free funds from the nuclear account on the financial market under conditions stipulated by the Atomic Act and under the supervision of the Ministry of Finance;
- Interest accrued on the nuclear account;
- Payments from the state budget to cover the cost of management of radioactive waste deposited as per regulations in force prior to the Atomic Act;
- State funding for the disposal of radioactive waste found in the Czech Republic for which no generators can be identified;
- Paid services provided by RAWRA, grants and payments from abroad (IAEA, EU projects).

The distribution of nuclear account funds and amounts and methods of payment are stipulated by certain government decrees. RAWRA administers payments to the nuclear account and prepares documentation on the level of payments.

A large proportion of nuclear account funds aims to cover the cost of activities to be carried out over a number of decades. Therefore, the methodology for determining the level of payments takes into account estimates of future costs, risks and other relevant factors (e.g. the condition and development of the national economy) and respects the concept of radioactive waste and spent nuclear fuel management. The creation of nuclear account funds will be compared at regular intervals (five years) with current requirements and, in case of material discrepancies, a government decree will be issued which will modify the level of payments.

5.2 Cost of Waste Disposal in Near-Surface Repositories

The costs of operation and closure of existing repositories will be covered by nuclear account funds. Individual generators of radioactive waste deposited will pay into the nuclear account depending on the character and amount of waste being deposited. The level of payments required to cover these costs will be determined according to relevant methodology and made in compliance with current government decree either in the form of one-off payments or regular instalments.

Radioactive waste repositories have been in operation for several decades, during which time no reserves were created for future high expenditure items (especially the decommissioning and closure of repositories). Therefore the state will allocate funds for the management of radioactive waste deposited prior to the Atomic Act. The state's commitment consists primarily of the following:

- Maintenance of repositories and repair of technologies
- Monitoring of the impact on the environment during and after the operation of repositories;

- Decommissioning of repositories – sealing of repository chambers and closure of repositories;
- Research and development work.

According to preliminary economic analysis, the future financial participation of the state has been calculated as CZK 250 million (at 1999 prices).

The operational costs of low-level and intermediate-level waste repositories (Dukovany, Richard, Bratrství) do not exceed CZK 25 million p.a. This expenditure covers primarily repository activities and the maintenance of land, buildings, equipment, and geological facilities (Richard and Bratrství) and provides for radiation protection, security, fire and technical safety, emergency preparation and monitoring of the environment.

An estimate of the cost of short-lived, low/intermediate-level waste disposal in the period up to 2100 is summarized in Table 3 (system discounted cost as at 2000, CZK millions):

Table 3: Summary of the Cost of Low/Intermediate-Level Waste Disposal

Capital expenditure *	423
Repository operation	1,210
Institutional supervision	12

* Including the cost of acquiring repository capacity and closure of repositories

5.3 Cost of High-Level Waste and Spent Nuclear Fuel Disposal

The costs of design, construction, operation and closure of a deep geological repository as well as the cost of spent nuclear fuel processing into a form suitable for disposal and that of high-level waste or spent nuclear fuel disposal itself will be settled by direct one-off payments or in regular instalments from high-level waste or spent nuclear fuel generators.

Basic technical and economic data used in the assessment of the deep geological repository option was acquired from the Deep Geological Repository Reference Project. Estimated costs are summarised in Table 4 (CZK millions at 1999 prices):

Table 4: Summary of the Cost of High-Level Waste and Spent Nuclear Fuel Disposal CZK millions, 1999)

Research and development	5,240
Public relations, legislation	200
Design support and studies	620
Total building cost	17,517
Operation	23,065
Closure	300
TOTAL COST	46,942

According to NEA/OECD[5] data, the total cost corresponds to estimates made for similar

[5] The Cost of High-Level Waste Disposal in Geological Repositories, NEA/OECD, Paris, 1993

projects in others countries. Due to the high ratio of fixed costs in the total cost of a deep geological repository however, the unit price (applied to one tonne of deposited spent nuclear fuel) is relatively high. For the currently proposed project for a deep geological repository the cost of disposal ranges from 10000 to 12000 CZK/kg of heavy metal depending on the amount of spent fuel created and economic development. If higher quantities of radioactive waste (e.g. from the operation of a new nuclear source) are deposited, the nominal unit cost of disposal will decrease. The costs of alternative methods of spent nuclear fuel disposal (e.g. spent nuclear fuel reprocessing and disposal of vitrified high-level waste) are currently higher. They range from 800 to 1200 USD/kg of heavy metal. In the case of the closed fuel cycle the cost of other items such as storage of high level waste and different storage containers must be included.

Since a considerable portion of the above costs will be incurred in the long-term, the appreciation of free funds on the nuclear account and inflation play an important part in the creation of nuclear account resources and the determination of the level of payments.

5.4 Provisions for Decommissioning

According to Article 18, Paragraph 1h), of the Atomic Act, licensees are obliged to make financial provision for decommissioning nuclear facilities or workplaces with significant or very significant sources of ionising radiation. Funds should be available both for the preparation for decommissioning and decommissioning proper at the required time and in an amount commensurate with the proposed method of decommissioning as approved by the SÚJB. Such financial provisions are tax-deductible and are maintained by respective licensees. The estimated cost of decommissioning is verified by RAWRA and licensees are obliged to update their estimates every five years. A summary of provisions for decommissioning is given in the table below (CZK millions at 1998 prices):

Table 5: Summary of the Cost of Decommissioning

Provision for Dukovany NPP decommissioning	12,520
Provision for Temelín NPP decommissioning	11,120
Provision for SNF intermediate storage decommissioning	*50
Other provisions for decommissioning	*500

* estimates

6 SPECIFICATIONS OF THE CONCEPT'S AIMS

6.1 Tools for Concept Implementation

The Concept defines in the area of radioactive waste management and spent nuclear fuel in the period up to 2015 the following aims:

1. In the area of low-level and intermediate-level waste management, to ensure the safe operation of current repositories.
2. In the area of spent fuel management, to ensure building of storage facilities and their safe operation.
3. In the area of high-level waste management, to begin intensive preparation for a deep

geological repository. Realisation of a deep geological repository is a necessity for the continuation of operation of nuclear power plants. In parallel, other approaches to high level waste management will be followed i.e. reprocessing and transmutation. In all cases the technical feasibility and economic aspects will be considered. Reprocessing technology will also be assessed on the basis of material resources availability.

4. While increasing the level of safety in radioactive waste disposal, attention will be focused on the technological processing of radioactive waste and strengthening disposal containers.

Suitable conditions should be created in which the Concept's conclusions and recommendations can be successfully integrated into the radioactive waste management system in the Czech Republic. These conditions include:

- Confirmation of the organizational framework for radioactive waste management – the Concept is to be put into operation and its implementation directly controlled by the Czech Ministry of Industry and Trade with the support of other government institutions; the professional sponsor is RAWRA supported by universities, and research and engineering organizations;
- Providing for financing – the source of finance is the nuclear account, the rules for the creation thereof are already established; the government will participate by financing certain activities arising from its previous commitments and the Atomic Act;
- Providing for professional expertise and research facilities – the basic research framework is already in place. It should be further developed and, simultaneously, its knowledge base deepened and the system supplemented by the involvement of academically qualified experts; it is also advisable to support the foreign training of specialists or participation in international programs;
- Involving the public – the public will be informed about significant activities in radioactive waste and spent nuclear fuel management in compliance with legislation, the systematic mutual exchange of information and opinions will be encouraged;
- Supporting international cooperation – foreign contacts help to verify whether the best methods are being employed, provide access to the most up to date techniques and information and reduce the cost of technically complex projects; foreign cooperation can take the form of participating in the activities of international institutions (IAEA, EU, NEA/OECD), regional cooperation (Central European countries) or bilateral contacts (national waste agencies and research and engineering organizations).

6.2 Concept Implementation

The Concept sets out the basic aims and the direction of the development of the radioactive waste and spent nuclear fuel management system. The evaluation of aims of the Concept is expected around 2010. An assessment of the progress made in the development of a deep geological repository or in the case of major changes, which would considerably affect implementation of the Concept. Crucial for implementation of the Concept is a speedy verification of the feasibility of a deep geological repository in the Czech Republic (i.e. to identify and confirm a suitable site) or a demonstration that transmutation or spent nuclear fuel recycling has been successfully developed.

The following specific targets are set out below so as to provide a framework for fulfilling the aims of the Concept:

a) Legislation

Target	Date
To harmonize the Atomic Act and related regulations concerning radioactive waste management with EU legislation	2002

b) Low/Intermediate-Level Waste Management

Target	Date
To operate existing near-surface repositories in compliance with requirements for radiation protection and relevant licenses issued by the SÚJB and CMO	continually
Coordination and implementation of a research program on minimisation of radioactive waste arisings and development of new methods for radioactive waste processing	continually
Preparation of schedule for final closure of parts of repositories Richard and Bratrství with radioactive waste disposed of before the Atomic Act came into force	2003
To create the necessary conditions for operation of the system of central processing of radioactive waste for generators from outside the nuclear power engineering sector (small generators) supervised by RAWRA	2003
To allocate or build storage capacity for radioactive waste that cannot be accepted at existing near-surface repositories	2004

c) High-Level Waste and Spent Nuclear Fuel Management

Target	Date
To construct a spent nuclear fuel storage facility as per Government Decree No. 121/1997 and Government Decree No. 695/2001	2005 and ongoing
To support and coordinate the involvement of research institutions in the development of new techniques for spent nuclear fuel reprocessing and transmutation and use all the available technologies for lowering the risk of high level waste and spent fuel	continually
To select sites with proper geological conditions taking into account local developments at proposed sites. After evaluation of relevant results include two sites into land use plans (main and reserve one) for deep geological repository	2015
On the basis of geological work performed and complex data analysis confirm the suitability of one site for a geological repository	2025
To prepare the necessary documentation for construction of an underground research laboratory and performance of long term experiments for confirmation of safety of deep geological repository	2030
Operation of deep geological repository	2065

d) Economic Aspects

Target	Date
To assess the creation and distribution of nuclear account funds, and if necessary, amend the government decree concerning payments to the nuclear account with the intention to maintain a long-term, stable and adequate balance of the nuclear account	continually
To provide for the valorisation of free financial resources of the nuclear account in compliance with the Atomic Act	permanently
To check, on a regular basis, the creation of funds for decommissioning nuclear facilities so as to provide for sufficient future financial resources	continually

e) Other

Target	Date
To systematically inform the public about issues concerning radioactive waste management (information centres, brochures, internet, etc.)	permanently
To provide independent scientific and technical support for RAWRA's Board to facilitate evaluation of work carried out as part of the deep geological repository development programme	2002

7 RISK OF THE PROPOSED CONCEPT

The reaching of the aforementioned targets depends on whether assumptions made in the Concept remain valid. There are factors, however, which could impede or even scupper the Concept's aims:

- The shortening of the operational life of nuclear power plants and, consequently the failure to create sufficient funds to cover the cost of spent nuclear fuel processing and the disposal of radioactive waste from the decommissioning of nuclear power plants;
- Material changes in prevailing economic conditions resulting in a depreciation of nuclear account funds with effects similar to the above;
- The failure to identify a suitable location for a deep geological repository (safety, technical obstacles, public resistance) and the need to find another technical solution;
- Material changes in the organizational structure of the radioactive waste management system resulting in its inability to function efficiently.

To reduce such risks and the probability of their occurring, it is necessary to monitor and analyze on a continual basis all the factors affecting the achievement of the aims of the Concept and if necessary, take timely preventative and corrective measures.

List of Abbreviations

Czech	English	
ČBÚ	CMO	Czech Mining Office
EDU, ET	EDU, ETE	Dukovany, Temelín Nuclear Power Plants
EU, EC	EU, EC	European Union, European Commission
HIC	HIC	High Integrity Container
HÚ	GR	deep geological repository (usually at least 300 meters below the surface)
JZ	NF	nuclear facility
MAAE	IAEA	International Atomic Energy Agency
MF ČR	MF CR	Czech Ministry of Finance
MPO ČR	MIT CR	Czech Ministry of Industry and Trade
MŽP ČR	ME CR	Czech Ministry of the Environment
NAO	LLW	low-level waste
NORM	NORM	Naturally Occurring Radioactive Material
RAO	RW	radioactive waste
SAO	ILW	intermediate-level waste
SEA	SEA	Strategic Environmental Assessment
SÚJB	SÚJB	State Office for Nuclear Safety
SÚRAO	RAWRA	Radioactive Waste Repository Authority
ÚRAO	RWR	radioactive waste repository
VAO	HLW	high-level waste
VJP	SNF	spent nuclear fuel
VNAO	VLLW	very low-level waste
EDU	DNPP	Dukovany nuclear power plant
ETE	TNPP	Temelín nuclear power plant
JE	NPP	nuclear power plant