NUCLEAR WASTE MANAGEMENT ORGANIZATION
SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

August 2004

NWMO BACKGROUND PAPERS
7. INSTITUTIONS AND GOVERNANCE

7-12 EDUCATION AND TRAINING IN NUCLEAR WASTE MANAGEMENT

ITC School of Underground Waste Storage and Disposal

NWMO Background Papers

NWMO has commissioned a series of background papers which present concepts and contextual information about the state of our knowledge on important topics related to the management of radioactive waste. The intent of these background papers is to provide input to defining possible approaches for the long-term management of used nuclear fuel and to contribute to an informed dialogue with the public and other stakeholders. The papers currently available are posted on NWMO's web site. Additional papers may be commissioned.

The topics of the background papers can be classified under the following broad headings:

1. **Guiding Concepts –** describe key concepts which can help guide an informed dialogue with the public and other stakeholders on the topic of radioactive waste management. They include perspectives on risk, security, the precautionary approach, adaptive management, traditional knowledge and sustainable development.
2. **Social and Ethical Dimensions** - provide perspectives on the social and ethical dimensions of radioactive waste management. They include background papers prepared for roundtable discussions.
3. **Health and Safety –** provide information on the status of relevant research, technologies, standards and procedures to reduce radiation and security risk associated with radioactive waste management.
4. **Science and Environment –** provide information on the current status of relevant research on ecosystem processes and environmental management issues. They include descriptions of the current efforts, as well as the status of research into our understanding of the biosphere and geosphere.
5. **Economic Factors** - provide insight into the economic factors and financial requirements for the long-term management of used nuclear fuel.
6. **Technical Methods** - provide general descriptions of the three methods for the long-term management of used nuclear fuel as defined in the NFWA, as well as other possible methods and related system requirements.
7. **Institutions and Governance** - outline the current relevant legal, administrative and institutional requirements that may be applicable to the long-term management of spent nuclear fuel in Canada, including legislation, regulations, guidelines, protocols, directives, policies and procedures of various jurisdictions.

Education and Training in Nuclear Waste Management

Survey of the Status of International Training and

Capacity Building Programmes

For

The Nuclear Waste Management Organization (NWMO),

Canada

August 2004

ITC

School of Underground Waste Storage and Disposal

ITC School of Underground Waste Storage and Disposal
www.itc-school.org

The ITC School of Underground Waste Storage and Disposal is a non-profit Association with broad membership, based in Switzerland. The aim of the international School is to propagate knowledge to future generations of scientists, engineers and decision-makers who will be involved in managing or evaluating projects aimed at storing or disposing of hazardous wastes in underground facilities. The School provides both theoretical and practical training and research in all aspects of science, engineering, decision-making and communication concerned with underground waste management and related environmental issues. It is linked directly to active underground experimental facilities, in particular, the Grimsel Test Site. It is able to provide professional training at all levels, ranging from academic courses and modules in association with universities around the world, to summer schools and retreat facilities for think-tanks and policymakers. The ITC is independent of any sector and provides educational services to industry, regulatory agencies, academia and government bodies. Membership of the association is open to any organization supporting its educational aims. The Association was founded in April 2003 and currently has a membership of more than 40 organisations world-wide that are committed to the objective of ensuring that training facilities are provided for the future. This survey was undertaken by the ITC at the behest of the Nuclear Waste Management Organization (NWMO) of Canada

Contents

1. Background

Radioactive waste management is only one facet of the nuclear sector and its need to educate, train and propagate knowledge. We thus begin by looking at the broader situation within the whole nuclear energy industry.

There has been growing concern worldwide that it might be difficult to maintain sufficient number of qualified experts to assure the sustainable utilisation of nuclear power into the future. Although there have been remarkable development in terms of the number of students enrolling nuclear engineering in some countries in recent years, nuclear education at universities has deteriorated in many countries. This general trend is due to decades of stagnation of the industry and the poor image that nuclear energy has had in some countries. Consequently, insufficient students are entering such programmes, raising concerns about the continuity of knowledge, experience and technology. Establishing a long-term programme and supporting the educational resources and infrastructures are generally seen as being the primary responsibilities of government, with industry supporting educational institutions in partnership with government.

If the infrastructure for nuclear education is not maintained, there will be a continued decrease in knowledge and expertise, and thus in capability to respond to new challenges. The lead time in developing replacement educational opportunities is very long, as most institutions will require some prospect for the number of potential students before investing resources, and potential students may look elsewhere in the absence of an attractive research programme and a growing career field. Once lost, it would require a vast input of resources to replace, on the scale of what was done to establish the infrastructure in the first place, when nuclear technology was new.

The following statements from the International Atomic Energy Agency (IAEA) and the Nuclear Energy Agency of OECD (OECD/NEA) clearly indicate the nature of worldwide concern described above.

"In recent years, funding for long term strategic activities such as research and development, preserving corporate knowledge and maintaining technical expertise has been reduced in many countries. Industry funding by the designers and operators has been reduced as a result of the belief that the research needed for the initial design of plants has been completed, a lack of commitment to build new plants, the effects of deregulation and a highly competitive market place, and a preoccupation with short term

profitability research. Government funding has been reduced as a result of scepticism in some governments and among parts of the public about nuclear power as a sustainable source of energy and the belief by some governments that the nuclear industry, as a user of a maturing technology, should be the primary source of research and development funding in the future. Because of the poor image that nuclear energy has had in some countries, teaching in nuclear technology and nuclear safety at universities has also diminished considerably. It follows that new researchers are not entering such programmes, raising concerns about the continuity of knowledge even in universities." (IAEA 2003a)

"There is a concern raised by NEA Member countries that nuclear education and training is decreasing, perhaps to problematic levels. Many diverse technologies, currently serving nations worldwide, would be affected by an inadequate number of future nuclear scientists and engineers. Mankind now enjoys many benefits from nuclear-related technologies. For example, advances in health care and medicine are increasingly dependent upon expertise in nuclear physics and engineering. The fabrication of advanced materials from components the size of computer chips to the largest construction equipment is dependent on knowledge that stems from the nuclear industry. Nuclear technology is widespread and multidisciplinary: nuclear and reactor physics, thermal hydraulics and mechanics, materials science, chemistry, health *science, information technology and a variety of other areas."* (OECD/NEA 2000)

There is a growing need for long-term solutions for the management of the especially toxic wastes from society. The last thirty years has already seen an enormous change in the way that we treat these materials. Every country is moving towards progressively more rigorous controls - a trend that is likely to continue and spread over the next few decades. Growing environmental awareness has led to this increased stringency, but at the same time it has made people more personally aware of the potential hazards of toxic wastes, and suspicious of waste management facilities. As a result, it is becoming harder to implement real solutions. Everyone acknowledges that something needs to be done, but there is often paralysis in decision-making, owing to the difficulties of achieving technical consensus and social endorsement of any specific proposal.

Underground storage and disposal of toxic chemical wastes and radioactive wastes is the focal point of these problems (the NWMO's study of approaches for long-term management of nuclear fuel waste includes above-ground storage). Whilst carefully engineered solutions for these wastes are being put into operation slowly in some countries (and, indeed, have been used for many years in a few), others are having real problems in moving forward. In the midst of this, the scientific and engineering communities must maintain the expertise to develop, improve and optimise solutions and to present them to society. Because there are frequently discontinuities in programmes as a result of seemingly unavoidable temporising by decision makers and the agencies concerned, it has been difficult in many countries to maintain expertise.

Regardless of the option finally chosen, safe and secure long-term management of radioactive and toxic wastes is a multidisciplinary activity. Researching and developing solutions requires the involvement of teams of experts in a diversity of disciplines: structural, nuclear and chemical engineering, geosciences, mathematics, physics, biological and health sciences being central. . There is also an important requirement for non-technical, social, ethical and political considerations to underpin realistic practical programmes. Project development and implementation teams must be able to communicate easily with the full spectrum of stakeholders, decision makers, the media and local communities.

Taking geological disposal for an example, considerable resources have been invested to demonstrate the fundamental feasibility of site selection and construction of radioactive waste repositories to date. In most cases, such repositories will not be operational before the middle of this century and their operations and final closure may stretch into the next century. Such a time perspective is unprecedented in the modern world and requires robust programmes, structured to transfer the vast inventories of knowledge and experience accumulated by today’s planners to their successors, who will make the key decisions. Equally important, the concepts, methods and tools that are currently state-of-the-art must be continuously updated in response to advances in science and technology and to requirements of the society.

It may be beyond the abilities of any national structure independently to maintain and enhance really broad-based knowledge. Owing to programme delays, some countries have already seen a decline in once comprehensive technical capabilities. Working together, programmes that are more active can help those that might be suffering temporary set-backs. Over a few decades, expertise will thus not only be preserved but also improved. This is a sensible plea for international cooperation, but the basic needs for T&E in this area arise at the national level.

2. Introduction

2.1 Objective

The Nuclear Waste Management Organization (NWMO) was established under the Nuclear Fuel Waste Act (NFWA) to investigate approaches for managing Canada's used nuclear fuel. The review of different management options involves diverse issues ranging from the identification of societal, ethical and community implications, to specific issues of safety and security in transportation and storage of used nuclear fuel. As is clear from the background review presented above, a key issue amongst those defined by the NWMO is that of training and capacity building in radioactive waste management (RWM). The NWMO thus decided to commission the preparation of a survey of national and international training and capacity building programmes related to high-level radioactive waste management (HLRWM).

The survey was conducted by the ITC (School of Underground Waste Storage and Disposal) to review the current status of training and capacity-building programmes related to the technical, economic, environmental, social and ethical aspects of HLRWM in the world. The review draws upon the recent NWMO Discussion Document 1 ("Asking the Right Questions") in identifying specific areas where training and capacity building may be needed, and includes a review of national and international training and capacity building programmes in the following areas specified by the NWMO:

- legal, administrative and regulatory aspects
- policy development and institutional oversight
- public, community and societal participation
- financing issues and economic analysis
- development and implementation plans for the long-term HLRWM
- mechanisms for considering alternatives and undertaking research
- definition and categorisation of wastes
- specific technical methods and related system requirements including storage, reprocessing, disposal, transportation and site selection
- other aspects.

2.2 Scope and Approach

We have focused the national reviews on those countries with the most developed waste management programmes, obtaining our information on their governmental industrial and academic training and capacity-building programmes from published and web sources. Given the limitations of quality/quantity of information and the language barrier, it has not been possible to access sufficiently comprehensive information from all countries and there thus remain 'blanks' in the tabulated results. The countries we have assessed are shown in the Table below.

Argentina	Germany	Switzerland
Belgium	Hungary	United Kingdom
Canada	Japan	United States
Finland	Spain	China*
France	Sweden	Russia*

*(*only limited references are listed for these countries)*

We have also looked at training and capacity-building initiatives within the relevant international organisations, as follows:

- European Union (EU)
- International Atomic Energy Agency (IAEA)
- ITC School of Underground Waste Storage & Disposal (ITC)
- OECD Nuclear Energy Agency (NEA)
- World Nuclear University (WNU)

The review looks at both directly 'nuclear' related technical training and capacity building programmes in the radioactive waste management sector and at peripheral areas which have broader applications (e.g. in the environment, law and social analysis). Clearly, these latter areas have the potential to extend the review far beyond its aims and we have thus been selective in the activities we report here – focusing on activities, which have real, intentional links with RWM issues.

Under each area specified by the NWMO the primary findings are presented in Section 3 in the following order.

- overview of the area
- examples of international programmes

- country specific examples in nuclear safety perspective
- examples of academic programmes.

As the level of detail of data sources varies, the following working criteria were adopted to select examples, in order to maintain the review at an appropriate level:

- higher weight was given to information obtained directly from IAEA, OECD/NEA, EU sources
- higher weight was given to information obtained directly from governmental organisation sources
- moderate weight was given to information from sources linked directly with the above
- moderate weight was given to information from other sources.

With the immense amount of information on training and capacity building courses on websites, the linguistic quality, technical quality and actual records of given courses, access numbers, up-dating frequency as well as number of links to other sites were assessed wherever possible. Supporting information and references are appended at the end of the report. Country specific information packages in tabular form are presented first followed by data on international organizations (Data Tables). The standard structure of the tables is as follows:

- a brief status note on the national waste management programme to provide context for the national training activities;
- any national legal requirements for education and training levels in nuclear sector organisations and/or policy statements on training;
- where available, information on recent graduate numbers from courses in 'nuclear universities was referred from NEA study (NEA 2000) on nuclear education and training. This study covers almost all types of organisations related to nuclear education. However, as it was difficult to cover all organisations related to nuclear education in some countries, it is the trends rather than the absolute numbers that are important.
- where available, a summary breakdown of training capabilities, training networks, courses and vocational training and capacity-building in various organisations.

Where we have identified very specific activities (that is, where the activity is 100% aimed at radioactive waste rather than having waste topics as one among a broader range) we have placed additional information in the Annexes at the end of the main report.

A key source of information on national policies concerning human resources development with regard to the safety of nuclear programmes is provided by the first national reports submitted in the scope of the IAEA *Joint Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management in 2003*. In the Annex tables, these are referenced as the ‘national reports’.

Section 3 of the report brings forward in simplified form the data gathered from national and international programmes (Data Tables) and presents the primary findings as bulleted lists. It then recasts them in the format of a simple matrix table whose objective is to show, at a glance, the strengths and weakness brought to light.

The final section of the report (Section 4) provides the main conclusions of the review. It comments on the scope of international education and training activities and identifies gaps and needs, as well as looking forward to future developments.

3. Primary Findings

3.1 Legal, administrative and regulatory aspects

Overview

Although legal, administrative and regulatory aspects of RWM are specific to the country, these are developed on the international collaborations and discussions both in technical and non technical domain. There are great benefits in knowing what other countries have done and are doing in their overall legal approaches. Regardless of the field and the level of expertise, it is of prime importance for those who are involved in RWM programmes to learn an overview of the international and national evolution of the management concept.

Examples of international programmes

- International School of Nuclear Law

Country specific examples in nuclear safety perspective

- Learning policy of the Canadian Nuclear Safety Commission (IAEA 2001 Appendix 2)
- U.S. Nuclear Regulatory Commission Personnel Qualification Programmes (IAEA 2001 Appendix 5)
- Systematic Training Approach at STUK, Finland (IAEA 2001 Appendix 6)
- On the Job Training Guideline of a STUK Inspector, Finland (IAEA 2001 Appendix 7)
- Staff Training at US NRC to Support Risk-Informed Regulation (IAEA 2001 Appendix 8)
- Staff Qualification System (proposal) of the Canadian Nuclear Safety Commission (IAEA 2001 Appendix 9)
- Education and Training for Inspectors of Nuclear Installations, France (IAEA 2001 Appendix 10)
- Training in the Nuclear Safety Directorate, United Kingdom (IAEA 2001 Appendix 11)

- Training Courses of the National Radiation Protection Board, United Kingdom (www.nrpb.org/)

Examples of academic programmes

- International and Comparative Nuclear Law and Policy, University of Dundee (www.dundee.ac.uk/) The Chartered Institution of Waste Management, United Kingdom (www.ciwm.co.uk)

3.2 Policy development and institutional oversight

Overview

The NWMO is mandated to analyze the alternatives and make a recommendation to the Canadian Government on the preferred method in 3 years (Phase 1). Expertise and capabilities in the relevant areas are essential in this phase to evaluate the various alternatives, taking into account all legal, technical and societal aspects in a balanced and comparative manner. It is important for those experts to update their knowledge and maintain the level of confidence by sharing the latest technical and societal experiences in the world and participating in discussions to formulate collective understanding as a basis for decision making. There seems to be a potential of collaboration between the Canadian and the French experts since they are in the phase of selecting the option within a similar timeframe.

Examples of international programmes

- Management level OJT (on the job training) is most effective for Phase 1 decision making. Interactions at relevant international fora such as the Radioactive Waste Management Committee (RWMC) of NEA and the equivalent of the IAEA.
- International Atomic Energy Agency (IAEA): Training in Radioactive Waste Management
- ITC School of Underground Waste Storage and Disposal: Fundamentals of Geological Disposal

3.3 Public, community and societal participation

Overview

As RWM programmes move into a phase of implementation, the training and education in this area becomes crucial for all the stakeholders. The role of social science is essential. There are a lot in common in the societal aspects of RWM programme and lessons can be learned internationally. However, as in the case of technical aspects, it is also important to learn the commonality and differences from country to country so that learnt lessons can be properly translated so that they can be applied. Case study and rationale can be taught by class room lectures but accumulation of experience is essential for the practical learning.

Examples of international programmes

- OECD/NEA Forum on Stakeholder Confidence (FSC) is one of the most active and extensive international programme in this area. The FSC organises an annual country specific workshop where the participants are given opportunities to have direct dialogues with a wide range of the stakeholders of the RWM programme in the host country.
- IAEA Training Courses to Support the Training of Regulatory Body Staff (IAEA 2001 Appendix 12) Communication with the Public.

Country specific examples in nuclear safety perspective

- Competency Profiles for Inspectors of the Canadian Nuclear Safety Commission (IAEA 2001 Appendix 4) Required skills include “Communicating Effectively” and “Dealing with Difficult Situations”
- Training Requirements for Inspectors within the Nuclear Materials or Nuclear Waste Safety Programmes (IAEA 2001 Appendix 5) Required core training includes “Effective Communications”.

3.4 Financing issues and economic analysis

Overview

Although fundamental knowledge can be achieved in some of the courses, specific international training and capacity building in this domain was not found in the survey. Economic and financial issues pertaining to nuclear activities can be dealt with in conventional economic and financial programmes, including the long time frames required.

3.5 Development and implementation plans for long-term HLRWM

Overview

The wealth of historical discussions on a variety of options has been documented by a number of international and national organisations, and general knowledge could readily be achieved through these materials. Requirement for training and capacity building differs significantly from one country to another, whether the long-term management concept is narrowed down to one option or not. Stepwise decision-making with stakeholder/public involvement will be of prime importance and hence requires training for the decision-makers and for the participant. Long-term institutional control will be one of the central issues in both technical and social domains, regardless of what the final choice of the concept will be and this requires further education and training

3.6 Mechanisms for considering alternatives and undertaking research

Overview

As mentioned above, Canada and France are two major countries where several alternative methods have been assessed in parallel and the preferred method will be recommended to the government within a period of several years. Bilateral information exchange and collaboration in particular with comparative assessment among alternatives could be useful both in technical and non-technical domains. An adequate level of qualified staff in a wide range of disciplines is essential for conducting the respective research or evaluation activities for alternatives, both from technical and social perspectives, but they may only be used over a short period of time: consequently, specific training in this issue is not regarded as feasible. Assessing detailed design alternatives within the frame of a given concept (e.g. vertical/horizontal displacement of the waste form in the geological repository) is a highly technical matter that can be learned in a variety of courses.

Examples of international programmes

- As a larger number of countries identify geological disposal as the preferable option, education and training on comparative evaluation of alternatives methods tends to be limited.

Country specific examples in nuclear safety perspective

In France, different organisations are responsible for R&D on different waste management alternatives and vocational education and training is carried out independently.

3.7 Definition and categorisation of wastes

Overview

This topic is frequently dealt with as one of the fundamentals in general courses, which seems like a reasonable way to approach it. We did not find any training and/or capacity building initiatives dedicated solely to this specific topic. The second module of Week 1 of the ITC course on Fundamentals, outlined in Annex 8, is devoted to this topic.

3.8 Specific technical methods and related system requirements including, storage, disposal, transportation and site selection

Overview

This area is extremely broad. Effectively it includes all the science and technology of disposal and long-term storage. Many of the examples provided in the Data Tables cover diverse topics under this heading. A comprehensive and well balanced programme, as well as sufficient infrastructure and resources, are needed to meet the NWMO's overall requirement for T&E, as each topic requires a range of training and capacity building resources. Options can be chosen depending upon the baseline knowledge and experience of trainees and the intended level of achievement. As a preliminary attempt, the types of expertise and capabilities defined by the NWMO (NWMO 2003) are tabulated below in parallel with the types of education and training required. The education and training programmes reviewed in this survey that might have some relevance to those requirements are also tabulated wherever appropriate. The vacancies in this right side column may reflect the weakness in the current status of education and training opportunities.

3.8.1. Types of expertise and capabilities common to all alternatives

Project management		
Expertise and capabilities required	**Type of Education and training required**	**Relevant programme**
. project management and control	- in-house OJT (Phase 1) - professional course (later phases)	- OECD/NEA - IAEA
. strategic planning	- in-house OJT (Phase 1) - professional course, international workshop (later phases)	- OECD/NEA - IAEA
. capacity building and institutional strengthening	- in-house OJT (Phase 1) - professional course (later phases)	- OECD/NEA - IAEA
. construction management	- in-house OJT (Phase 1) - professional course (later phases)	
. operational risk management	- in-house OJT (Phase 1) - professional course (later phases)	
. data management	- IT course - Knowledge management course	- universities - (Out-sourcing?)
. training and human resources development	- in-house OJT (Phase 1) - professional course (later phases)	- ITC

Studies		
Expertise and capabilities required	**Type of Education and training required**	**Relevant programme**
. economic models for the cost of site and facility design, construction and operation	- postgraduate civil engineering course - in-house OJT - international workshop	-
. site and route selection	- in-house OJT - international case study	-
. risk, cost and benefit analysis	- risk/benefit analysis course	-
. expert peer reviews of studies and reports	- international peer review	- NEA international review team
. technology evaluations and feasibility studies	- professional course - in-house OJT	-
. logistical studies (fuel handling and shipping logistics)	- nuclear fuel cycle course - radiation protection course	- IAEA training course
. benchmarking of technologies, designs, costs and assessment approaches	- international workshop - peer review	-
. institutional requirements analysis	- OJT	-
. issues analysis and management	- professional course	-

Environmental aspects		
Expertise and capabilities required	**Type of Education and training required**	**Relevant programme**
. environmental impact assessment	- academic course - EIA course - In-house OJT	- case studies available - Finland, Sweden, Canada, USA,
. environmental effects monitoring and follow-up	- academic course - professional course	- case studies available - Finland, Sweden, Canada, USA,
. ecological sciences	- academic course	-
. cumulative effects assessment	- professional course	-
. aquatic and terrestrial biology	- academic environmental course - academic biology/ecology courses - academic geochemistry course	ITC University Bern course "Geochemical Modelling of natural and contaminated groundwaters
. environmental policy, regulation, guideline development	- academic postgraduate course	University of Leeds University of Lancaster
. environmental auditing, site assessment and remediation	- environmental professional course - academic social environmental course	International and comparative nuclear law and policy, University of Dundee
☐environmental software development	- engineering workshop - OJT	-

Radiological assessment		
Expertise and capabilities required	**Type of Education and training required**	**Relevant programme**
. fuel waste characterization	- academic nuclear engineering course - professional course on nuclear fuel cycle	ITC fundamental course
. waste-form behaviour	- professional course	ITC fundamental course
. materials sciences and waste package handling and design	- academic nuclear engineering course - OJT and professional course	
. radiation shielding	- academic nuclear engineering course - radiation safety, control courses	
. radiological safety assessment	- professional course	INSTN course
. occupational radiation exposure management	- radiation safety course - environmental chemistry academic course	NRPB course
. decontamination methods development and management	- professional course and training	

Transportation		
Expertise and capabilities required	**Type of Education and training required**	**Relevant programme**
. design of on-site and off-site equipment for the transportation of spent fuel	- OJT - Simulation	-

Safety analysis		
Expertise and capabilities required	**Type of Education and training required**	**Relevant programme**
. reliability and probabilistic risk assessment	- professional course - international benchmark exercises	-
. hazard and consequence analysis	- professional course - academic environmental course	-
. licensing services to meet regulatory requirements	- in-house OJT - radiation protection course	-
. safety and security audit and assessment	- safety assessment course - international workshop	- OECD/NEA - ITC
. emergency response planning and management	- professional course on emergency	-

Engineering design		
Expertise and capabilities required	**Type of Education and training required**	**Relevant programme**
. geological and geotechnical engineering	- academic earth-sciences course - professional course - international workshop	- ITC fundamentals course
. hydrology and water resource engineering	- environmental professional course - academic geochemistry course	-
. safety engineering	- academic engineering course - OJT	-

Quality management audits and reviews		
Expertise and capabilities required	**Type of Education and training required**	**Relevant programme**
. quality assurance program and oversight	- QA/QC course and exercise - academic courses	-

3.8.2 Types of expertise and capabilities for the storage at nuclear reactor sites

Expertise and capabilities required	Type of Education and training required	Relevant programme
. design and fabrication of dry storage containers for spent fuel	- OJT at the operational facilities - academic course	- ongoing sites in Canada
. design and manufacture of on-site fuel handling and transportation equipment	- OJT at the operational facilities - academic course	- ongoing sites in Canada
. design and construction of on-site infrastructure	- OJT at the operational facilities - academic course	- ongoing sites in Canada
. operation and maintenance of on-site waste management facility	- OJT at the operational facilities - academic course	- ongoing sites in Canada

3.8.3 Types of expertise and capabilities for deep geological disposal in the Canadian Shield

Site and Facility Studies		
Expertise and capabilities required	**Type of Education and training required**	**Relevant programme**
. site screening and site selection	- professional course - academic course - societal issues course	- case studies - ITC course siting of deep geological repositories
. site investigation and characterisation	- OJT - International case studies	- ITC fundamentals course - IAEA
. geochemistry of radionuclides	- professional workshop - URL course	- ITC international workshop on radio-nuclide migration
. groundwater flow and mass transport modelling	- professional course - academic postgraduate course - international benchmark tests	- ITC University of Bern course on geochemical modelling - DECOVALEX
. disposal facility conceptual design studies	- professional course	- ITC fundamentals course - IAEA
. container spacing – temperature and criticality constraints	- repository engineering course - civil and nuclear engineering course - URL research	
. waste emplacements arrangements: in-floor borehole vs. in-room	- repository engineering course - URL research	

. performance and safety assessment (e.g., mathematics, physics, computer science)	- academic post graduate course - professional course	NEA
. costing the repository life cycle from the siting, through construction, operation and decommissioning and ending with the closure and monitoring	- OJT - environmental course - professional course	-
. developing and demonstrating a repository and geosphere system safety assessment methodology	- professional course - URL research	-
. facility decommissioning and closure options, long-term monitoring, nuclear material safeguards and security	- professional course - URL research	-

Facility Sciences		
Expertise and capabilities required	**Type of Education and training required**	**Relevant programme**
. environmental science (e.g., biology, limnology, climatology, meteorology, ecology, microbiology)	- academic postgraduate course - professional course	-
. geology and geophysics . hydrogeology and hydrology . geochemistry and hydrogeochemistry	- academic course - URL research - OJT	-
. characterizing and modelling spent-fuel dissolution	- nuclear engineering course - OJT	-
. characterizing candidate corrosion-resistant materials for spent-fuel disposal containers	- academic course - laboratory experiment course	-
. developing and modelling durable spent-fuel disposal-container designs	- nuclear engineering course - international workshop	-
. characterizing and modelling the thermal-mechanical-hydraulic-hygroscopic interactions for the rock-mass, engineered-barrier and groundwater systems	- international workshop - international benchmark test - URL research	-

. characterizing and modelling radionuclide transport in the engineered barriers and geosphere	- international workshop - international benchmark test - URL research	-
. characterizing candidate sealing and backfilling materials for a repository	- academic course - URL research	-

Repository Engineering		
Expertise and capabilities required	**Type of Education and training required**	**Relevant programme**
. geotechnical engineering	- repository engineering course - civil/mining engineering course - URLs in the construction phase provide an ideal environment for training - existing URLs may also provide training	
. rock mechanics	- civil engineering course - URL research	
. engineering repository conceptual designs consistent with the conditions of the geosphere, candidate disposal containers and candidate sealing and backfilling systems	- professional course - URLs in the construction phase provide an ideal environment for training - existing URLs may also provide training	
designs for major components of a repository	- civil engineering course - material/system engineering course - URLs in the construction phase provide an ideal environment for training - existing URLs may also provide training	
. backfill and sealing systems design	- academic course	

	- international workshop	
. major structures and water conducting features	- academic course - professional course - URL research	
. repository layout	- civil engineering course - international workshop - URLs in the construction phase provide an ideal environment for training - existing URLs may also provide training	
. waste and container handling	- remote technology course - URL demonstration	
. rock-recycle and concrete-batch plants	- URL demonstration -	
. environmental and performance assessment technology	- academic environmental course - international expert group exercise	NEA/IGSC
. nuclear material safeguard containment/surveillance measures, and site security	- international expert course - international nuclear law school	IAEA/Nuclear safety course NEA Nuclear regulatory school
. disposal facility closure	- professional course - URL demonstration	

Surface works		
Expertise and capabilities required	**Type of Education and training required**	**Relevant programme**
. spent-fuel receipt and packaging plant	- OJT	
. radioactive and non-radioactive materials handling and processing	- radiation protection course	
. spent-fuel container-fabrication plant	- canister laboratory	SKB Canister laboratory (Sweden)
. remote site infrastructure	- academic course	

Underground works		
Expertise and capabilities required	**Type of Education and training required**	**Relevant programme**
. underground construction technology	- URL research - URL demonstration - URLs in the construction phase provide an ideal environment for training - existing URLs may also provide training	
. repository shafts and access tunnels with single and multiple levels	- URL demonstration - URL research	

. waste disposal rooms using in-floor borehole or in-room waste emplacement configurations	- URL demonstration - URL research	
. repository layouts and disposal-room configurations designed (thermal-mechanical-hydraulic responses) for site conditions (e.g., geological structures, groundwater inflow, in-situ stresses, geothermal gradient, waste form heating, conductive heat transfer, thermal expansion, sealing and backfill system)	- URL demonstration - URL research - Engineering scale research facility - URLs in the construction phase provide an ideal environment for training - existing URLs may also provide training	
. backfill and sealing materials preparation plant and distribution system	- URL demonstration - URL research	

Transportation of spent fuel from the reactors sites to the disposal facility	- OJT - Simulation (virtual reality)	

3.8.4. Types of expertise and capabilities for centralized storage

Expertise and capabilities required	Type of Education and training required	Relevant programme
. site investigation and characterization (geosciences, modelling, engineering)	- same as geological disposal option	- same as geological disposal option
. geochemistry of radionuclide	- same as geological disposal option	- same as geological disposal option
. groundwater flow modelling and mass transport	- same as geological disposal option	- same as geological disposal option
. geotechnical engineering	- same as geological disposal option	- same as geological disposal option
. facility conceptual design studies	- same as geological disposal option	- same as geological disposal option
. transportation mode and route analysis	- same as geological disposal option	- same as geological disposal option
. design and fabrication of dry storage containers for spent fuel	- same as geological disposal option	- same as geological disposal option
. site development (infrastructure design and construction)	- same as geological disposal option	- same as geological disposal option
. design and manufacture of centralized fuel handling and transportation equipment	- academic course - international workshop	-
. design and construction of centralized infrastructure	- academic course - international workshop	-

Expertise and capabilities required	Type of Education and training required	Relevant programme
. design, construction and operation of transportation infrastructure from power plants to disposal facility	OJT	
. operation and maintenance of centralized waste management facility	OJT	

3.9 Summary Status of Training & Capacity Building

	International (regional)	National (institutional)	Academic (university)	Commercial (industrial)	In-house (vocational)	On the Job Training
Legal, administrative and regulatory aspects	++	++	+++	+	+	+
Policy development and institutional oversight	+++	+	++	+	+	+
Public, community and societal participation	++	+++	++	++	+++	++++
Financing issues and economic analysis	++	+	+	++	+	+
Development and implementation plans for the long-term HLRWM	+++	+++	++	++	+	+
Mechanisms for considering alternatives and undertaking research	+++	+	+	+	+	+
Specific technical methods and related system requirements	++	+++	+	++	+	+
Fundamentals (horizontal knowledge)	++++	++	++	++	+	+
+ (weak) ++++ (strong)						

4 Conclusions

Evaluation of the summary table in the preceding section indicates an overall weakness in education and training (E&T) across most sectors identified by the NWMO. This is perhaps the prime conclusion of this review. The capacity exists within national and international organizations to provide E&T, but it is rarely harnessed into tangible initiatives.

Of interest to the NWMO at present is a lack of specific training that would assist them at the 'optioneering' stage of the Canadian programme. Because few countries are looking at alternatives to geological disposal, there is little specific training aimed at how to evaluate and compare alternatives. The building blocks to establish activities in this area exist, but have not been needed elsewhere and have never been brought together. There is also a dearth of E&T in some of the fundamental aspects of defining RWM policy within a national socio-economic framework. This is perhaps unsurprising, as the process is generally only undertaken once in most countries, so propagation of knowledge is not seen as a requirement. Indeed, the overall issue of RWM policy-setting tends to be used as a curiosity in academic courses on decision-making (often as a negative example). Nevertheless, RWM E&T does have some relative strengths – predominantly in the more technical (and legal) areas associated with repository development. The following discussion looks into the specific areas in more detail.

All countries have some form of legal requirement for training to ensure the safe operation of nuclear facilities. The intention of most of these regulations is to ensure that adequately trained people manage radioactive materials and training is generally regarded as compulsory. The regulations are mostly not specific to radioactive waste management facilities and are usually not prescriptive of the exact level of E&T that must be fulfilled. However, regulatory agencies have the power to refuse operating licenses if they are not satisfied with the training and skills base of the operator.

Long-lived waste repositories do not exist in most countries and the legal requirements for a skilled nuclear workforce are principally associated with operating power reactors and fuel cycle plants, and with regulatory agencies. National RWM programmes are still largely at the R&D stage and no specific training is legally required for those involved in R&D support. The availability of university level technical education reflects this, as courses are predominantly in nuclear engineering.

Because very long-term SF-HLW stores and geological repositories are still many years into the future, training has not yet been tuned to the requirements that such facilities will generate and there is consequently very little specific E&T available. Worldwide, we have only identified a handful of dedicated postgraduate courses in radioactive waste management in universities.

Long-lived radioactive waste management is only a corner of the nuclear industry and the problem of potential lack of skilled people in the future is endemic to the whole sector. With a downturn in nuclear energy development over the last twenty years and several countries proposing nuclear phase-out, it has been increasingly difficult to attract young people into the industry. There is evidence that this situation may now be changing. For example, there have been significant improvements recently in terms of the number of students enrolling in nuclear engineering and related degree programmes in North America (Power Engineering 2003). On the other hand, a study conducted in the UK in 2003 to follow up the former NEA study (NEA 2000) on nuclear education in British universities (HSE 2002) concludes "If nuclear education were a patient in a hospital it would be in intensive care" and recommends "Immediate action is needed; otherwise nuclear education will slowly disappear". In any case, it will take many years before a career in nuclear power is seen as being as attractive as it was in the 1970s. In response, a growing initiative in several countries over only the last two or three years has been for industry organisations and, in some cases, government agencies, to club together to co-ordinate efforts to support university level courses. As a result, there are supported networks of 'nuclear universities' in a few countries such as Canada (UNENE: University Network of Excellence in Nuclear Engineering) and Belgium (BNEN: Belgian Network for Nuclear Education), but waste management is not a dominant theme in any of these as yet.

University level teaching about radioactive waste tends to be focused in engineering, chemistry or environmental studies faculties – predominantly the former. There are a number of general nuclear engineering or radiation protection courses that include waste management modules. Some of these are sponsored by industry and used to supplement their own in-house training. Most teaching is at the postgraduate level (typically, Masters postgraduate diploma), although at least one UK university offers an undergraduate module in solid waste management, with a large component concerning radioactive wastes.

Outside the purely technical E&T provided mainly by engineering departments, interest in radioactive waste management in universities tends to be at the 'case study' level. Several environmental courses use the mixed national experiences of repository site selection as examples when teaching environmental decision-making, stakeholder values and ethics. In fact, a new generation of such courses seems to be at the leading edge of societal involvement in environmental matters. Several courses (in the UK and USA in particular) have components that consider public involvement, public communication and ethical aspects of environmentally sensitive developments. These are not specialist courses in radioactive waste, but the capability exists to educate people in these critical areas, which were missing only a few years ago.

Nuclear law is one area where there is a good range of international courses and degree-level modules available in Europe and North America. Because waste transport (especially cross boundary and marine shipments) and the potential for cross-border contamination as a result of nuclear incidents are topical, there has been a growth in multi-national legal interest in the nuclear sector. Proposed waste repository sites in coastal areas as well as existing and historic waste discharges to the sea also bring up numerous legal issues. Those legal students and practitioners who want to pursue the legal issues in waste management seem to be reasonably well catered for.

The NWMO was interested to know if any specific E&T exists in the economic and strategic planning aspects of long-term waste management. We were unable to identify any dedicated activities here. As with other such highly focused topics, the capability to mount training on these topics as specialist courses certainly exists in the industry and in academia, but it would need to be requested by end-users and properly co-ordinated. Whilst it may be possible to do this in the university sector, it may be best handled by international organisations (e.g. the ITC School). Another topic identified by the NWMO where there is also no specific E&T at present is that of definition and characterisation of wastes.

In-house E&T by waste management organisations is limited, if one removes the radiological safety and waste handling training components. There is little effort to provide broader courses covering the full scope of waste management issues, especially the non-technical aspects of economics, legal and social factors. Often, training is limited to standard management courses or to public communication (media) courses for more senior management staff. In fact, many WMOs seem to place rather low priority on providing broader training. Many of their staff are highly specialised and there seems to be a common view that contextual training is unnecessary. There is thus scope for WMOs to send staff to broad-scope courses to place their own functions within the WMO into a proper context.

There are very few wholly commercial training activities specifically in radioactive waste management. A company in the UK (IBC Advanced Technologies Inc.) has successfully run an annual one-week course in radioactive waste management and decommissioning for about ten years, with its participants drawn almost entirely from the European nuclear industry sector. The focus is mainly on practical case studies. Clearly, commercial ventures can only flourish as long as there is sufficient interest and in the absence of alternative, competing in-house training capacity.

The mainstream international nuclear organisations (IAEA and NEA) provide little direct training in radioactive waste management, although the IAEA provides experts to teach courses on a number of aspects of nuclear materials and nuclear safety in developing countries. The agencies do act as clearing houses that deal with training requests and have recently begun to co-ordinate requirements from smaller programmes with the capabilities of more advanced programmes (e.g. the IAEA Network on Underground Training). A major new initiative is the foundation of the World Nuclear University (born out of collaboration between the IAEA and the World Nuclear Association). However, the WNU has not yet begun activities and so far does not have a working group focussed onto radioactive waste management. The ITC School of Underground Waste Storage and Disposal is the only fully dedicated E&T organisation for radioactive waste management. ITC too was only recently formed but has established an active programme of courses aimed at both the nuclear industry and government, and with the extensive participation of universities.

The European Union has anticipated a growing need for E&T in radioactive waste management by launching a short project to evaluate needs and capabilities in existing Members States and those European countries joining the Union in coming years. The project (called CETRAD) is due to report in mid-2005. The 6th Framework programme for Research and Training activities of the European Atomic Energy Community (EURATOM) represents the latest multi-national initiative. It is a collection of actions at EU level to fund and promote nuclear energy research. The priority thematic areas are 1) Fusion energy research, 2) Management of radioactive waste, 3) Radiation protection. The aims in the area of radioactive waste management are to establish a sound technical basis for demonstrating the safety of geological disposal of HLW/SNF, and to study the practicability on an industrial scale of partitioning and transmutation techniques. In the framework of this programme, education and training is placed as a horizontal activity to support actions in the priority areas with an objective to promote and develop human resources and mobility.

The instruments for the programme include, among others, Networks of Excellence (NoE) and actions to promote and develop human resources and mobility. NoEs are multi-partner projects aimed at strengthening on a particular research topic by networking together the critical mass of resources and expertise needed to be a world force in a given domain. The latter actions provide a variety of possibilities for individual researchers in different stages of their career as well as institutions acting as hosts for fellows. Training fellowship, special training courses, grant for co-operation with third countries and trans-national access to large infrastructure are considered as relevant actions.

As there is no geological repository for HLW/SNF yet operational, the role of URFs is of prime importance for all experts, as these facilities to some extent simulate the geological repository. They enable the integration of confidence in the scientific and technical community with the propagation of such confidence worldwide. ITC envisages that URFs will play a central future role of being a confidence integration vehicle in the non-technical domain.

In 2003, four underground research facilities (URFs) in Belgium, Canada, Switzerland and the USA provided learning opportunities to experts of the younger generation from around the world associated with the IAEA Network of Centres of Excellence on Training and Demonstrations in Radioactive Waste management technologies in URFs.
(http://www-tc.iaea.org/tcweb/projectinfo/projectinfo_body.asp)

The ITC School of Underground Waste Storage and Disposal offered a three-week training course featuring the Grimsel Test Site (granitic rocks in Switzerland) and the HADES Underground Research Laboratory (plastic clay in Belgium). From this point of view, the planned decommissioning of the Canadian URL in Manitoba by Atomic Energy of Canada Limited is unique.

The future outlook for E&T in radioactive waste management is mixed. Despite the need, the funding of training is still apparently widely regarded as of low priority and it seems often to be regarded as a marginal organisational expenditure, with training activities sometimes being rather opportunistic rather than well planned and structured. Provision of high quality education requires much preparation, access to large facilities and the input of the best expertise – it is expensive.

An obvious solution is for concerned institutions to work more closely together, both nationally and internationally. Whilst there are today many academic teaching groups and isolated modules that are highly relevant, there is only limited co-ordination of activities and a small capacity to provide E&T to meet what will be a growing and constant requirement over the next decades. The trend toward forming educational networks supported by the industry is encouraging and it is clear that industry must take the lead if governments do not. The funding of training is clearly an 'end user' responsibility, although the very long term implications of waste management imply that governments and international groupings should be taking a keen interest (e.g. current EU initiatives to encourage training network formation on a European scale, such as ENEN European Network for Nuclear Education). Bringing end-users together and developing a structured approach to training that allows sensible use of resources is the rationale behind the foundation of both the WNU and the ITC.

Data Tables

Argentina
Belgium
Canada
Finland
France
Germany
Hungary
Japan
Spain
Sweden
Switzerland
United Kingdom
United States

International Organisations

European Union (EU)
International Atomic Energy Agency (IAEA)
Nuclear Energy Agency of OECD (OECD/NEA)
World Nuclear University (WNU)
ITC School of Underground Waste Storage and Disposal (ITC)

ARGENTINA

National Strategy for management of SNF/HLW

A deep repository is anticipated to be developed in granitic rock formations. It is anticipated that the deep repository will accommodate all radioactive waste that cannot be deposited in near-surface repositories, spent nuclear fuel once it is declared as waste and HLW from decommissioning of NPP's

National training requirements in the nuclear safety sector

- The availability of properly trained human resources and appropriate financial resource is a fundamental element to assure the safety conditions of nuclear facilities. The national Government, responsible for SNF and radioactive waste management, delegated such responsibility to CNEA*.
- The Regulatory Body requires that all personnel working at SNF and radioactive waste management facilities are properly trained and qualified in accordance with the tasks performed and that the personnel assigned to safety-related tasks are licensed.
- The arrangements to have qualified and trained personnel in accordance with the current legal and regulatory framework and the provision of the necessary financial resources to achieve the proposed goals falls in both cases, CNEA and NASA**, on the Responsible Organization.* CNEA: National Atomic Energy Commission

**NASA: Nuclear Power Plant National Operator

BELGIUM

National strategy for management of SNF/HLW
Storage at the centralized facility of returned vitrified HLW from reprocessing at La Hague. SNF is now being stored in *AFR facilities on NPP sites – current policy is not to allow further reprocessing contracts. Underground research continues at the Underground Research Facility at Mol concerning the concept of deep geological disposal in clay. *AFR: Away From Reactor (storage)

Trend in Nuclear Education	1990	1995	1998
Number of universities with education in nuclear sector	7	6	4
Number of awarded degrees Undergraduate	12	12	6
Graduate Master	18	26	12
Graduate Doctor	1	1	1
Average age of Faculty Members	-	-	52

(NEA 2000)

National training requirements in the nuclear safety sector
The Safety Analysis Report* (chapter 13) deals particularly with personnel qualification, training and re-training. Qualification of the personnel (at the origin or later replacement) is inspired from the ANS 3.1** standard, though adapted to the Belgian educational system. The Safety Analysis Report defines the level of qualification corresponding to each of the safety related functions. It does not state the individual qualifications of each person in the organisational chart. However, proof of qualification of all the operating personnel is available to AVN (Authorized Inspection Organization). ** The report required for licensing application for the operation of nuclear facilities* *** American Nuclear Standards*

(Belgium National Report 2003)

Examples of Education and Training

Type	Programme	Status
Regional University Education Network	**ENEN** (European Network for Nuclear Education) Education not only in reactor design, construction and maintenance, but also in waste management and radiation protection.	Based on a Contract among 22 European organisations from academic, industrial and governmental sectors and co-ordinated by the Belgian National Nuclear Research Centre (SCK-CEN). The underlying objective of the concerted action is the preservation of nuclear knowledge and expertise through the preservation of higher nuclear engineering education. Presumably this is intended to benefit Europe generally and not just Belgium. http://www3.sckcen.be/Enen/objectives_prospects.html
Domestic University Education Network	**BNEN** (Belgian Nuclear Higher Education Network) Postgraduate degree in nuclear engineering ***More information: Annex 1***	Based on an Agreement between five Belgian universities and SCK-CEN. 24 weeks/year courses include "Nuclear Fuel Cycle and Applied Radiochemistry" in which "Waste Management and Disposal" is taught (20 hours of lectures and 10 hours of exercises). Field visits include URL (Underground Research Laboratory) at Mol http://www3.sckcen.be/bnen/

Vocational Training Radiation Safety	**IsRP** (International School for Radiation Protection) Training for radiation protection experts	Operated by SCK-CEN The basic course on radiological protection is 5 or 9 days. The content of the general courses is adapted to the previous knowledge of the group concerned. For the specialized topics, a basic knowledge of radiological protection and/or nuclear engineering is mandatory. http://www.sckcen.be/sckcen_en/activities/train/isrp/index.shtml

Type	Programme	Status
Vocational Training	**Training Course MOL** Vocational training course for specific areas	Organised by SCK-CEN 5-day Course on Off-site Emergency Planning and Response to Nuclear Accidents (example in 2002) http://www.sckcen.be/sckcen_en/activities/train/tcm2002/index.shtml
Training Facility for Decommissioning	**EUNDETRAF** (European Nuclear Decommissioning Training Facility)	Organised by SCK-CEN Objectives to centralise European know-how and to transfer it to third parties. These two objectives meet the wish of the European Commission for centralising know-how and are also an answer to a high level of requests for training. The proposal covers three years with the main objective to give an annual course by European Decommissioning experts. The course comprises a one-week theoretical course and a two-week practical training course. The theoretical part is for a broad audience; the practical part is for selected persons. Detailed information on the training courses is available at http://www.eu-decom.be/network/eundetraf/initeundetraf4.htm

CANADA

National strategy for management of SNF/HLW
The Nuclear Waste Management Organization (NWMO) is to submit its study of approaches for the long-term management of nuclear fuel waste no later than November 15, 2005 to the Federal Government. Each of the following technical methods must be considered. - deep geological disposal in the Canadian Shield; - storage at nuclear reactor sites; and - centralized storage either, above or below ground. The NWMO may also consider and evaluate other technical methods in its study.

Trend in Nuclear Education	1990	1995	1998
Number of universities with education in nuclear sector	5	5	5
Number of awarded degrees Undergraduate	25	26	24
Graduate Master	27	17	16
Graduate Doctor	5	10	6
Average age of Faculty Members in 1998	-	-	45

(NEA 2000)

National training requirements in the nuclear safety sector	
Nuclear Safety and Control Act (NSCA)	- Each licensee in Canada has the prime responsibility for the safety of its spent fuel and radioactive waste management facilities. This responsibility includes providing adequate human resources to support the safety of each spent fuel and radioactive waste management facility throughout its lifespan. Adequate human resources are defined as the employment of enough qualified staff to carry out all normal activities without undue stress or delay, including the supervision of work done by external contractors. - Section 44(1)(*k*) of the NSCA provides the legislative basis for the qualification, training and examination of personnel. Sections 12(1)(*a*) and 12(1)(*b*) of the *General Nuclear Safety and Control Regulations* specify that the licensee must ensure the presence of a sufficient number of trained qualified workers. (Canadian National Report 2003)

Examples of Education and Training

Type	**Programme**	Overview
Nuclear Safety National	**Staff Qualification Plan of Canadian Nuclear Safety Commission (CNSC)** - Develop a system in which knowledge, skills and attitudes needed by staff to carry out their duties are understood and documented - Refine and finalize the system that ensures staff is given the opportunity to obtain and maintain the necessary knowledge, skills and attitudes in a systematic and auditable way (IAEA 2001)	- the staff qualification system has three main elements (four are shown) ➢ corporate policy basis ➢ training system “stakeholders’ responsibilities” ✧ the organisation ✧ Directors General and Directors ✧ Section Heads ✧ Training Units ✧ Individuals ➢ Training system “corporate responsibilities” ✧ Procedures, training plans and databases ✧ Regulatory functions ✧ Job families and groups ✧ Positions and levels ➢ Qualification, verification and records ✧ The qualification process ✧ The certification process

Type	Programme	Overview
University Industry Network	- **University Network of Excellence in Nuclear Engineering (UNENE)** - Queen's University - University of Toronto - McMaster University - University of Waterloo - University of Western Ontario - University of Ontario Institute of Technology - Ontario Power Generation (OPG) - Bruce Power Atomic Energy of Canada Limited (AECL)	- Industry funding to support university programmes - The funds will create six Research Chairs and sponsor up to 30 students in Master's level programs. In addition, OPG has committed funding to a Natural Sciences and Engineering Research Council (NSERC) research chair in nuclear fuel waste research, and for nuclear engineering scholarships. All the research chairs are expected to attract matching government research funds. The total projected funding between industry and the government is in the order of $15M (CDN) for the first five years. http://www.unene.com, http://www.unene.ca ➢

University-Industry Network	**CANTEACH** AECL, OPG, CANDU Owners Group Bruce Power, McMaster University, Ecole Polytechnique, University of New Brunswick, University of Ontario Institute of Technology, CNSC, Canadian Nuclear Society	- The CNSC has committed to contributing information to the CANTEACH program. CANTEACH is an initiative being developed in an effort to meet succession planning requirements. The aim of the CANTEACH proposal is to develop a comprehensive set of education and training documents, at several Canadian universities. http://www.canteach.ca/ -
Universities	**Universities** A number of Universities listed on the right are known to have researchers with specific expertise in engineering and the physical, biological and social sciences that are expected to be involved in HLRWM (http://www.nwmo.ca/Default.aspx?DN=249,211,199,20,1,Documents (NWMO Background Papers 7-5 Appendix B for details)	Carleton University, Ecole Polytechnique, Laurentian University, McMaster University, Queens University, Royal Military College, Trent University, Universite Laval, University of Alberta, University of British Columbia, University of Calgary, University of Guelph, University of Manitoba, University of New Brunswick, University of Ontario Institute of Technology, University of Ottawa, University of Saskatchewan, University of Toronto, University of Waterloo, University of Western Ontario

FINLAND

National Strategy for management of SNF/HLW
SNF stored in *AFR facilities on NPP sites. The Decision in Principle by the Finnish Parliament in 2001 endorsed the selection of Olkiluoto as the site for the development of a deep disposal facility, subject to approval by the regulatory authorities. POSIVA is now embarking on a programme of detailed investigations at this site. *AFR: Away From Reactor (storage)

Trend in Nuclear Education	1990	1995	1998
Number of universities with education in nuclear sector	3	3	3
Number of awarded degrees Undergraduate	-	-	-
Graduate Master	13	15	13
Graduate Doctor	2	8	9
Average age of Faculty Members in 1998	-	-	46

(NEA 2000)

National training requirements in the nuclear safety sector	
Nuclear Energy Act,	A necessary condition for granting a construction licence of a nuclear facility is the availability of the necessary expertise. According to Section 20 of the Nuclear Energy Act, an operating licence of a nuclear facility can be granted if the applicant has competent operating staff.

(Finnish National Report 2003)

Example of Education and Training

Type	Programme	Overview
University	**Helsinki University of Technology (HUT)** Department of Engineering Physics and Mathematics, Laboratory of Advanced Energy Systems.	- The nuclear engineering programme at HUT is included in the Engineering Physics study programme. The Laboratory of Advanced Energy Systems gives education both in nuclear energy (fission and fusion) and in renewable energy sources such as wind and solar power. - The main research activities are focused on radiation and reactor physics, and on fusion technology. The unit has a laboratory for radiation measurements, and access to the Triga training and research reactor, hot cells and laboratory of radiochemistry at the Technical Research Centre of Finland (VTT) http://www.hut.fi/English/

University	**Lappeenranta University of Technology** (LUT), Department of Energy Technology, Laboratory of Nuclear Engineering.	- The Laboratory of Nuclear Engineering along with the Physics Laboratory of LUT has laboratories for conducting radiation measurements. In association with VTT, the Laboratory of Nuclear Engineering has a thermal-hydraulics laboratory equipped with a facility (PACTEL) for simulating the primary circuit of the Loviisa NPP units - The main research activities are concerned with the safety of nuclear power plants, with a special focus on thermal-hydraulics. The VTT Triga training and research reactor in Espoo is used in the reactor physics course. http://www.lut.fi/en/

Type	Programme	Overview
University	**University of Helsinki**, Department of Chemistry, Laboratory of Radiochemistry . (University of Helsinki is a Member of ITC)	- Master of Science degree. Students attend about three years of basic courses in inorganic, organic and physical chemistry and then do specialisation courses in radiochemistry for a minimum of two years. - The Laboratory of Radiochemistry also offers courses to students from the other branches of chemistry, as well as further education for teachers. - The main research activities focus on the management and final disposal of radioactive wastes, on environmental radiochemistry, on ion exchange purification of effluents, and on radiation chemistry. An important addition to the research and teaching facilities is a new cyclotron. http://www.chemistry.helsinki.fi/english/

Research Centre	**VTT** (Technical Research Centre of Finland) Finland has no nuclear research centre. Instead, there are various units inside the multidisciplinary national research centre	- VTT has activities in nuclear engineering. The most important unit in this respect is VTT Energy, which has excellent expertise in reactor physics and thermal-hydraulics calculations. - VTT Energy and LUT have built the thermal-hydraulic facility PACTEL, as mentioned above. VTT Chemical Technology runs the Triga training and research reactor, as also mentioned above. - The main research area of Triga is focused on boron neutron capture therapy of brain tumours. - VTT Manufacturing Technology has hot cells for non-transuranium materials. Located mainly on the same campus in Espoo as HUT, VTT has good links with the universities. The personnel of VTT are strongly encouraged to do post-graduate studies. http://www.vtt.fi/indexe.htm

Type	Programme	Overview
Vocational	**STUK** (Radiation and Nuclear Safety Authority)	Similar to the nuclear power plants, the Finnish nuclear regulatory body STUK has well established training programmes for its personnel. As the national authority of radiation issues, STUK has laboratories for radiation physics and radiochemistry that are necessary for monitoring environmental radioactivity. http://www.stuk.fi/english/ • On the job training guideline of a STUK Inspector (IAEA 2001) • Use of systematic training approach at STUK (IAEA 2001)
Research Programme	**FINNUS** (Finnish National Research Programme on Nuclear Safety)	Referring to the government's decision to keep the nuclear option open and to maintain the high level of expertise in the country, FINNUS was defined for the period 1999-2002 Among its aims is the education of nuclear experts. Every project in FINNUS offered both master's and doctor's level thesis positions. http://www.vtt.fi/pro/tutkimus/finnus/

FRANCE

National Strategy for management of SNF/HLW
Routine reprocessing of most, but not all, SNF. Un-reprocessed SNF is stored at La Hague pending decisions regarding future fuel-cycle policy. Present policy regarding HLW management is dictated by the Bataille Law of 1991, which requires three parallel programmes of research until 2006 covering deep geological disposal, indefinite surface storage and P&T. The choice will then be made by the government.

Trend in Nuclear Education	1990	1995	1998
Number of universities with education in nuclear sector	8	9	12
Number of awarded degrees Undergraduate	35	43	31
Graduate Master	230	295	274
Graduate Doctor	55	99	98
Average age of Faculty Members in 1998	-	-	34

(NEA 2000)

National training requirements in the nuclear safety sector
French regulations set no official amount of resources to be assigned by nuclear facility operators to safety aspects. Nonetheless, there is an indirect requirement, in that the regulations stipulate that the holder of an operating licence must guarantee that all measures needed to guarantee safety are taken, according to the nature of the activities and the conditions in which they are performed. This guarantee must extend up to the facility dismantling and clean-up phase, since these operations must be carried out in conditions approved by decree. It is therefore at the licensing application stage that the Safety Authority checks that the operator will have the human resources and financial capacity to operate its facility correctly (French National Report 2003)

Examples of Education and Training

Type	Programme	Overview
Research Institute	**INSTN** (Advanced education institute of the French Atomic Energy Commission=CEA) ***More information: Annex 2***	The INSTN provides students who have high scientific qualifications, and professional engineers, with specialized education in all disciplines related to nuclear energy applications. The INSTN is also in charge of the coordination of PhD programmes in CEA laboratories. International cooperation has been set up through specific collaboration programmes. http://www-instn.cea.fr/html/A_gene/a_accuei.htm

Vocational Training	**Education and training for inspectors of nuclear installations** (IAEA 2001)	At present, there is a reference list of 40 courses for education and training. The course duration is comprised between 1 or few days up to 6 weeks. Most of the courses are not specific for the regulatory body but they were selected as relevant for the different tasks the inspectors have to cope with. Example of mandatory training for sub-direction in charge of NPP; • Nuclear engineering 10 weeks, radiation protection 2 days, • IPSN role 2 weeks, inspection 1week, legal framework 2 days, QA 1day
Vocational Training	**INSTN** Vocational training for nuclear Industry **This implies senior high school or junior college level.**	To maintain a high level of general expertise, considerable importance is also attached to in-house training at INSTN and adult education organised at INSTN. For example, every year, the INSTN trains 7 000 people in 600 sessions on about 120 different topics, mainly in radiological protection, but also in materials, fuel cycle, safety, radiobiology, radioactivity measurements, etc. http://www-instn.cea.fr/html/A_gene/a_accuei.htm

Type	Programme	Overview
Vocational	**ANDRA** (National Radioactive Waste Management Agency) employs about 350 people A science department of about 50 staff in fields such as geology, hydro-geology, materials, the biosphere. They thus take part in safety studies for both operational and planned repositories. A project department with a staff of about 80, runs the design studies into future waste management solutions, and environment department. It is responsible for the Bure underground laboratory.	In 2000, 4.16 % of employees underwent vocational training courses as follows. ➢ Quality, safety, security and radiation protection: ➢ Human resources management ➢ Skill improvement and maintenance ➢ Managing IT tools ➢ Agency personnel integration ➢ Internationalisation (foreign language) ➢ Work station adaptation ➢ Project management ANDRA's involvement in training via research is one of the key aspects of its scientific policy. The Agency finances over 40 doctorate students, the majority of whom are directly employed by ANDRA via thesis covenants. http://www.andra.fr/home.asp

GERMANY

National Strategy for management of SNF/HLW
Following the new energy policy of the current Federal Government, the German radioactive disposal programme presently is re-examined. The political objective is to erect one single repository in Germany for all types of radioactive waste by 2030. According to this new approach, further sites in various host rocks will be investigated for suitability. Thus, BMU set up an expert group to develop new repository site selection criteria and respective procedures on a scientific basis and on thorough discussions with public participation.

National training requirements in the nuclear safety sector (mainly radiation protection and regulatory)	
Radiation Protection Ordinance	Contains regulations concerning the required scope of expert knowledge in the field of radiation protection as well as its acquisition and conservation. Actual requirements?
Ordinance on the Nuclear Safety Officer and on the Reporting of Accidents and Other Events	Regulates the appointment of nuclear safety officers for nuclear installations licensed for the storage of nuclear fuel.
Guideline on Technical Qualification in Radiation Protection	Specifies the extent and required proof of the technical qualification of radiation protection supervisors and radiation protection commissioners.
Guideline Relating to the Assurance of the Necessary Knowledge of Other Persons Engaged in the Operation of Nuclear Power Plants	The contents of this guideline can be applied analogously to other nuclear installations.

(German National Report 2003)

Examples of Education and Training

Type	Programme	Overview
University	Training in the field of nuclear and reactor technology 17 universities and 11 technical colleges are involved	- At Aachen, Berlin, Essen, Karlsruhe, Munich and Zittau universities. - Recognised radiation protection courses are held e.g. at FZK in Karlsruhe, at GSF in Munich and at Ilmenau Technical University.

Vocational	Training for different levels of profession	- Group 1: A completed education at a university, college or technical college in a relevant technical or mathematical-scientific area is required for radiation protection supervisors. Persons in this group include the Head of the Radioactive Waste Repository Projects department at the Federal Office for Radiation Protection (BfS). - Group 2: For other persons engaged in the operation of nuclear power plants and who must possess the necessary expert knowledge in radiation protection, the requirements for vocational training may be restricted according to their specific activities. Persons in this second group include the head of disposal of radioactive waste and the head of radiation protection. - Group 3: Radiation protection officers who are appointed by the radiation protection supervisor. Radiation protection officers are responsible for the management or supervision of measures designed to ensure compliance with radiation protection principles and protective measures - Group 4: Comprises all other persons engaged in a nuclear facility. Training is held at the employee's workplace and takes place prior to commencing work.

Type	Programme	Overview
Research Centre	**Nuclear Technology Research Pool.**	The Nuclear Competence Pool within the Framework of the HGF Nuclear Technology Research Pool. (Kompetenzverbund Kerntechnik im Rahmen des HGF-Forschungsbereiches Energie) has been founded in order to maintain an adequate level of know-how in the nuclear and radiation protection sector. It consists of the Karlsruhe Research Centre together with the universities of Karlsruhe and Stuttgart, the Jülich Research Centre together with the Aachen RWTH (university) and the Aachen/Jülich technical college, the Rossendorf Research Centre together with Dresden technical university and Zittau/Görlitz technical college and the Gesellschaft für Anlagen und Reaktorsicherheit (GRS mbH) together with Munich Technical University. This competence pool analyses the education and training situation and provides forecasts for the future, aimed at clarifying the current training situation

HUNGARY

National Strategy for management of SNF/HLW
Geological disposal in clay formation in Boda remains one of the preferred options. In parallel with the development of a new policy, a country-wide screening to identify potential new rock areas for the HLW repository, to continue the surface investigations of the Boda area, and to continue processing the accumulated geological parameters.

Trend in Nuclear Education	1990	1995	1998
Number of universities with education in nuclear sector	3	3	3
Number of awarded degrees Undergraduate	101	86	94
Graduate Master	22	21	28
Graduate Doctor	7	7	4
Average age of Faculty Members in 1998			48

(NEA 2000)

National training requirements in the nuclear safety sector
The future of nuclear training in Hungary is closely related to the changes in the nuclear energy industry. The Paks NPP performs all the necessary measures to fully comply with the worldwide accepted nuclear safety and technical standards. Another major objective is to remain competitive under the conditions of a liberalised electricity market. Achieving these objectives imposes strict requirements on the plant staff and also on the supporting institutes. To perform the related tasks successfully we should maintain a high level of competency for professionals, and attract new specialists into the nuclear field. (Hungary National Report 2003)

Examples of Education and Training

Type	Programme	Overview
University	**Budapest Technical University** Mechanical Engineering Faculty	Between 1968 and 1996, the university hosted a postgraduate programme for the training of engineers in the specialisation of reactor techniques: 175 persons were awarded diplomas here and they now hold middle and high-level managerial positions in different fields of nuclear engineering, mainly at Paks nuclear power plant and the Hungarian Atomic Energy Authority.
University	**Budapest Technical University** Natural Sciences Faculty and the Institute for Nuclear Techniques	Launched a physicist engineering training course in 1992, specialising in nuclear techniques. After taking a three-year physicist training course, participants studied nuclear physics, reactor physics, reactor technology, nuclear engineering, thermal-hydraulics, radiochemistry, nuclear measurement techniques as well as radiation and environmental protection. The majority of the engineers who graduated from this programme have found jobs in scientific work.

JAPAN

National Strategy for management of SNF/HLW
High Level (vitrified) waste will be disposed of in a deep geological repository following a period of 30 – 50 years of interim storage. The responsible organisation is NUMO.

Trend in Nuclear Education	1990	1995	1998
Number of universities with education in nuclear sector	13	13	13
Number of awarded degrees Undergraduate	481	476	503
Graduate Master	257	281	339
Graduate Doctor	23	42	60
Average age of Faculty Members in 1998	-	-	50

(NEA 2000)

National training requirements in the nuclear safety sector
In issuing the establishment licence of a nuclear facility, the regulatory body confirms that the applicant possesses the technical capability necessary to establish and operate it adequately. (Exempted are the reprocessing activities by JNC and JAERI, two national institutes established by legislation.) Any operator of facilities licensed under the Reactor Regulation Law appoints, and notifies the regulatory body of, a Chief Engineer of Reactors to supervise safety preservation in the operation of a reactor facility, a Chief Nuclear Fuel Engineer to supervise safety preservation in the operation of a nuclear fuel fabrication facility or a reprocessing facility, a Supervisor of Spent Fuel to supervise safety preservation in the handling of spent fuel in a spent fuel storage facility and a Supervisor of Radioactive Waste to supervise safety preservation in the handling of nuclear fuel materials etc. in radioactive waste management facilities. (Japan National Report 2003)

Examples of Education and Training

Type	Programme	Overview
Vocational	Any operator of facilities licensed under the Reactor Regulation Law is requested to provide items (see box on right) concerning training and education in the Safety Preservation Rules.	- matters relating to regulations and the Safety Preservation Rules - structure, performance and the operation of the facility - matters relating to radiation management - matters relating to the handling of nuclear fuel materials and material contaminated with nuclear fuel material - steps to be taken in the case of emergency **This is helpfully a little more specific than most.**
Vocational	Any operator of facilities licensed under the Radiation Hazards Prevention Law is requested to provide education and training programmes on the items listed to the right.	- radiation impact on human body - safe handling of radioisotopes - regulation relating to the prevention of radiation hazards due to radioisotopes - Internal Rules for Prevention of Radiation Hazards

International Training Centre	ITC School of Underground Waste Storage and Disposal	- 15 organisations from academic, public and private sectors in Japan have joined ITC as Members. - These organisations are sending trainees as well as professional staff to support the ITC courses to promote and transfer the relevant expertise in the field of geological disposal.
University	**Saitama University** Geosphere Research Institute	- Provides post graduate courses include geo-scientific studies on geological disposal of toxic wastes

SPAIN

National Strategy for management of SNF/HLW
All SNF is currently stored in AR fuel ponds, though a dry cask AFR the storage is under construction at Trillo NPP (started operating in July 2002). Some vitrified waste is due to be returned from La Hague in 2010. The government has stated that a decision regarding long-term strategy will not be taken before 2010.

Trend in Nuclear Education	1990	1995	1998
Number of universities with education in nuclear sector	6	6	6
Number of awarded degrees Undergraduate	74	80	59
Graduate Master	74	73	63
Graduate Doctor	51	50	50
Average age of Faculty Members in 1998	-	-	45

(NEA 2000)

National training requirements in the nuclear safety sector	
Regulation on Nuclear and Radioactive Installations (RNRI)	- The availability of adequate human resource is a key element for the maintenance of safe conditions at nuclear facilities. The RNRI, which regulates the system of administrative authorisations, both for nuclear and radioactive facilities and for other specific activities relating to the application of ionizing radiations, establishes requirements regarding the organisations to be presented by the licensee in the different authorisations, as well as for personnel licences and accreditations. (Spanish National Report 2003)

Examples of Education and Training Initiatives

Type	Programme	Overview
University	**Polytechnic Universities**	- There are 7 polytechnic universities that offer nuclear education, but as a specialisation in energy courses, because graduation in nuclear engineering does not exist. - These polytechnic universities are located in Madrid, Barcelona, Valencia, Bilbao, and Oviedo. In 1976, a six-year plan was implemented with the study of technical subjects in the nuclear field during the last two years of the course. - After the sixth year, graduation in industrial engineering, mining engineering or naval engineering could be reached. At present, this old plan is only in use at the Polytechnic University of Madrid. - The remainder of the technical schools have a five-year plan, in which nuclear subjects are of an optional nature. Doctoral courses with nuclear subjects have been opened and each university offers different courses. After 32 credits, students can present their theses (*viva voces*), after which they receive their Doctor's title. - Funding for university research comes from several sources: the Ministry of Industry and Energy, the Spanish Nuclear Regulatory Council, the Spanish Nuclear Waste Management Company (ENRESA), utilities, and the European Union Programmes.

Research Centre	**CIEMAT** (Centre for Energy-Related Environmental and Technological Research)	- CIEMAT is a Public Research Institution attached to the Ministry of Industry and Energy through the State Secretariat of Energy and Mineral Resources. - As a technological research centre, there has to be a link between basic research, mainly performed in the academic world, and the national industry. - CIEMAT's projects in the nuclear field are directed at making progress in the safety of nuclear fission energy and demonstrating the role of nuclear fusion as an alternative energy with a future.

SWEDEN

National Strategy for management of SNF/HLW
All SNF is stored centrally in the CLAB facility at Oskarshamn. SKB is proceeding with detailed site investigations at two possible deep disposal sites, with the approval of the local municipalities and the government.

Trend in Nuclear Education	1990	1995	1998
Number of universities with education in nuclear sector	3	3	3
Number of awarded degrees Undergraduate	0	0	0
Graduate Master	4	8	5
Graduate Doctor	1	5	9
Average age of Faculty Members in 1998	-	-	47

(NEA 2000)

National training requirements in the nuclear safety sector	
Nuclear Energy Act	A necessary condition for granting a construction licence of a nuclear facility is the availability of the necessary expertise. (Swedish National Report 2003)

Examples of Education and Training

Type	Programme	Overview
University	Engineering	- There is no specific nuclear engineering course. The engineering programme is based on a 3-year senior high school science/ technical course. Engineers who graduate from this programme fit very well the basic educational requirements for many positions in nuclear power operation, maintenance and manufacturing. - The original university courses for graduate engineers are 4-5 years, based on a three-year senior high school science/technical course. The courses are offered at technical universities and institutes. There is no specific, complete course in nuclear engineering, but in some courses, students can specialise in reactor technology, nuclear power safety, reactor physics, nuclear chemistry and health physics towards the end of the course - A new international M.Sc course in Sustainable Energy Engineering (including nuclear energy) has recently been introduced at the Royal Institute of Technology in Stockholm. The number of students in traditional nuclear science at Master and Ph.D. level is rather constant. A trend that can be observed is that the number of Swedish students slightly decreases whilst the number of foreign students increases.

Vocational	Regulatory **Swedish Nuclear Power Inspectorate (SKI)** **Swedish Radiation Protection Authority (SSI)**	In both organizations, about 10% of working time is allocated to the development of individual competence as each professional staff member is typically involved in several tasks, for instance inspections, regulatory reviews and approval tasks, revision of regulations, handling research contracts and participation in public information activities, each requiring his or her expertise. Students specialising in nuclear science are a small but important part of the number of engineers recruited by the nuclear industry. Most engineers and scientists recruited are mechanical and electrical chemistry graduate engineers. To meet the specific theoretical training needs of engineers with a more general background, the nuclear industry has developed applied nuclear training courses, provided to the industry as "in-house training" by a jointly owned company. The average number of students is about 150 per year. http://www.ski.se/extra/tools/parser/index.cgi?url=/html/parse/index_en.html&selected=1&mainurl=/page/5/ http://www.ssi.se/english/english.html
Type	**Programme**	**Overview**
Vocational	Waste management **Swedish Nuclear Fuel and Waste Management Company (SKB)**	As the repository site investigations due to continue for the next 7-8 years. SKB will be employing 40 or so people, and civil engineers, technicians, laboratory assistants and administrative personnel are just some of the professional groups who will have an excellent opportunity to start their careers with SKB. SKB will also be expanding in the IT sphere. Interesting. For every employee, SKB provides a personal development programme that includes additional training in the individual's area of responsibility http://www.skb.se/templates/Page.asp?id=2656

Centre	**Swedish Centre of Nuclear Technology**	Established with members from the Royal Institute of Technology and other universities together with the nuclear power industry. The centre supports nuclear research in order to safeguard national nuclear competence.

SWITZERLAND

National Strategy for management of SNF/HLW
Concerning the disposal of high level and long-lived intermediate level waste, the work is still concentrated on the demonstration of the feasibility of such a repository in Switzerland both in a crystalline and in a sedimentary rock environment

Trend in Nuclear Education	1990	1995	1998
Number of universities with education in nuclear sector	8	8	9
Number of awarded degrees Undergraduate	93	86	85
Graduate Master	-	-	-
Graduate Doctor	8	8	8
Average age of Faculty Members in 1998	-	-	53

(NEA 2000)

National training requirements in the nuclear safety sector	
Atomic Energy Act	Requires qualified senior staff to manage and supervise any nuclear installation and to fulfill all legal, regulatory and licence requirements. This is a prerequisite for granting a licence for nuclear installations, including spent fuel and radioactive waste management facilities.
HSK* Guidelines	Define specific regulatory requirements on the organisation (HSK-R-17), the operating staff of NPPs (HSK-R-27), and on the radiation protection staff (HSK-R-37). These requirements also apply to other nuclear installations (*i.e.*, spent fuel and radioactive waste management facilities) by analogy, where appropriate (Swiss National Report 2003)

Examples of Education and Training

Type	Programme	Overview
University	Engineering	The number of undergraduate students choosing nuclear related optional courses (usually in their final year) has remained fairly steady during the 1990-98 period. This is so in spite of the fact that a countrywide moratorium with respect to new NPP projects has been in force during this time. A factor which has contributed to the relative constancy of student interest is that course titles and contents have commonly been modified to broaden the scope of the topics covered. Thus, for example, nuclear engineering optional courses offered at one of the universities currently include related or overlapping power engineering aspects (energy production and use, safety, heat transfer, simulation, etc.). This makes the subject matter more attractive to students who are motivated to enter the energy field with a general, rather than specifically nuclear, orientation. In any case, it is only a fraction (typically 20%) of the students taking nuclear course options at the various educational institutions, who also carry out a nuclear-related research project (“Diplomarbeit”) as part of their degree work. The overall situation with respect to doctoral research is qualitatively similar in that the total number of Ph.D. students in the nuclear field has remained relatively constant as well. This is, however, to be viewed in the context of a significant general increase in the number of doctoral degrees awarded in scientific and engineering disciplines across the country.

Vocational	**HSK** (Swiss Federal Nuclear Safety Inspectorate)	Together with the University of Bern and Nagra, HSK is the Founding Members of ITC and support its activities. http://www.hsk.psi.ch/english/start.php
Vocational	**Nagra** (National Cooperative for the Disposal of Radioactive Waste)	Together with the University of Bern and HSK, Nagra are the Founding Members of ITC and support its activities. Aha! First description of ITC. Put it up front! http://www.nagra.ch/english/nagra/nagra.htm

Type	Programme	Overview
Research Institute	Nuclear Science and Engineering **Paul Scherrer Institute (PSI)** - the national research centre	- More than 240 students from the world are currently using PSI facilities to prepare for their doctorates. - In 2002, 34 students completed their doctorate studies at PSI - PSI has a Radiation Protection School - In-house training, Summer schools, Further education for teachers http://www.psi.ch/index_e.shtml

UNITED KINGDOM

National Strategy for management of SNF/HLW
The situation is currently under review by the government. Following the recent consultation exercise run by DEFRA (The Department of Environment Food and Rural Affairs) and other Environment Departments, the government's decision is now awaited regarding restructuring in this sector, including the future of the WMO. Stay tuned! Most, but not all, SNF is reprocessed at Sellafield, and the HLW residues stored by BNFL.

Trend in Nuclear Education	1990	1995	1998
Number of universities with education in nuclear sector	9	9	9
Number of awarded degrees Undergraduate	320	319	356
Graduate Master	77	84	82
Graduate Doctor	15	15	15
Average age of Faculty Members in 1998	-	-	47

(NEA 2000)

National training requirements in the nuclear safety sector

In order to comply with its nuclear site licence, a licensee of a spent fuel or radioactive waste management facility must demonstrate to Health and Safety Executive (HSE)'s satisfaction that it has:

- identified through its safety case all safety related activities on the site;
- adequate staff resources to carry out all safety related activities;
- a clear definition and documentation of all safety related duties;
- all staff who carry out safety related activities are suitably qualified and experienced; and
- all staff that carry out safety related activities are suitably trained. Again, what is suitably?

(UK National Report 2003)

Examples of Education and Training

Type	Programme	Overview
University	International & Comparative Nuclear Law and Policy **University of Dundee** MSc PhD Diploma	Required courses include: Nuclear Law and Policy with particular emphasis on relevant legal and institutional mechanisms for the regulation of nuclear safety and disposal of radioactive waste. http://www.dundee.ac.uk/
University	Waste Management **University of Sheffield** Department of Engineering Materials Postgraduate MSc degree	The Department hosts the Immobilisation Science Laboratory, a centre of excellence for the study of waste immobilisation that has been funded by BNFL and NIREX. The course modules include “Glass Processing and Durability” and “Waste Management in the Nuclear Industry” http://www.shef.ac.uk/ Very specific to UK reprocessing programme.
University	**University of Birmingham** School of Physics and Astronomy	Post graduate certificate course in radioactive waste management and decommissioning http://www.bham.ac.uk/

University	**University of Leeds** Undergraduate Module	Environmental decision making (Fieldwork) Environmental risk management, Decision making and communication Solid and radioactive waste management http://www.leeds.ac.uk/
University	**Lancaster University** Decommissioning and Environmental Clean-up **The formatting in this table is not clear. Shouldn't the university be on top in each rectangle?**	Post graduate course on Environmental Decision Making Scientific, technical and societal issues http://www.lancs.ac.uk/
Network Course	**MERN** (Mining & Energy Research Network) Professional Training and Guided study Network	Nuclear reactor decommissioning and Sustainable Development http://users.wbs.ac.uk/group/mern/research/nuclear_reactor_decommissioning

Courses	Management of Radioactive Waste 3.5-day course for professionals **National Radiation Protection Board (NRPB)**	Course introduces the various disposal options that are available in the UK and examines the associated pathways by which the public can be exposed. The methodologies by which the radiological impact can be assessed from activities discharged are presented, together with a discussion on the rationale for environmental monitoring. Practical issues of radioactive waste disposal are discussed http://www.nrpb.org/
Commercial Course	**IBC** (Advanced Technologies Inc.) Annual Course 'Radioactive Waste Management and Decommissioning'	A one week course held annually at Cambridge University structured around the use of invited lecturers and comprising lectures and short workshop sessions that focus on case studies. Principally used by UK industry for junior staff training.
Centres	**Project Dalton** Institution focused on nuclear science and engineering starting in 2004 - **University of Manchester** - **The Northwest Development Agency** - **BNFL (British Nuclear Fuel Co.)** ***More information: Annex 3***	Post Graduate Programmes - MSc in Nuclear Engineering will include "Nuclear Fuel Cycle" and "Decommissioning, Waste, Environmental Management" as core units - MSc in Nuclear Sciences will include "Geological Storage and Disposal" and "Management Practice (regulations and safety) as proposed specializations Undergraduate Programmes, Distance Learning, Public Courses are also planned http://nuclear.ph.man.ac.uk/~jb/daltonmodel.htm

National Nuclear Safety Centre	**Training in the Nuclear Safety Directorate**	In the UK the Nuclear Safety Directorate (NSD) is part of the Health and Safety Executive (HSE). Whilst NSD has discretion to organise specific training courses to meet its own needs it makes heavy use of a range of standard training provided by HSE. As such the NSD training prospectus contains training events that cover both technical, legal and staff development. There is a core training element that is undertaken by all new inspectors but subsequent training is tailored to individual needs and personal development. The training courses are categorized as following (IAEA 2001) GROUPING OF TRAINING COURSES Section 1 — Core and Priority Training Section 2 — Technical Training (other) Section 3 — Legal Training (other) Section 4 — Personal Effectiveness and Management (other) Section 5 — IT Section 6 — Policy Making Section 7 — Further Education and other

UNITED STATES

National Strategy for management of SNF/HLW
Geological disposal at Yucca Mountain, Nevada.

Trend in Nuclear Education	1990	1995	1998
Number of universities with education in nuclear sector	9	9	9
Number of awarded degrees Undergraduate	320	319	356
Graduate Master	77	84	82
Graduate Doctor	15	15	15
Average age of Faculty Members in 1998	-	-	47

(NEA 2000)

National training requirements in the nuclear safety sector	
Staff Qualifications for Spent Fuel and Radioactive Waste Management Facilities	- The *USNRC regulations (10 CFR Part 63) for the operational practices for disposal of spent fuel at the proposed Yucca Mountain repository require the submittal of a Safety Analysis Report and include a provision for the personnel qualifications and training requirements. - Operations of systems and components that have been identified as important to safety in the Safety Analysis Report and in the license must be performed only by trained and certified personnel or by personnel under the direct visual supervision of an individual with training and certification in such operation. Supervisory personnel who direct operations that are important to safety must also be certified in such operations. The **USDOE must establish programs for training, proficiency testing, certification, and requalification of operating and supervisory personnel. (US National Report 2003)
USDOE Technical Capability Efforts	The USDOE is committed to developing and maintaining a technically competent workforce to accomplish its missions in a safe and efficient manner through the Federal Technical Capability Program. Through this program, the USDOE strives to recruit and hire technically capable personnel, continuously develop the technical expertise of its existing workforce and, within the limitations of executive policy and Federal law, retain critical technical capabilities within the USDOE at all times. Although specifically relating to the safe operation of defense nuclear facilities, the principles and intent of the Federal Technical Capability Program are applied to organizations that fall outside the purview of the Defense Nuclear Facilities Safety Board. Most of the USDOE spent fuel and radioactive waste management facilities are

	considered defense nuclear facilities. The USDOE is determined to continue making improvements in the capabilities of the Federal workforce and to fully utilize all of the tools at its disposal.

Examples of Education and Training

Type	Programme	Overview
National Nuclear Safety	**NRC Technical Training Program** Nuclear Regulatory Commission	The Associate Director for Training and Development (ADTD) of the Office of Human Resources manages the NRC technical training program. ADTD coordinates with the NRC headquarters offices and regions in the development and implementation of formal NRC staff qualification, development, and training programs. A technical training curriculum is provided to best meet the integrated needs defined by these formal NRC staff qualification, development, and training programs in the areas of reactor technology, probabilistic risk assessment, engineering support, radiation protection, fuel cycle technology, security and safeguards, and regulatory skills. New courses are developed and existing courses are modified to meet new or changing needs identified by the NRC line organization. This Technical Training Course Catalog provides a description and schedule of the technical training courses that are available to NRC employees.
National Nuclear Safety	**NRC Personnel Qualification Programs** Nuclear Regulatory Commission	Qualification and training requirements are defined for selected U. S. Nuclear Regulatory Commission (NRC) personnel in the nuclear reactor safety (NRS), nuclear materials safety (NMS), and nuclear waste safety (NWS) program areas. Initial qualification is achieved through self-study, formal classroom, and on the job training. Additional training is also specified to maintain and enhance the effectiveness of experienced personnel in identified speciality areas. These qualification programs ensure that NRC program area personnel meet minimum knowledge and qualification standards and that a standardized methodology is used for determining that inspectors, license reviewers, project managers, and technical reviewers have met the established qualification requirements.

National Environmental Protection	**EPA** (US Environmental Protection Agency) Radiological Training Courses	- Fundamental/refresher course for Radiological Monitors - Advanced Course for Professionals (as above)
Consortium	**WERC** A Consortium for Environmental Education and Technology Development, http://www.werc.net/	WERC was established in 1990 through a cooperative agreement with the US Department of Energy. The WERC consortium combines the expertise from New Mexico's higher education institutions and national laboratories. Partner institutions include New Mexico State University (WERC headquarters), the University of New Mexico, the New Mexico Institute of Mining and Technology and Diné College, in collaboration with Los Alamos and Sandia National Laboratories. WERC's three-fold mission is to expand the nation's resources to address waste management and pollution prevention issues through: - education, technical and professional training programs - public outreach activities - technology development and deployment of new environmental applications

Radiation safety training organisation	**Radiation Safety Academy** http://www.radiationsafetyacademy.com/	Training courses include a wide range of topics such as Radiation Safety Management, Site Characterisation, Decontamination and Decommissioning, Radiation Regulations, Licensing, Inspection and Compliance, Radiation Risk Communication

Type	Department	Programme
University	**University of California Berkeley** **Nuclear Engineering**	Nuclear Waste Research Laboratory http://tauon.nuc.berkeley.edu/Group/group.html
	Oak Ridge Institute for Science and Education (OREISE)	Radiation Protection and Monitoring Course http://www.orau.gov/orise.htm
	Texas A&M University **Nuclear Engineering**	Nuclear Materials Management Research Group http://trinity.tamu.edu/research/waste/index.htm
	Penn State University	Graduate Programs http://www.nuce.psu.edu/
	Mechanical and Nuclear Engineering **University of Florida**	Graduate Courses http://www.nre.ufl.edu/courses/grad_courses.php
	Nuclear and Radiological Engineering **The Ohio State University**	Graduate Program http://rclsgi.eng.ohio-state.edu/nuclear/
	Nuclear Engineering **The University of Texas at Austin**	Nuclear and Radiation Engineering Program http://www.me.utexas.edu/~nuclear/

International Education and Training

Type	Title/organization/structure	Overview
International fund to promote nuclear energy research and training activities	The EURATOM 6th Framework Programme (**FP6**) “Research and training on nuclear energy” http://www.cordis.lu/fp6-euratom/ FP6 has been structured into three themes - fusion energy research - management of radioactive waste - radiation protection plus - “other activities” in the field of nuclear technologies and safety that includes education and training The main instruments for the programme include:: - Networks of Excellence - Integrated Projects - Specific Targeted Research or Training Projects - Actions to promote and develop human resources and mobility **More information: Annex 4**	- Proposals submitted in response to Calls for proposals undergo a selection process. For successful proposals, the European Commission enters into (financial and scientific-technical) contract negotiations. Successful negotiation will lead to a contract between the European Commission and participants - Participation is open for a research group at university, a company intending to innovative, Undergraduate students, Institutions running a research facility of trans-national interest, Organisations and persons from third countries. - Education and training on nuclear energy has the following objectives ➢ Development of a more harmonized approach for education in nuclear sciences and engineering and radiation protection ➢ Support for fellowship, training courses and grants for young researchers from NIS and CEEC - Budget for “the other activities” that include education and training is 50 million EUR (Total programme budget 190 mEUR) - Duration of programme: 2004-2008

University students mobility grants	**SOCRATES-ERASMUS** http://europa.eu.int/comm/education/index_en.html	The European Community programme in the field of higher education promotes students to carry out a period of study (between 3 months and a full academic year) in another of the 24 participating countries and provides Mobility Grants for Students.
Courses and Workshops	**International Atomic Energy Agency (IAEA)** Training in Radioactive Waste Management http://www-rasanet.iaea.org/training/wss-training.htm#events : ***More information: Annex 5 & 6***	The scope of the reference training material currently under development is focused on general fundamental principles for radioactive waste (RAW) (a different acronym from RW or SNF) management, safety requirements on predisposal and disposal activities. It has been structured in six main areas (30 modules): General Aspects, Predisposal Management of RAW, Disposal of RAW, Management of Special Waste, Environmental Restoration and IAEA Activities on Safety of Radioactive Waste Management http://www-rasanet.iaea.org/downloads/training/disp-training1.pdf (Training modules) http://www-rasanet.iaea.org/downloads/training/WSSStraining03.pdf (Courses and workshops 2003)

Nuclear Energy Agency of OECD (OECD/NEA)	**International School of Nuclear Law** http://www.nea.fr/html/law/isnl/index.html Participants enrolled in the ISNL programme have the possibility of applying for a University Diploma (Diplôme d'Université - D.U.) in International Nuclear Law. ***More information: Annex 7***	The objective of the School is to provide a high quality course of education on the various aspects of this discipline both to law students pursuing their studies at doctoral or masters level, who wish to follow an introductory course on nuclear law and familiarise themselves with career opportunities open to them in this field, and also to young legal professionals who are already active in the nuclear sector and who wish to develop their knowledge. http://www.nea.fr/html/law/isnl/PROGRAMME.pdf (Course programme 2003)

International University	**WNU** (World Nuclear University) http://www.world-nuclear-university.org/html/wnu_prospectus/ Through a worldwide network that coordinates, supports and draws on the strengths of established institutions of nuclear learning, the WNU will promote academic rigour and high professional ethics in all phases of nuclear activity, from fuel and isotope supply to decommissioning and waste management. **Mission statement. Worth noting the WNU has not begun operations yet.**	Facilitating development of standard curricula and Designing courses with strong international content: - Operational safety and performance - Radiological protection - Nuclear reactor engineering and fuel cycle technology - Industry economics - The non-proliferation regime and safeguards - Probabilistic risk analysis - Nuclear trade law, licensing and regulation - Liability and insurance - Nuclear transport - Clean-up, decommissioning and waste management - Nuclear applications in agriculture, medicine, hydrology and environmental protection - Innovation in a nuclear-renewables-hydrogen economy. Length of courses? Level?

School for Geological Disposal	**ITC School of Underground Waste Storage and Disposal** http://www.itc-school.or - Independent and non-profit educational/training school supported by 44 Member Organizations worldwide representing Universities, R&D Institutes, Waste Management / Regulatory Organizations and Industry - Featuring Underground Research Facilities that provide effective education/training infrastructures for geological disposal experts similar to the role of simulators for training reactor experts. - Some courses with accreditations from the Universities ***More information: Annex 8***	Scientific, Technical and Societal Issues on Geological Disposal such as - Fundamentals of Geological Disposal* - Theory and Practice of URL** - Design and trial of sophisticated URL experiments (e.g. Radionuclide Migration) - Academic/Specialist's Courses (e.g. Groundwater Geochemical Modelling, Safety Assessment Methodology) - Societal/communication aspects ITC held a 3-week training course featuring* and **above in collaboration with IAEA and SCK-CEN (Belgium) in autumn 2003 (See Annex 8)

Regional initiatives in Asia

Type	Title	Overview
Regional education network	**ANENT** Asian Network for Education in Nuclear Technology	- Proposed by the Republic of Korea and established in 2003 as a network of education and training institutions in Asia - Participated by 17 institutions from 11 member countries and 3 collaborating institutions - Action plan has been approved in February 2004 in the following areas ➢ Exchange of information and materials for education and training ➢ Exchange of students, teachers and researchers ➢ Distance learning ➢ Establishment of reference curricula and facilitation of credit transfer and mutual recognition of degrees ➢ Liaise with other networks and organizations http://www.pinenet.jp/english/e_f-symposium/pdf/gowin_p.pdf
Regional cooperative	**FNCA** Forum for Nuclear Cooperation in Asia	- Established in 1999 as a new framework to succeed the International Conference for Nuclear Cooperation in Asia (ICNCA) - Participated by 9 countries - Cooperation projects in the following areas

		➢ Utilisation of research reactor ➢ Mutation breeding ➢ Biofertilizer ➢ Medical use ➢ Public information ➢ **Radioactive waste management** ➢ Nuclear safety culture ➢ **Human resources development** ➢ Low-energy electron accelerator http://www.fnca.jp/english/index.html

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IAEA 2003b Managing human resources in the nuclear power industry: Lessons learned IAEA-TECDOC-1364

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GLOSSARY OF ACRONYMS

AEC Atomic Energy Commission (Japan)

AECL Atomic Energy of Canada Ltd

AFR Away from Reactor

ANDRA Agence nationale pour la gestion des déchets radioactifs

ANSTO Australian National Science and Technology Organisation

BGR Bundesamt für Rohstoff (Germany)

BMBF Federal Ministry for Education and Research (Germany)

BMU Federal Ministry of the Environment (Germany)

BNFL British Nuclear Fuels Ltd.

CEA Commissariat à l'energie atomique (France)

CNSC Canadian Nuclear Safety Commission

COGEMA Compagnie générale des matières nucléaires (France)

CORA Committee on Radioactive Waste Disposal (The Netherlands)

COVRA Central Organisation for Radioactive Waste (The Netherlands)

CRP Co-ordinated Research Project (IAEA)

DEFRA Department of Environment, Food and Rural Affairs (UK)

DiP Decision in Principle

DOE Department of Energy (United States)

EIA Environmental Impact Assessment

EKRA Expert group for waste management (Switzerland)

EM Environmental Management (United States)

ENRESA Empresa Nacional de Residuos Radioactivos SA (Spain)

EPA Environmental Protection Agency (United States)

ER Environmental Restoration

ERAM Morsleben ultimate storage site (Germany)

EURATOM European Atomic Energy Community

FEPs Features, Events and Processes

GTS Grimsel Test Site (NAGRA's underground research facility)

HADES High Activity Disposal Experimental Site (Belgium)

HRL Hard Rock Laboratory (Sweden)

HSE Health and Safety Establishment (UK)

JNFL Japan Nuclear Fuel (Japan)

IAEA International Atomic Energy Agency

IGSC Integration Group for the Safety Case
IPSN Institut de protection et sûreté nucléaire (France)
JAERI Japan Atomic Energy Research Institute
JAPCO Japan Atomic Power Company
JNC Japan Nuclear Cycle Development Institute
KAERI Korea Atomic Energy Research Institue
KINS Korean Institute of Nuclear Safety
L/ILW Low and intermediate level waste
LLW Low-level waste
MOX Mixed Oxide
NAGRA National corporation for the disposal of radioactive waste (Switzerland)
NAS National Academy of Science (United States)
NEA Nuclear Energy Agency
NPP Nuclear Power Plant
NRC Nuclear Regulatory Commission (United States)
NSC Nuclear Safety Commission (Japan)
OCRWM Office of Civilian Radioactive Waste Management (United States)
OMEGA Options for Making Extra Gains from Actinides and fission products
ONDRAF/NIRAS Organisme national des déchets radioactifs et des matières fissiles (France)
OPG Ontario Power Generation (Canada)
PAAG Performance Assessment Advisory Group
PRACLAY A project managed by SCK•CEN
PSI Paul Scherrer Insitute – Swiss Federal Research Institute
P-T Partitioning and Transmutation
QC Quality Control
RAWRA Radioactive Waste Repository Authority (Czech Republic)
RESRAD RESidual RADioactive Material (United States)
RWM Radioactive Waste Management
RWMC Radioactive Waste Management Committee of NEA
SF Spent Fuel
SNF Spent Nuclear Fuel
SKB Svensk Kärnsbränslehantering AB (nuclear fuel and waste management company – Sweden)

SKI State Nuclear Power Inspectorate (Sweden)
SOGIN Nuclear Facilities Management Company (Italy)
SSI Statens Strälskyddinstitute (state institute for radiation protection – Sweden)
STUK Radiation and Nuclear Safety Authority (Finland)
TC Technical Co-operation
TRU Transuranic
TVO An Electricity Utility (Finland)
URL Underground Research Laboratory
URF Underground Research Facility
USGS US Geological Survey (United States)
VLLW Very low-level waste
VTT Technical Research Centre of Finland
WASSAC Waste Safety Standards Committee
WATRP Waste Management Assessment and Technical Review Programme
WIPP Waste Isolation Pilot Plant (United States)
WMO Waste Management Organisation
ZWILAG Interim Storage Facility (Switzerland)

(after NEA 2001)

Web Portals

China Atomic Energy Authority

http://www.caea.gov.cn/english/index.htm

China has set up the personnel education and training system with universities, colleges and nuclear training organizations for systematic training young people in the field of nuclear technology and nuclear safety. At the same time, more attention has been given to the on-the-job training, all nuclear power and nuclear facilities dispatch a numbers of staff to universities or other training method, a lot of person would be well trained. The training center and training department within the nuclear power or installations also take a variety of measures to achieve and maintain a high level of capability on nuclear technology and safety culture. Some encouragement measures are also considered to being taken to attract and promote more young people devoting to nuclear technology work.

(IAEA Country Profiles)

http://www-pub.iaea.org/MTCD/publications/PDF/cnpp2002/index.htm

International Nuclear Research Center of Russian MINATOM

http://www.insc.ru/main/adver-frame.html

Founded in accordance with a Joint Declaration on Establishing International Nuclear Safety Centers, adopted in January 1996, in Washington during the Sixth Session of the Gore-Chernomyrdin Commission on economical and technological cooperation.

The Russian and U.S. International Centers are under the general direction of the RF Minister for Atomic Energy and the US Secretary of Energy, respectively.

Collaboration between the Centers is effected through coordination of work and the organization of joint projects.

Russian Methodological and Training Center
http://www.nti.org/db/nisprofs/russia/forasst/doe/rmtc.htm

In March 1994, the Russian Federation Ministry of Atomic Energy (Minatom) decided to establish the Russian Methodological Training Center (RMTC) at the Institute of Physics and Power Engineering (IPPE) in Obninsk, Russia. In March 1995 an agreement was reached between Minatom and Gosatomnadzor (GAN) (Is GAN the nuclear regulator?) to share the facility as a state training center.[1] On 4 November 1998 the RMTC was officially opened.[2] The purpose of this center is to train Russian nuclear specialists in the area of materials protection, control, and accounting (MPC&A).[1] Two other principal tasks of the RMTC are to provide scientific and technical assistance to companies and facilities that develop MPC&A techniques and to test and evaluate methods and instrumentation for measuring nuclear material mass and content. This seems to be non-proliferation oriented. The NWMO might well want some international training in this area, but more likely from the US, the UK or France. Or the IAEA.

Center for Nuclear Safety for Central and Eastern Europe
http://www.censee.org/cens.php?id=1

The Center for Nuclear Safety (CENS) in Central and Eastern European Countries (CEEC) traces its origins to bilateral, technical co-operation projects of the Swiss Federal Nuclear Safety Inspectorate (HSK) in the late 1990s. Funding for these projects was provided by the Swiss Agency for Development and Cooperation (SDC), which supported the development of the CENS as a new approach to technical co-operation between regulatory bodies of East and West. Designing the CENS involved close collaboration between the HSK, the International Atomic Energy Agency (IAEA), GRS (Gesellschaft für Anlagen- und Reaktorsicherheit mbH), and the Nuclear Regulatory Authority of the Slovak Republic (UJD).

Annexes

The Annexes referred to in the Data Tables are presented in the following pages. These are examples of existing training and educational activities relevant to the field of radioactive waste management.

Some Annexes are presented as embedded files that can be accessed only in the electronic version of this report. The links for these Annexes are shown below – simply click on the portal below.

Annex 1 BNEN

http://www3.sckcen.be/bnen/

Annex 4 EUFP6

http://www.cordis.lu/fp6-euratom/

Annex 5 IAEA Training Modules

http://www-rasanet.iaea.org/downloads/training/disp-training1.pdf

Annex 6 IAEA Courses 2003

http://www-rasanet.iaea.org/downloads/training/WSSStraining03.pdf

Annex 9 IAEA TECDOC-1254

http://www-pub.iaea.org/MTCD/publications/PDF/te_1254_prn.pdf

Annex 2: INSTN

http://www-instn.cea.fr/html/A_gene/a_accuei.htm

Nuclear engineering education in France" Génie Atomique "

Nuclear Engineering education in France falls within a specific " Génie Atomique " (Nuclear Engineering) post-graduate programme. In fact, contrary to the American system, for example, no such complete academic cycle exits at the post-graduate level within French universities. Of course, there are various university programmes in nuclear physics, materials, radiochemistry and other fields, but all of these theoretical and practical areas that combine to make up what can really be called " nuclear engineering " are covered only by the " Génie Atomique " programme within the INSTN.

Since the early 1950's, the need became apparent in France as in many other countries to train engineers to have an overall view of all of the sciences and technologies involved in building and operating nuclear plants and fuel cycle plants. Training engineers in nuclear engineering meets this need.

Students pursue their study programmes at the INSTN, either at the Saclay centre (near Paris) or the Cadarache centre (near Aix-en-Provence). An other site is dedicated to the training of military personnel, but hereafter is presented only the civil part of the " Génie Atomique ".

The " Génie Atomique " programme lasts one academic for students already graduated from engineering schools or equivalent [for students graduated from the University, a preparatory year has been organised for 17 years] and is broken down into two successive periods :

- **A six-month study period during which students become acquainted with a set of disciplines often totally new to them. For example :**

  - neutronics
  - reactor physics : kinetics, reactor control
  - thermal physics and diphasic thermohydraulics
  - nuclear and structural materials
  - nuclear instrumentation
  - physico-chemistry of the nuclear fuel cycle
  - radiation protection
  - safety...

During this period, students also study more thoroughly the conception, operation and safety of a Pressurized Water Reactor.

Emphasis is placed on the fact that over these first periods, students carry out many " practical tasks ", specifically on CEA experimental reactors and on normal operation or emergency situation simulators.

One of the characteristics of this study programme is the fact that the teachers are mostly " professionals " in the industry or the nuclear research field, high-level engineers or researchers communicating their knowledge and personal experience.

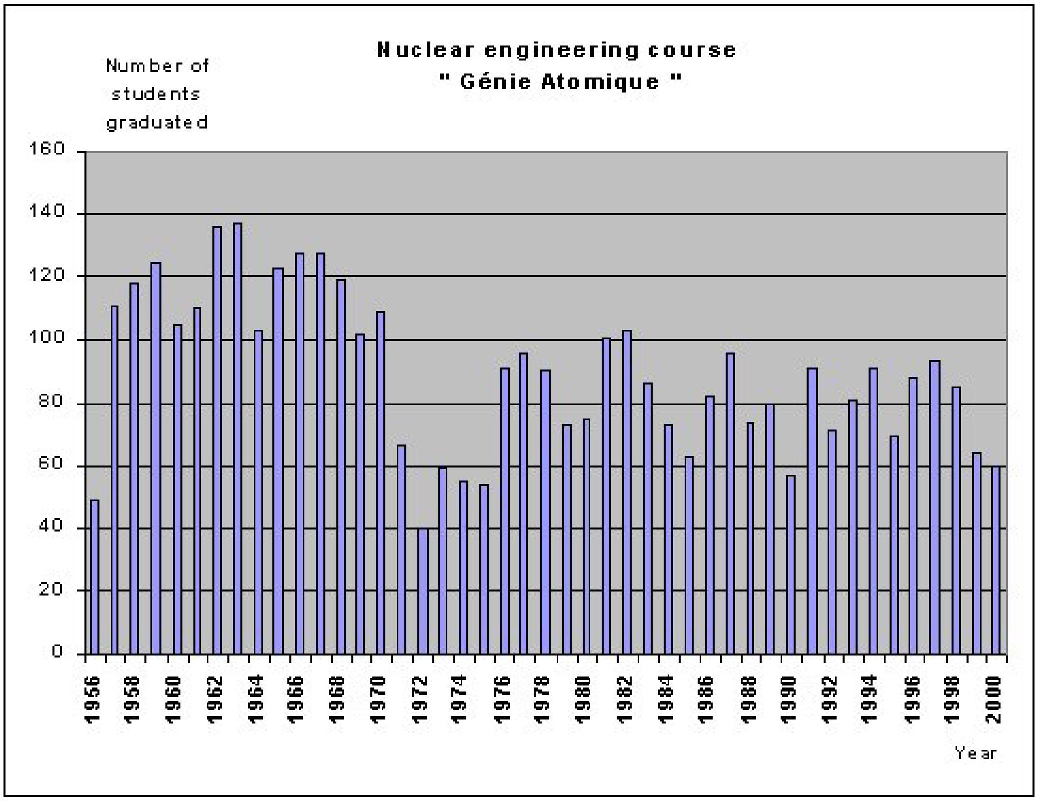
- **Study " Project " over five months**

  Students, in groups of two or three, study a project during a course of instruction held in a CEA Division, in the main nuclear branch companies (AREVA Group, TECHNICATOME...), in an EDF department or in foreign institutions.

The project involves studying a nuclear plant completely, and allows the student to tackle all the aspects of nuclear engineering and to master their complex interactions. The overall study of nuclear " systems " helps the student to understand the necessary choices inherent in any achievement of such importance.

After completing this course of study, the student is awarded the " Génie Atomique " degree. There are currently 70 students a year in these classes. Approximately 4,000 degrees have been awarded by this program since it was created in 1956.

Nuclear engineering study programmes, unique in France, make up the specific training of all of those who, afterwards within multidisciplinary teams, will hold positions of responsibility for the design of entire nuclear systems, nuclear plant operation, safety analyses, radiation protection...


Nuclear engineering course
" Génie Atomique "
Number of students graduated
160
140
120
100
80
60
40
20
0
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
Year

Annex 3. UK National Radiation Protection Board

http://www.nrpb.org/

Course on Management of Radioactive Waste

New discharge authorisations for nuclear sites will specifically require operators to have formally qualified experts who will be involved in, and advise on, compliance with the conditions of authorisations, including commissioning, testing and calibration of instruments and devices used to measure discharges and protect the environment. This course has been developed to provide the necessary technical knowledge for those experts advising on radioactive waste management issues.

Scope

This 3½-day course introduces the various disposal options that are available in the UK and examines the associated pathways by which the public can be exposed. The methodologies by which the radiological impact can be assessed from activities discharged are presented, together with a discussion on the rationale for environmental monitoring. Practical issues of radioactive waste disposal are discussed.

It is strongly recommended that students should have attended the Foundation in Radiological Protection Course, or have a detailed knowledge of its content, and have attended the UK Legislation and International Recommendations Course, or have detailed knowledge of the principal requirements of the Radioactive Substances Act 1993.

Aims

To provide an understanding of:

- radioactive waste disposal options and associated exposure pathways in UK practice.
- methodologies for estimating the radiological impact of radioactive waste disposal.
- methodologies for monitoring.
- regulatory and policy issues relevant to radioactive waste management and disposal.
- practical implications for radioactive waste management and disposal.

Course Content

- Review of radioactive waste and the disposal options
- Guiding principles for the control of radioactive waste
- Control through the regulatory process
- Discussion: the role of the regulator
- Radiological impact of authorised discharges
- Radiological impact of radioactive waste repositories
- Discharges to atmosphere
- Monitoring of radioactive gaseous discharges
- Discharges to aquatic environments
- Exercise: calculation of radiological impact of discharges
- Environmental monitoring
- Nuclear industry waste disposals
- 'Small user' waste disposals
- Exercise: considerations for authorisation
- The role of the radioactive waste disposal contractor
- Student assessment

The course will be held at the NRPB Training Centre at Chilton.

Please consult the booking conditions before returning the form as they are a pre-requisite for its completion. Details of the standard administrative arrangements for courses are available in HTML format.

For further information about professional level courses, please contact Ian Collingwood, Scheme Manager:

National Radiological Protection Board
Chilton
Didcot
Oxon
OX11 0RQ
Telephone: +44 (0)1235 822703
Fax: +44 (0)1235 822650
E-mail: rpts@nrpb.org

Annex 4: OECD/NEA International School of Nuclear Law

http://www.nea.fr/html/law/isnl/index.html

Sponsorship

The International School of Nuclear Law was established by the University of Montpellier 1 in co-operation with the OECD Nuclear Energy Agency. The School benefits from the support of the European Commission and the International Nuclear Law Association.

Course Objective

The objective of the School is to provide a high quality course of education on the various aspects of this discipline both to law students pursuing their studies at doctoral or masters level, who wish to follow an introductory course on nuclear law and familiarise themselves with career opportunities open to them in this field, and also to young legal professionals who are already active in the nuclear sector and who wish to develop their knowledge.

Independently of its teaching role, the School serves as a forum for students to meet recognised specialists in nuclear law in a studious yet convivial atmosphere.

Programme

The current educational programme of the School essentially consists of an introductory course on nuclear law.

The School will hold its next Session from Monday 25 August to Friday 5 September 2003 inclusive.

The programme for the 2003 session will include the following classes: protection against ionising radiation (including the use of radiation sources); safety of nuclear installations; radioactive waste management; transport of nuclear materials; physical protection (including the illicit trafficking of nuclear materials); non-proliferation; regulation of trade; third party liability and the indemnification of nuclear damage.

The number of participants is limited to approximately 50 persons. Should any selected participants subsequently withdraw their application, persons on the waiting list will be allowed to participate in the session.

Persons selected to participate in the programme will receive documentation in advance enabling them to prepare for their courses, and they may be requested to undertake a certain amount of research work.

The School will deliver a certificate to each student, testifying to their active participation in classes. Students are also encouraged to submit a written dissertation approximately two months after the annual session on a subject of their choice. The best dissertations are then selected for publication in the NEA *Nuclear Law Bulletin* or in other legal reviews.

The School is in the process of developing an internship programme for ISNL participants in co-operation with international organisations, national administrations and companies specialised in the field of nuclear law. As the number of internships available is limited, they will be awarded to the most deserving students each year, based on their active interest and participation in the course, and on the quality of the dissertation submitted.

Director

Pierre Bringuier, Professor of Public International Law, University of Montpellier 1, France

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Jacques Percebois, Dean, UFR Sciences économiques, Espace Richter, Montpellier, France

Hisashi Tanikawa, Director, Japan Energy Law Institute, Tokyo, Japan

Location: University of Montpellier

Annex 5: ITC School of Underground Waste Storage and Disposal

www.itc-school.org

Objective

The school provides both theoretical and practical training and research in all aspects of science, engineering, decision-making and communication concerned with underground waste management and related environmental issues. It is linked directly to active underground experimental facilities - in particular, the Grimsel Test Site. It will offer professional training at all levels, ranging from academic courses and modules in association with universities around the world, to summer schools and retreat facilities for think tanks and policymakers.

Worldwide, there are many initiatives to store or dispose of highly toxic chemical and radioactive wastes in deep underground facilities. Geological disposal is seen as the only safe, practical and sustainable solution for many of the intractable residues that inevitably remain after waste minimisation and recycling. The NWMO has a mandate to look at long-term management options other than disposal.

The timescale over which any one of these projects will be developed, operated and subsequently decommissioned is typically several decades. Those who initiate the planning of projects will be unlikely to implement them or see them through to completion. Like a space journey to the nearest star. In some countries, there is already a problem of maintaining the expertise base and ensuring that trained scientists and engineers will be available when and where they are needed.

Over the next few decades, the ITC international school will provide a focus for the propagation of knowledge and experience and the continued training of scientists, engineers and decision-makers to meet the future needs of industrial organizations and government agencies worldwide. The ITC will not be biased towards implementor, regulator, research organization (z in English) or any interest group, but will provide a balanced service for all, in the interests of environmentally sound waste management.

The impetus to launch the school comes from the radioactive waste sector. However, almost all of the science, engineering and societal issues involved in that sector are mirrored in other environmental areas. Chemical waste and contaminated land management, as well as the broad field of environmental and sustainable development (?) decision-making, require scientists, engineers, managers and regulators with the same key skills. ITC will integrate teaching and experience across all of these fields. Seems like a great approach.

The intention of ITC is to act as the hub of a network of industrial, academic and governmental organizations and to provide a broad service to all of them. It is principally a venue for structured teaching activities and an anchor point for individuals undertaking progressive learning programmes over several years. It is not intended to usurp the functions of any organization, but to supplement and enhance their activities.

ITC will be one of several planned training centres that are currently being discussed in Europe, the USA and Japan. The demand is such that a network of facilities would be expected to develop as more projects move from a planning to an implementation stage.

Users

The users include:

- Professionals in waste management who have just started a career.
- Experienced professionals in waste management who have changed or broadened responsibilities.
- Masters and PhD students
- Undergraduate students
- Policymakers
- Interest groups and the media
- Technicians?

Most of the scientific and engineering development of underground disposal concepts has come from the nuclear industry, although progress has been slow, and, in some countries, more practical experience exists in disposing of other types of hazardous wastes. Past practices in disposal of hazardous waste underground (e.g. liquid injections) have not always been appropriate. It is likely that the environmental requirements for all types of underground disposal will converge towards the approaches and standards being developed for long-lived radioactive waste disposal.

There is a widely acknowledged need to propagate knowledge, both in countries with active underground disposal programmes (where there is a shortage of experts) and in those experiencing delays or slow progress, particularly in radioactive waste disposal programmes, where skilled people move out of the field and knowledge is being lost. Programmes started in the 1970s and 80s will soon find their experienced managers retiring - where programmes are 'on hold', the succession of trained staff may be hard to assure. Some countries are only just starting to develop programmes, and here there is a need to provide basic training for people new to the field. A key issue is to develop the confidence of managers in new programmes, by exposing them to the experience of those who have had to make and justify decisions on important public sector matters, such as facility siting or licensing.

Services offered

Professional Courses 3, 5 and 10 days	Introductory courses for professionals in waste management who have just started a career Update/transition/refresher courses for experienced professionals in waste management who have changed or broadened responsibilities (e.g. at major programme milestones) Progressive, linked courses to allow development of training over a period of years, tailored to individual requirements Underground R&D training for those starting practical testing or experimental work
Academic Modular Courses 5 to 10 days	Postgraduate modules for Masters and PhD students in environmental science, engineering and policymaking
Research	Postgraduate research training leading to masters or doctorate level degrees, with special emphasis on the use of underground laboratory facilities
Summer Schools 5 to 10 days	Undergraduate summer schools: introduce concepts to high-flier students about to enter research or professions

	Information dissemination on topical areas and issues for interest groups and the media
Retreats 3 to 5 days	Quiet retreats for focussed analysis of problems in a 'think-tank' environment: for policymakers or groups facing complex decisions (facilitators and services provided as required)
Distance Learning	Continuation and supplementary courses using the internet: to prepare students for courses and to follow up after courses

Membership

Membership of the Association is open to organisations willing to support and promote the purpose of the Association. ITC is a non-profit Association, operated for the benefit of its members. Its finances are arranged so as to cover its costs and allow a small development margin to provide extended services to the waste management community.

ITC needs to be able to provide a service to the broadest range of users if it is to achieve its aim of perpetuating knowledge in order to provide optimum waste management solutions. Consequently its programme and objectives are not biased towards any sector (e.g. industry, regulators, research groups) This means that members have a clear voice in its operation and management and that its funding is not tied to one source.

ITC has been established as an independent organisation within Switzerland, with the legal structure of an association (Verein). Membership of the Association is open to any organisation supporting the aims of the ITC.

ITC Members (as of January 2004) This seems to encompass a number organizations that are not in the national Data Tables, and vice-versa.

Belgium

- SCK-CEN, Belgian Nuclear Research Center
  www.sckcen.be/

Czech Republic

- RAWRA, Radioactive Waste Repository Authority www.rawra.cz/

Finland

- University of Helsinki
  Department of Chemistry www.chemistry.helsinki.fi/english/
- POSIVA OY. www.posiva.fi/

Germany

- BfS, Federal Office for Radiation Protection www.bfs.de/bfs?setlang=en

Hungary

- PURAM, Public Agency for Radioactive Waste Management www.rhk.hu/

Italy

- University of Rome "La Sapienza", Department of Earth Sciences Fluid Geochemistry Laboratory http://tetide.geo.uniroma1.it/

Japan

- AIST (National Institute of Advanced Industrial Science and Technology)
  Research Center for Deep Geological Environments
  www.aist.go.jp/index_en.html
- CRIEPI (Central Research Institute of Electric Power Industry
  http://criepi.denken.or.jp/eng/
- Hazama Corporationwww.hazama.co.jp/
- IAE, The Institute of Applied Energy www.iae.or.jp/

- IEAJ, IEA of Japan Co. Ltd. www.ieaj.co.jp/
- JGC Corporation www.jgc.co.jp/en/index.html
- JNC, Japan Nuclear Cycle Development Institute www.jnc.go.jp/jncweb/
- JNFL, Japan Nuclear Fuel Limited www.jnfl.co.jp/english/
- KAJIMA Corporation www.kajima.co.jp/welcome.html
- Nagoya University
  Division of Environmental Engineering and Architecture
  Graduate School of Environmental Studies www.civil.nagoya-u.ac.jp/
- The Nagoya University Museum www.num.nagoya-u.ac.jp/flame.html
- OBAYASHI Corporation www.obayashi.co.jp/english/
- RWMC, Radioactive Waste Management Funding and Research Center
  www.rwmc.or.jp/
- Saitama University, Geosphere Research Institute www.gris.saitama-u.ac.jp/
- SHIMZ Corporation www.shimz.co.jp/english/
- Taisei Corporation www.taisei.co.jp/english/index.html

Slovenia

- ARAO, Agency for Radioactive Waste Management
  www.sigov.si/arao/

Spain

- UPC, Technical University of Catalonia, Department of Geotechnical
  Engineering and Geo-Sciences www.upc.es/
- UPV, Polytechnic University of Valencia
  Department of Hydraulics and Environmental Engineering
  www.upv.es/informa/estudiosi.html

Sweden

- SKB, Swedish Nuclear Fuel and Waste Management Co www.skb.se/
- SKI, Swedish Nuclear Power Inspectorate www.ski.se/se/index_english.html
- SSI, Swedish Radiation Protection Authority www.ssi.se

Switzerland

- ARIUS, Asociation for Regional and International Underground Storage www.arius-world.org/

- ETH, Swiss Federal Institute of Technology
  Institute of Hydromechanics and Water Resources Management
  www.ihw.ethz.ch/uebersicht_en.html
- Geotechnisches Institut AG www.geo-online.com
- HSK, Swiss Federal Nuclear Safety Inspectorate, Switzerland
  www.hsk.psi.ch/
- Nagra, National Cooperative for the Disposal of Radioactive Waste, Switzerland
  www.nagra.ch/
- PSI, Paul Scherrer Institute http://www.psi.ch/index_e.shtml
- SOLEXPERTS Ltd. Switzerland http://www.solexperts.com/
- University of Bern www.unibe.ch/
- University of Fribourg
  Department of Geosciences www.unifr.ch/geoscience/

United Kingdom

- British Geological Survey www.bgs.ac.uk/
- University of Leeds, Centre for Decision Research
  www.leeds.ac.uk/decision-research/
- University of Manchester, Environment Centre, UK www.man.ac.uk/umec/
- University of Sheffield Engineering Materials Department
  www.shef.ac.uk/materials/

USA

- CNWRA, Center for Nuclear Waste Regulatory Analysis
  www.swri.edu/4org/d20/d20home.htm
- University of Michigan Department of Nuclear Engineering and Radiological Sciences http://www.ners.engin.umich.edu/

ITC Inaugural Course

The Fundamentals of Geological Disposal & The Theory and Practice of Underground Rock Facilities

A modular one, two or three-week course, including practical scientific and technical exercises underground

October 20th – November 7th 2003

Programme

This course outline looks very worthwhile and has lots of detail, perhaps more than needed. There should be a list of acronyms. Apart from the content, it would be useful to know where the course takes place, how much it costs, the prerequisites (is it only for scientists and engineers?), etc. The two 3rd weeks are presumably either/or options.

The course is very technical. Are other courses contemplated that would look more at the social and process aspects of radioactive waste management?

FRIDAY 24th October		
0830 - 1000 **90 mins**	**Strategic issues facing new programmes: structuring a disposal programme** Integrating all national disposal requirements; development of national policy; issues in establishing a regulatory framework and appropriate standards; defining organisational roles and inter-relationships; links with other environmental problems; ensuring equity of resource allocations; establishing funding mechanisms. The key components of a repository programme and how they fit together and evolve during the lifetime of a disposal programme: identification of the problem and options for solution, the necessary R&D, the technical, legal and social framework; movement from generic to specific in field studies and safety studies; optimisation of the system	Piet Zuidema Nagra
1030 - 1200 **90 mins**	**Problem wastes** Wastes on the fringes of geological disposal - NORM wastes, spent sources, ex-weapons fissile materials; amounts and characteristics; policies and standards applying to these wastes; current approaches to management; the problem issues associated with each type; possible geological disposal solutions.	Neil Chapman ITC
1200 - 1300	Lunch	
1300 -1430 **90 mins**	**Geological disposal, past and future** Where the concept originated and how it has developed since the 1950s; how national programmes started and developed; successes and failures; major evolutionary changes in the concept; alternative ideas that have been abandoned; future developments - international repositories, likely obstacles to national programmes, remaining technical issues to be solved.	Charles McCombie ARIUS
1430 - 1445	**Wrap-up and close**	Neil Chapman ITC

WEDNESDAY 22nd October		
0830 - 1000 **90 mins**	**Safety standards and regulations** Basic international ethical and radiological principles underlying regulatory standards (IAEA, ICRP, etc); concepts of dose and risk; other components of regulations - e.g. non-human impacts, requirements for contents of safety assessment, treatment of timescales, uncertainty, etc; how standards and principles are applied in different countries; future developments internationally (e.g. ICRP recommendations).	Auguste Zurkinden HSK
1030 - 1300 **150 mins**	**Objectives, structure and implementation of safety assessments** Definitions of performance and safety assessments; their varying objectives at different stages of a repository development programme; components of a safety case; structuring a safety assessment; types of modelling and calculations performed; use of scenarios; presenting results in different ways for different audiences; example results for different geological disposal concepts in different countries.	Jürg Schneider Nagra
1300 - 1530	Lunch and afternoon study break	
1530 -1730 **120 mins**	**Gathering data for design and safety assessment** Identifying and prioritising data requirements within a PA/SA using sensitivity analyses; types of data and typical data needs at different stages of a programme; current sources of data (what has been completed already and what remains to be done) - laboratory programmes, field data, URLs; natural analogues and their use (examples); useful existing databases.	Hiroyuki Umeki NUMO
THURSDAY 23rd October		
0830 - 0945 **75 mins**	**Selecting a repository site** International guidelines on site suitability; national experience in selecting sites; political and technical constraints; stepwise narrowing down to an acceptable site; contentious issues in siting	Charles McCombie ARIUS
1000 - 1230 **150 mins**	**Repository site characterisation: hard rocks (& generic strategies)** Stages in characterising a site during the selection process; deployment of various field techniques - appropriate strategies for regional and site scale characterisation; advanced geosciences techniques (geophysics, hydrogeology, geochemistry, rock mechanics, eco-systems, active faults, neotectonics); managing data & QA; data synthesis and interpretation of site properties and evolution into descriptive models; approaches in different geological environments (rock types, geographical situations: e.g. inland, coastal) and for different repository concepts.	Olle Olsson SKB
1230 - 1500	Lunch and afternoon study break	
1500 - 1630 **90 mins**	**Repository site characterisation: sediments** Regional and site scale characterisation in sediments; advanced geosciences techniques (geophysics, hydrogeology, geochemistry, rock mechanics, neotectonics). Approaches in different geological environments (rock types, geographical situations: e.g. inland, coastal) and for different repository concepts. Examples from national programmes worldwide.	Tim McEwen SAM Ltd
1630 - 1800 **90 mins**	**Building trust and confidence** Social and political problems with achieving a repository programme - examples for different countries; designing programmes to account for stakeholder views and input; identifying concerns; addressing concerns; techniques for building confidence; communicating with different audiences; dialogue projects and their findings; how to be open and transparent.	Hideki Sakuma JNC / ITC

Week 2: Concepts and theories of underground rock facilities

Time	Topic	Presenter
	MONDAY 27th October	
0900 - 0945 **45 mins**	**Orientation** Introduction of participants. How the week will work: structure and objectives of course, practical information for participants.	Wolfgang Kickmaier Nagra / ITC
0945 - 1045 **60 mins**	**Types of URF and their place at different stages of a national programme** URFs as generic and site/formation-specific research laboratories, rock characterisation facilities at potential repository sites, pilot test and demonstration facilities in the construction of a repository. How these are used at different times in national programmes: the different types of information that will arise and how these fit into a repository development programme	Neil Chapman ITC
1115 - 1230 **75 mins**	**A topical example: the use of data from Mt Terri in the Opalinous Clay repository feasibility study, 2003** How information from the Mt Terri URL was used to support the scientific and technical basis of the repository design and performance assessment studies for a potential repository in the same formation at a different site: how the PA & design work provided feedback into experimental design at the URL	Andreas Gautschi Nagra
1230 - 1530	Lunch and afternoon study break	
1530 - 1730 **120 mins**	**The history of URFs: lessons learned for the future** The history of URFs from the 1960s to date, showing how objectives have evolved and knowledge has grown, which issues have been resolved and which topics remain to be studied. Practical experiences of gaining approval to build URFs, running large scale experiments, multinational experiments, active tests and demonstrations. The future direction of URF work in different geological environments	Hideki Sakuma JNC / ITC
	TUESDAY 28th October	
0830 - 0900	Travel to Grimsel Test Site	
0900 - 1000 **60 mins**	**Working in hard rock environments: Grimsel introduction** The main topics that have been studied in the GTS and how these have related to the evolving Swiss programme. The practical factors involved in setting up and running a hard-rock URL; access, ownership, construction, using active tracers, management of site, maintenance, visitors, etc.	Wolfgang Kickmaier Nagra / ITC
	Coffee	
1030 - 1200 **90 mins**	**Introduction to the current experiments** **HPF** Hyperalkaline Plume in Fractured Rock **CRR** Colloid and Radionnuclide Retardation Experiment. **GAM** Gas Migration in Shear Zones **CTN** Conclusions of the Tunnel Nearfield **FEBEX I/II** Full-scale Engineered Barrier Experiment **GMT** Gas Migration Test in the EBS and Geosphere	Paul Marschall Colin Biggin Wolfgang Kickmaier Nagra
1200 - 1245	Buffet Lunch (underground)	

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1245 - 1415 **90 mins**	**Visit to the experiments** Examination of the experimental sites and equipment and continued discussion.	Paul Marschall Colin Biggin Wolfgang Kickmaier Nagra
1415 -1545 **90 mins**	**Practical limitations of test and experimental design** Constraints on test methodology as a result of formation properties and response times, borehole properties, measurement limits, equipment design and capabilities, with specific reference to hydraulic test equipment.	Paul Marschall Nagra
1600 - 1630	Return to hotel	
	WEDNESDAY 29th October	
0900 - 1030 **90 mins**	**Evaluation of large-scale EBS projects: FEBEX** Detailed evaluation of the objectives, design, instrumentation and operation of FEBEX, at how the results were interpreted and their implications for EBS design and repository operation and perfromance. Assessment of experimental problems and interpretation uncertainties. Lessons learned for future experiment design	Fernando Huertas ENRESA
1100 - 1230 **90 mins**	**Evaluation of large-scale EBS projects: GMT** Detailed evaluation of the objectives, design, instrumentation and operation of GMT, at how the results were interpreted and their implications for EBS design and repository operation and performance. Assessment of experimental problems and interpretation uncertainties. Lessons learned for future experiment design	Stratis Vomvoris Nagra
1230 - 1530	Lunch and afternoon study break	
1530 -1730 **120 mins**	**Working in sedimentary environments: the Mol experience** The key issues connected with design and PA in sediments that have been studied in the Boom Clay at Mol. How these were identified and how experiments were designed to address them. Evaluation of the principal Mol experiments: past and present. How knowledge has evolved. Operational and safety aspects of working in soft sediments. Issues in sedimentary formations other than clays.	Bernard Neerdael SCK•CEN
	THURSDAY 30th October	
0730 - 1030	**Travel to Mt Terri URL**	
1030 - 1100 **90 mins**	**Introduction to the site and the experiments** Presentation of the Mont Terri Project (Purpose, organisation, management, information)	Marc Thury FOWG
1100 - 1130	The Mont Terri Research Programme	Paul Bossart GI Ltd
1130 - 1230 **60 mins**	**Visit to the experiments** Visit of the Rock Laboratory and main experiments	Marc Thury Paul Bossart
1230 - 1330	Lunch (buffet)	
1330 - 1500 **90 mins**	Presentation and discussion of the main experiments	Paul Bossart Marc Thury
1500 - 1800	Return to hotel	

FRIDAY 31st October		
0900 - 1000 **60 mins**	**Geosphere Retardation Processes** The role of the geosphere and methods of gaining process understanding. **1. Why do we do tracer tests?** Objectives of the exercise and how it will be run. 1.1 Why do we do tracer tests? 1.2 Overview and discussion of the Radionuclide Retardation Programme (RRP) performed at the GTS 1.3 The integration of related studies such as natural analogues and laboratory experiments.	Russell Alexander and Bernd Frieg Nagra Russell Alexander
1000 - 1200 **60 mins** **60 mins**	**2. Tracer test exercise** 2.1 Design and set up of a tracer test using radionuclides in (fractured) rocks to meet specified objectives. 2.2 Experimental approach 2.2.1 Choice of equipment 2.2.2 Experimental approach and time planning 2.2.3 site selection and characterisation 2.2.4 Tracer selection	Russell Alexander Bernd Frieg
1200 - 1300	Lunch	
1300 -1445 **105 mins**	**3. Equipment development for tracer testing** 3.1 Introduction 3.2 At the beginning of MI - a steep learning curve 3.3 A maturing MI programme 3.4 EP - something else	Bernd Frieg
1445 - 15-30 **45 mins**	**4. Lessons learned and how this should be reflected in future programmes**	Russell Alexander
1530 - 1600 **30 mins**	**Final Remarks week two**	Wolfgang Kickmaier Nagra / ITC

Week 3: Practical Training in Hard, Fractured Rocks at the GTS

MONDAY 3rd November

Departure from the hotel → around 8:15 depending on weather conditions

Introduction, geological mapping and drilling

Starting time	Duration	Location at GTS	Topic	Responsible
09:15	30'	Meeting room	**Introduction** – Logistics, Safety, Programme week 3	W. Kickmaier Nagra / ITC
09:45	30'	Meeting room	**Geology of GTS** - Regional geology and structure structural evolution at the GTS (taking the Migration shear zone as an example) - Properties of the Migration shear zone on a microscopic scale (architecture, mineralogy, geochemical properties)	M. Mazurek University of Berne
10:15	60'	Meeting Room	**Geological and hydraulic properties of water conducting features in crystalline rocks - a review** - Definition and attributes - Investigation methodology - Structural, hydraulic and geochemical properties - Case studies and examples	M. Mazurek
11:15	60'	On site	**Excursion into the tunnel system** Show lithological variations within the lab (ZAgr, GrGr, Lamprophyres etc.) - Shear zones - Mineralogical and structural description of the host rocks present at Grimsel	A. Möri (lead) GI Geotechnical Institute (M. Mazurek)
12:15	45'	ZB	Lunch	
13:00	30'	Meeting room	**Methodology for shear zone (water conducting features) characterisation** - Surface mapping: what can we learn from the surface and boreholes for an URL - Tunnel and core mapping - Structural data base - Structural geological model (2D&3D)	A. Möri
13:30	2*1.5h; in two groups	VE-tunnel (TBM-excavated) BK tunnel drill & blast excavated)	**Practical mapping exercise** - Detailed, structural mapping of a tunnel surface - Core mapping	A. Möri (lead) (M. Mazurek)
	2*1.5h; in two groups	WT-tunnel or BK area	**Practical drilling exercise** - Drilling exercise through matrix and through a shear zone - Discussion on core recoveries techniques (undisturbed core sampling)	T. Baer (W. Kickmaier)
16:30			Departure	

TUESDAY 4th November

Departure from the hotel → around 8:15 depending on weather conditions

Pore space characterisation & Radioprotection

Starting time	Duration	Location at GTS	Topic	Responsible
9:15	120'	Meeting room VE-Tunnel	**In-situ shear zone and Matrix impregnation** - In situ application of different types of resign for shear zone and matrix impregnation - Application for porosity determination and conceptualisation of flow paths in shear zones	A. Möri
11:15	60'	Meeting room	**Summary and open discussion**	W. Kickmaier all
12:15	60'	ZB	Lunch	
13:15	60'	Meeting room	**Radioprotection** - Principle of radioprotection - Legislative aspects of radioprotection - Radioprotection in underground facilities	C. Biggin Nagra
14:15	120'	Controlled zone	- Practical demonstration of instrumentation and infrastructure required for in-situ testing - Radioprotection in underground facilities - Discussion	C. Biggin (A Möri)
16:15			Departure	

WEDNESDAY 5th November

Departure from the hotel → around 8:15 depending on weather conditions

Tracer testing: injection and test evaluation

Starting time	Duration	Location at GTS	Topic	Responsible
9:15	45'	Meeting room	**Introduction to Hydrotesting**	R. Alexander Nagra Th. Fierz Solexperts AG
10:00	90	CRR site	**Hydrotest** - field stability and data acquisition - preparation of tracers	Th. Fierz R. Alexander
11:30	100'	Meeting room	**Evaluation of hydrotests (with existing data)** - - Errors/precision of data (emphasis – not reading too much into the data	Th. Fierz R. Alexander
13:00	60'	ZB	Lunch	
14:00	120	Meeting room CRR site CRR site CRR site	**General introduction to in-situ tracer testing** - flow field stability , data acquisition - preparation of tracer cocktail - perform tracer injection, measure input function **Presentation of field equipment and data acquisition** - packer systems - data acquisition - injection device - flow controller, probes for Eh, pH etc. - minimisation of dead volume **Installation of test equipment** - flow field stability and data acquisition - prepare tracer cocktail No.1 - perform tracer injection **Establish flow field** - field stability and data acquisition	Th. Fierz R. Alexander
16:15			**Departure**	

THURSDAY 6th November

Departure from the hotel → around 8:15 depending on weather conditions

Tracer- and hydrotesting: Equipment and installation, hydrotesting

Starting time	Duration	Location at GTS	Topic	Responsible
09:15	90'	CRR site	**Tracer breakthrough:** - Finalise field phase of the Wednesday session, check data, extract field data from data acquisition	Th. Fierz
10:45	30'	CRR site	**Evaluation of test data:** - Distribute raw data (ascii files), produce Excel plot of breakthrough curve and recovery (work two by two) - Determine characteristic times of curve (first arrival, peak residence) - Determination of error - Interpretation of results	Th. Fierz
11:15	60'	CRR site	**Tracer breakthrough** - Follow the tracer breakthrough on site	Th. Fierz
12.15	45'	ZB	Lunch	
13:00	60'	CRR site	**Tracer breakthrough** - Finalise field phase of morning session; check data, extract field data from data acquisition system	Th Fierz
14:00	120'	Meeting room	**Evaluation of test data** - Distribute raw data (ascii files), produce Excell pots of breakthrough curve and recovery (group session) - Determine characteristic times of curves (first arrival / peak residence) - Determination of errors - Interpretation of results - Assessment of data using SANTA code	Th Fierz R. Alexander
16:00		ZB	Departure	

FRIDAY 7th November

Departure from the hotel → around 8:15 depending on weather conditions

Review of week 3, lessons learned, application examples

Starting time	Duration	Location at GTS	Topic	Responsible
09:15	30'	Meeting room	- Discussion & Review of week three: techniques, methodologies	W. Kickmaier all
09:45	45'	Meeting room	- Summarise in-situ tracer testing	R. Alexander
10:30	60'	Meeting room	**Example of a blind prediction study made for Äspö** - Water-conducting features at Äspö - Derivation of a structural conceptual model of the TRUE-1 block - Properties on a microscopic scale - Transport modelling: Scoping calculations and identification of relevant processes - Model calibration - Blind predictions of tracer breakthrough curves - Comparison with actual measurements - Lessons learnt	M. Mazurek
11:30	15'	Meeting room	- Final remarks week three	W. Kickmaier
11:45	15'	Meeting room	- Closing Ceremony	N. Chapman
12:00	60'	ZB	Lunch	
13:00			SURPRISE ☺	all
15:00			Transfer back to the hotel	

Week 3: Practical Training in Clays at the Mol URL

MONDAY 3rd November

Venue: Luxembourg-Kirchberg, European Commission, Jean Monnet Building

Participation in the European Commission CLUSTER Conference

Impact of the Excavated Disturbed/Damaged Zone (EDZ) on the performance of radioactive waste geological repositories

Jointly organised by the EC and the Economic Interest Grouping (EIG) EURIDICE.

Plenary session for invited lectures followed by a poster session with a large audience

Main topics:

- present understanding on the nature and properties of the EDZ
- practical consequences of the EDZ for different repository stages
- impact of the EDZ on performance

Time	Topic	Presenter
	Tuesday 4th November	
0900 - 1200	**Transfer from Luxembourg to Mol (organised by SCK.CEN)**	
1330 - 1400	Introduction of participants and discussion of the week's programme	
1400 – 1500	Presentation of the Belgian programme on high-level and long-lived waste (Safir 2)	Phillipe.Lalieux (ONDRAF/NIRAS)
15:00 – 17:00 **2 hours**	Visit to the **ISOTOPOLIS** exhibition on the Belgoprocess site Visit of the **EURIDICE** exhibition hall on SCK•CEN site	

Wednesday 5th November	
A detailed visit of the HADES URL will be followed by more practical discussions with the experts involved on topics and experiments of common interest. A visit of the surface laboratories supporting the development of in-situ tests is also planned (clay sampling and conditioning, introduction to migration experiments and characterisation techniques).	
The key topic for this training is the follow-up of running field work (borehole drilling, core drilling, installation) that will be organised for hands-on experience of working in a URL. These activities refer to the installation of several arrays of piezometers to characterise the hydraulical field around the URL. Information on measuring gauges and data acquisition will also be provided.	J. Verstricht
Some time will be devoted to a presentation of the **CORALUS** experiment (**COR**rosion of **A**ctive g**L**ass in **U**nderground **S**torage conditions), a large, integrated, in-situ experiment studying the interaction behaviour between alpha-active vitrified waste samples and backfill material.	E. Valcke