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CETRAD

Coordination Action on Education and Training in Radiation Protection and Radioactive Waste Management

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Geological Disposal of Radioactive Waste: Review of European Education and Training Needs and Capability

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Dissemination Level		
PU	Public	x
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the partners of the [CETRAD] project	
CO	Confidential, only for partners of the [CETRAD] project	

Executive Summary

This report details the findings of a review of educational and training needs in radioactive waste management focusing in particular on geological disposal. Data for this review was gathered using a survey conducted across 17 states within the European Union and Associated Countries where a group of National Correspondents were responsible for gathering data on a national level. The review has considered training and education needs of i) national radioactive waste management organisations, ii) regulatory and government advisory organisations, and iii) other nuclear industry organisations employing staff in this area, and provision of education and training by university and non-university organisations to address these needs.

The main conclusions are:

- A minimum of 200 specialist staff are to be recruited in the next five years. If national programmes are activated, these numbers are expected to sharply increase.
- The survey confirms the emergence of a generation gap. Clearly this is an issue of concern.
- There are no strong legislative drivers for education and training in this area.
- Staff with expertise in i) earth sciences and rock engineering, ii) civil engineering and underground construction and mining, iii) nuclear and chemical engineering, iv) radiation protection and safety assessment are currently utilised and will continue to be required.
- Public relations and communication is a growth area as social acceptability has an increasingly important role to play.
- New and replacement staff educated to MSc and PhD level in the areas listed above are required to meet the target of 200 new staff. However, if the upturn mentioned above takes place, these numbers will increase significantly.
- There is a strong demand for internally and externally sourced training provision.
- Education in this area is predominantly provided by 66 Universities. This is achieved at MSc level via modules of more general courses, where accreditation falls under the Bologna process, and at PhD level via research programmes.
- On-the-job training is common practice enabling the transfer of tacit knowledge and experience of older generations.
- A European level MSc in this area, based on European Centres of Excellence, is worthy of further consideration.
- It is apparent that there are sufficient education facilities available in Europe.
- The main feature absent from the provision of education is the co-ordination of education needs and provision at a European level.
- In terms of training, external courses are provided by 16 non-university organisations. External training needs are currently met by this mechanism. If the upturn in activity in this area occurs and training requirements greatly increase, further provision will be demanded.
- Mechanisms to allow recognition and accreditation of the training provided are absent.
- Co-ordination of training needs and provision at a European level is also absent.

The key recommendations are:

- The introduction of a mechanism to co-ordinate education needs and provision at a European level.
- In relation to training needs and provision, the introduction of mechanisms to i) allow recognition and accreditation of the training provided and ii) co-ordination of training needs at a European level.

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CHAPTER 1: INTRODUCTION

1.1 Introduction

Within the European Community and world-wide there is extensive experience in the principles and practice of radiation protection and radioactive waste management. Nuclear skills and capabilities have grown and evolved since the inception of nuclear technology in the 1940s. However, with the current stagnation of the nuclear industry it is increasingly acknowledged that the skills and expertise are not being passed on to new generations of experts. This poses a significant risk to the community who will need to manage nuclear liabilities for long times into the future in order to protect future society from radiological hazards.

The CETRAD project aim is to assess the current and future position of education and training in radioactive waste management (RWM) focusing on geological disposal. The project will then develop proposals for structuring and delivering both education and training in the management of the geological disposal of high-level and long-lived radioactive wastes and spent fuel in geological formations across Europe.

Within this context, a review of educational and training needs in RWM has been undertaken and the results of which are presented in the report.

Data for this review was gathered using a survey conducted across 17 states within the European Union and Associated Countries where a group of National Correspondents were responsible for gathering data on a national level. The review has considered training and education needs of i) national radioactive waste management organisations, ii) regulatory and government advisory organisations, and iii) other nuclear industry organisations employing staff in this area, and provision of education and training by university and non-university organisations to address these needs.

During the study, ITC School of Underground Waste Storage and Disposal has been responsible for writing the national survey and for the collection of results from each of the National Correspondents, whilst the Geoenvironmental Research Centre at Cardiff University has been responsible for the analysis of results and the production of this report.

1.2 Contributors

The CETRAD consortium consists of 20 partners; two with expertise in provision and development of education and training forming a secretariat, and a further 18 which act as National Correspondents or corresponding bodies representing each participating country, responsible for the gathering of national information.

Secretariat

- Geoenvironmental Research Centre, Cardiff University, United Kingdom
- ITC School of Underground Waste Storage and Disposal, Switzerland

National Correspondents

- Studiecentrum voor Kernenergie - Centre d'Etude de l'Energie Nucléaire, Belgium
- Kozloduy NPP Plc, Bulgaria
- Technical University of Sofia, Bulgaria
- Správa úlozist radioaktivních odpadu, Czech Republic
- Posiva Oy, Finland
- Commissariat à l'Energie Atomique, France
- Forschungszentrum Karlsruhe, Germany
- Public Agency for Radioactive Waste Management, Hungary
- Ente Nazionale per le Nuove Tecnologie, l'Energia e l'Ambiente, Italy
- Nuclear Research and Consultancy Group, Netherlands

- Instituto Technológico e Nuclear, Portugal
- Centre of Technology and Engineering for Nuclear Projects, Romania
- DECOM Slovakia, spol. s r.o., Slovak Republic
- Agency for Radwaste Management, Slovenia
- Universidad Politecnica de Madrid, Spain
- Svensk Kaernbraenslehantering AB, Sweden
- National Cooperative for the Disposal of Radioactive Waste, Switzerland
- Nirex Ltd, United Kingdom

1.3 Structure

The report is organised as follows:

- Chapter 1 identifies schemes aimed at developing nuclear skills and capabilities
- Chapter 2 describes the research method used
- Chapter 3 presents a national overview of each participating country
- Chapter 4 provides detailed results and analysis of survey responses at a European level
- Chapter 5 presents survey conclusions
- Chapter 6 provides overall conclusions

1.4 International and European Initiatives

Education and training requirements for nuclear skills and capabilities are currently being addressed internationally by the International Atomic Energy Agency (IAEA) and at a European level by the Sixth Framework Programme of the European Atomic Energy Committee (EURATOM). The various programmes and initiatives are presented below to provide an overview of activity in this area.

1.4.1 International Initiatives

ITC School of Underground Waste Storage and Disposal (ITC)

The ITC School of Underground Waste Storage and Disposal is an Association founded in April 2003 with broad membership (currently 49 organisations from 14 countries), 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 World Nuclear University (WNU)

Inaugurated in September 2003, the WNU is a partnership of the world's leading institutions of nuclear learning. Its mission is to foster inter-institutional cooperation and establish accepted global standards in professional and academic qualification.

IAEA Network of Centres of Excellence (COE) in Training and Demonstration of Waste Disposal Technologies in Underground Research Facilities.

In 2002 a group of Member States offered the use of their underground rock laboratories and some associated surface facilities to help build confidence and capacity throughout the world in

geological disposal of radioactive wastes.

This group includes the following:

- Canada with the Underground Research Laboratory of Lac-du-Bonnet, Manitoba;
- Belgium with the Underground Laboratory in Mol, operated by EURIDICE;
- Switzerland with the Grimsel Test Site and the Mont Terri Underground Research Laboratory;
- Sweden with the Aspo Underground Research Laboratory;
- Wales, United Kingdom, with the Geoenvironmental Research Centre in Cardiff; and
- United States of America, with the WIPP facility near Carlsbad, New Mexico, the Yucca Mountain Project in Nevada, and Lawrence Berkeley National laboratory in California.

The in-situ laboratories in this network also provide the opportunity for hands-on training in waste disposal technologies for countries which do not have their own underground research facilities.

1.4.2 European Initiatives

The nuclear energy activity area of the Sixth Framework Programme (FP6) aims at intensifying and deepening the already well established co-operation at European level of the field of nuclear research. This is through i) controlled thermonuclear fusion ii) management of radioactive waste iii) 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.

In addition to CETRAD, the following research projects within the Sixth Framework Programme involve the development of nuclear skills and capabilities through education and training;

ACTINET 6 Network of Excellence, Network for Actinide Sciences "Partitioning and transmutation and other concepts to produce less waste in nuclear energy generation"

One major issue for nuclear energy, requiring intensive research and development programs, remains a broadly agreed approach to waste management, in particular long-lived waste components. Research and development is also needed to explore new concepts for nuclear energy generation that make better use of fissile material and generate less waste. Actinide science is one central theme to respond to these needs. Few laboratories in Europe possess knowledge and tools in actinide science, none of them covers the full spectrum at the scale required by the technical challenges, and few interact. Existing and future knowledge and tools in Europe should therefore undergo a process towards integration and optimisation. In this context, the general objective of ACTINET is to gather the concerned scientific community through a network, aiming to reach sustainability in a few years. Knowledge dissemination, education and training activities through the network will ensure highest level of expertise in Europe. Transnational access to experimental facilities will valorise existing and future facilities and optimise their use. In general, research and education networking will revitalise actinide science, facilitate the development of joint European scientific programmes, and make the field more attractive to young scientists.

EURAC "Securing European radiological protection and radioecology competence to meet the future needs of stakeholders"

The European educational skill base has become fragmented to a point where universities in most countries lack sufficient staff and equipment to provide education in all but a few nuclear areas. Of particular concern, to the European Commission, authorities, industry and professional, university-based scientists are special skill-base deficits within nuclear radiological protection, radioecology and radiochemistry at masters and doctorate levels. It is contended that skills in these areas are of strategic, as well as immediate importance for the maintenance of nuclear operations and options within the evolving European economy. They are also important for meeting the challenges presented by unpredicted nuclear events such as the Windscale fire, Chernobyl accident as well as terrorist and sabotage activities. The objectives of EURAC are to strengthen the scientific academic competence and analytical skills within radiological protection, radioecology and radiochemistry and to secure the future recruitment of appropriately skilled post-graduates to meet the needs of European stakeholders. EURAC will assess the current and potential levels of postgraduate university provision in these disciplines

within the EU and new entrant nations - paying particular attention to scientific and administrative issues, infrastructural requirements, constraints and issues of human mobility. Based on consultations with stakeholders, EURAC will focus on innovative solutions and best coordinated practice within the current provision base. Actions that could be taken by European institutions to secure the future of radiological protection, radiochemistry and radioecology postgraduate education in an expanded EU will be recommended.

EUNDETRAF II "European Nuclear Decommissioning Training Facility"

Safety in the nuclear industry at all stages, during the operational activities as well as in decommissioning, is paramount. To maintain high safety standards a sufficient number of qualified and skilled manpower is perpetually required. However, the present situation indicates a rather bleak picture. Due to lack of interest on the part of the young generation and due to a somewhat tarnished image, the nuclear industry is not getting sufficient high grade intake. In addition the existing skill base is gradually eroding due to retirement of the aging workforce. The European Nuclear Decommissioning Training Facility II following on the success of the EUNDETRAF I, will address this shortfall in skills by facilitating the transfer of knowledge and skills from the existing and experienced experts to the new generation or new entrants in an accelerated way.

NF-PRO "Understanding and physical and numerical modelling of the key processes in the near-field and their coupling for different host rocks and repository strategies"

There are a number of Integrated Projects in this area such as ESDRED and FUNMIG. The principal objective of NF-PRO for example (amended) is to establish the scientific and technical basis for evaluating the safety function "containment and minimisation of release" of the near-field of a geological repository for high-level radioactive waste and spent fuel.

In addition to the scientific-technical objectives, the consortium will make the acquired data, knowledge and expertise available and accessible to the broad scientific community within the EU and NAS, use its expertise for public information purposes and promote knowledge and technology transfer through training. Component 6 brings together all activities concerning training (including knowledge management and transfer particularly a summer school programme in 2005.

NEPTUNO: "Nuclear European Platform of Training and University Organisations"

The aim of this project is to better integrate European education and training in nuclear engineering and safety to combat the decline in both student numbers and teaching establishments, thus providing the necessary competence and expertise for the continued safe use of nuclear energy and other uses of radiation in industry and medicine. The project focuses on a harmonised approach for education and training in nuclear engineering in Europe and its implementation, including the better integration of national (governmental as well as industrial) resources and capabilities.

The expected result is an operational network for training and life-long learning schemes as well as on academic at the master, doctoral and post-doctoral level, underpinning:

- Sustainability of Europe's Excellence in nuclear technology
- Harmonised approaches to safety and best practices, both operational and regulatory, at European level in Member States and Accession Countries
- Preservation of competence and expertise for the continued safe use of nuclear energy and other uses of radiation in industry and medicine

ENEN: "European Nuclear Engineering Network"

Created in 2000, the underlying objective of the network is the safeguarding of nuclear knowledge and expertise through the preservation of higher nuclear engineering education. Through co-operation between universities and universities and research centres, better use will be made of dwindling teaching capacity, scientific equipment and research infrastructure.

The outcome from this project should be a clear road map for the way ahead in nuclear engineering education in Europe.

BNEN: "Belgian Nuclear Higher Education Network"

In parallel with the creation of ENEN, the merging of two post-graduate programmes, into a single programme, taught in English by the Belgian universities in collaboration with SCK•CEN

has resulted in the Belgian Nuclear Higher Education Network which offers a Master of Science in Nuclear Engineering.

PETRUS: "Programme for Education, Training and Research on Underground Storage"

The Petrus initiative aims at developing both research and educational expertise in underground disposal. Educational objectives are i) to construct a common educational programme for radioactive waste underground storage by bringing together university teachers and researchers in various disciplines, ii) to organise periodic courses, based on a common educational programme, in the partner universities adhering to the project. The course targets second cycle students (final year) and aim at arousing their interest to continue the radioactive waste studies in the third cycle (PhD). The research objective is to promote the scientific research potential in partner universities, notably by pooling human and material resources and by facilitating doctoral and postdoctoral exchange.

This chapter has presented the objectives of this coordination action, identified contributors to this work and a summary of the report structure. International and European schemes and initiatives aimed at developing nuclear skills and capabilities have been identified, particularly those currently supported by the Sixth Framework Programme of the European Commission. Each of these initiatives and activities address some of the issues covered in this report however no specific study has been initiated to address educational and training needs in radioactive waste management.

CHAPTER 2: RESEARCH METHOD

2.1 Introduction

This chapter identifies the research method for this review of educational and training needs providing an explanation of the way in which data was collected and analysed. To ensure direct and targeted conclusions flaws found with the data have been addressed, details of which are identified below.

2.2 Collection and Analysis of Data

In order to evaluate and review needs for education and training and the competencies, facilities and courses already available to provide education and training across the EU and associated countries, a questionnaire was created (Appendix A) composed of three sections:

Section 1: Training Needs

Identification of training requirements for all organisations employing staff in RWM in each country enabled the detection of training needs and requirements providing a general overview of demand across participating countries.

Organisations employing staff in RWM were divided into three categories;

- A national RWM organisation (generally agencies involved in the management of nuclear waste),
- Other nuclear industry organisations employing staff in RWM (private and public organisations employing staff in RWM, e.g. consultants and contractors),
- Regulatory and government advisory organisations employing staff in RWM.

Section 2: Capabilities and Activities

Identification of capabilities, activities and facilities of education and training providers enabled the detection of ability to supply demand on a national and therefore European level;

- Non-university organisations providing education and training in RWM (private and public RWM education and training providers)
- Universities

Section 3: General

Identification of activities at a national level provided contextual information assisting in the identification of each country's current situation and future direction used to generate the national overviews in the next chapter.

- National incentives to improve education and training in RWM,
- National strategy to improve education and training in RWM,
- National funding provisions for education and training in RWM.

Responses were received from all participating countries thus a large quantity of data collected and analysed. Weaknesses and gaps within the data were identified as:

- Subjectivity issues regarding terminology and interpretation of questions
- Differences in national perceptions
- Provision of non-specific data
- Quantitative data was not always provided to enable accurate measurement of results. Where some quantitative data was made available, analysis acknowledges the data as a sample and not wholly representative.

In order to address such flaws, following receipt of responses to the initial survey, additional questions (Appendix B) were distributed to address gaps identified in both the original

responses to the questionnaire and the questionnaire itself. Of seventeen countries, nine returns were received and analysed.

Following further review, it was deemed necessary to seek supplementary clarification through the distribution of a concise third set of questions (Appendix C) to obtain specific data and improve the value of the review. Responses to the questions were obtained at the internal project meeting (sixteen of seventeen countries providing returns) where National Correspondents presented findings supplying clarification regarding terminology and interpretation.

The national overviews presented in chapter 3 have been reviewed to ensure an accurate reflection of the current national situation regarding education and training in geological disposal aspects of radioactive waste management.

CHAPTER 3: NATIONAL OVERVIEWS OF PARTICIPATING COUNTRIES

3.1 Introduction

This chapter presents an overview of the current nuclear waste management industry, policy training requirements and capabilities and activities for each participating country. Contextual data has been taken from the survey responses to identify national incentives to coordinate or improve education and training in RWM focusing in particular on geological disposal and highlight any existing long term national strategies or special national funding provisions for RWM education and training.

3.2 Belgium

3.2.1 The National Nuclear Industry

The Belgian Agency for Radioactive Waste and Enriched Fissile Materials (ONDRAF/NIRAS) ensures the safety of RWM. The Federal Agency for Nuclear Control (FANC-AFCN) is the regulatory and government advisory agency. Others employing staff in RWM include Belgoprocess, a privately owned firm specialising in the processing of radioactive waste involved in RWM and the decommissioning of nuclear facilities; and the Institute for Radioactive Elements (IRE) which has no specific education and training activity. SCK•CEN is a public utility establishment and the only non-university organisation in Belgium to provide education and training in RWM. The International School for Radiological Protection (SCK•CEN-isRP) provides courses on a wide variety of subjects all associated with radiological protection and nuclear science and technology. SCK•CEN also contracts research on radioactive waste management, storage and disposal for, and in cooperation with, the national RWM organisation NIRAS/ONDRAF and with other national and international institutions.

3.2.2 National Policy including any specific education and training in RWM Policy

There is no long-term national strategy for RWM education and training and no special national funding to provide RWM education and training.

3.2.3 Training Requirements

Contrary to the qualified expert in radiation protection and the medical personnel, there are no specific requirements in Belgian law for education and training on RWM related functions. Generalists rather than specialists are found to be available on the labour market and each organisation or company develops their own training specifications which are directly applicable to their situation.

3.2.4 Education and Training Capabilities and Activities

The Belgian Nuclear Higher Education Network (BNEN) is an interuniversity programme in Nuclear Engineering organised within the Framework of the European Nuclear Engineering Network (ENEN). This BNEN agreement is made between Free University of Brussels (VUB); University of Ghent (UG), Catholic University of Leuven, (KUL), Université de Liège (ULg), Université Catholique de Louvain (UCL), and in collaboration with SCK•CEN. Beyond this programme, none of the universities are involved with RWM education and training or nuclear engineering in general[1].

It must be noted that SCK•CEN and the Federal Agency for Nuclear Control will organise the 3rd International Conference on Education and Training in Radiological Protection in November 2005, in cooperation with the European Nuclear Society and under the patronage of the European Platform for Education and Training in Radiological Protection. RWM issues will be part of the conference programme and debates.

1 Some of the universities have special courses and programmes dealing with radiation protection in general or medical applications of radioactivity, but they fall beyond the scope of the CETRAD study.

Summary: Such networks and partnerships in RWM education and training indicate ability for the industry to work closely together and although current RWM specialist figures are unavailable, several respondents have noted a fall in nuclear engineering students thus predicting possible shortages in the future.

3.3 Bulgaria

3.3.1 The National Nuclear Industry

There are four major players in the national nuclear field; The Nuclear Regulatory Agency, Kozloduy Nuclear Power Plant (KNPP), The State Facility for Radioactive Waste Management (the national RWM organisation), and the Institute for Nuclear Research and Nuclear Energy (responsible for functioning of existing low and intermediate level RW storage). The main institution in nuclear education and training is the Technical University of Sofia that works in cooperation with relevant departments at Sofia University and the United Technical College. Additionally, there are several engineering and consulting companies, which support the nuclear industry.

3.3.2 National Policy including any specific education and training in RWM Policy

A long-term national strategy for RWM education and training exists as part of the State Strategy for Education and the State Strategy for Energy (in the nuclear energy field). Special national funding provisions to provide RWM education and training are allocated as part of the National Fund for Storage of Radioactive Wastes and the National Fund for Decommissioning of Nuclear Facilities. There also exist three national legal incentives related to coordination and improvement of education and training in nuclear area and particularly in RWM.

3.3.3 Training Requirements

Numerous national legal requirements demand qualified RWM specialist staff. Specialist numbers are steadily increasing within The State Facility for Radioactive Waste Management where training is provided by KNPP Training Centre. The Nuclear Regulatory Agency also anticipates the recruitment of more inspectors in the area of RWM due to the decommissioning of some (two or four) KNPP units.

The Nuclear Regulatory Agency regularly sources education and training from International Atomic Energy Agency (IAEA), Nuclear Regulatory Agency (NRA), Western regulators and European programs such as PHARE[2]; other users rely on KNPP Training Centre, The Technical University of Sofia and on-the-job training. This indicates a potential gap in the market for further education and training provision once part of KNPP is decommissioned. It is worth noting that projects for education and training are usually funded by the end user or relevant government body and additional funding for specific courses provided by different international programmes or bilateral projects.

3.3.4 Capabilities & Activities

KNPP Training Centre provides both consultants and the State Facility for Radioactive Waste Management with RWM education and training. The Technical University of Sofia has two departments providing RWM related courses and works in partnership with industry, particularly KNPP and with many universities from all over Europe.

3.4 Czech Republic

3.4.1 The National Nuclear Industry

The Act on the Peaceful Uses of Nuclear Energy and Ionising Radiation (No. 18/1997) stipulates the following main principles of RWM in the Czech Republic:

- State guarantees safe disposal of all radioactive waste including monitoring and supervision of repositories after their closure.

2 The Phare programme is one of the three pre-accession instruments financed by the European Union to assist the applicant countries of Central and Eastern Europe in their preparations for joining the European Union.

- To provide for activities associated with radioactive waste disposal, the Ministry of Industry and Trade set up Správa úložišt radioaktivních odpadu (SÚRAO)[3] as the State organisation.

The main activities of SÚRAO are preparation, construction, operation and closure of repositories, environmental monitoring, RWM and drafting of proposal for determination of levies to the nuclear account. Currently SÚRAO operates three repositories of Low Level Waste (LLW) and Intermediate Level Waste (ILW).

SÚRAO is currently experiencing difficulties with regard to the geological repository siting process as there is strong public opposition with all perspective sites chosen to date against the future construction of a deep geological repository as well as against the exploration of sites. In June 2004, the government confirmed the postponement of geological activities related to the siting for at least five years.

State administration and supervision of the utilisation of nuclear energy and ionising radiation and in the field of radioactive protection is performed by the Státní úrad pro jadernou bezpecnost (SÚJB)[4]. SÚRAO cooperates with large number of universities, research institutes and companies on studies and research necessary for the siting process, research of engineering barriers and long-term safety.

3.4.2 National Policy including any specific education and training in RWM Policy

National policy of RWM is presented in document "The Concept of Radioactive Waste and Spent Nuclear Fuel Management in the Czech Republic" which was adopted by the Government in May 2002. The document states long-term capacity of existing LLW and ILW repositories and identified the direct disposal of spent fuel as a main option for deep geological repository and supports research in the field of partitioning and transmutation. The main milestones for deep geological repository are identified in chapter 4.3.

3.4.3 Training Requirements

External education and training is required to focus on site-specific safeguard requirements and long term surveillance and monitoring approaches specified by the IAEA for both organisations.

3.4.4 Training Provision

SÚJB depends on in-house training provided by SÚJB senior staff and external training provided by IAEA. Just one course is provided by Czech Technical University Faculty of Civil Engineering, Prague. The course considers the disposal of LLW and High Level Radioactive Waste (HLW) and will only be run if a sufficient number of English speaking students enrol. There are no non-university organisations providing education and training in RWM.

Summary: Overall, demand for RWM education and training in the Czech Republic is closely connected with deep geological repository development. In 2004, the siting process was suspended therefore reducing some of the activities of the geological repository programme, yet this does provide an opportunity to develop education and training for the new generation of specialists.

3.5 Finland

3.5.1 The National Nuclear Industry

Regulatory and government advisory organisations make up the majority of the Finnish RWM industry organisations. The Ministry of Trade & Industry has overall national control of the industry organisations and use of nuclear energy, The Radiation and Nuclear Safety Authority regulates RWM, and several various government research organisations (including universities) support the industry. The two private NPP and utility operators, Fortum Power and Heat Oy and Teollisuuden Voima Oy, own the National RWM organisation Posiva Oy, and several private consultant firms support these key players. Data reveals relationships with RWM service providers abroad indicating a very closely linked national industry.

3 Also known as The Radioactive Waste Repository Authority (RAWRA)
4 Also known as The State Office For Nuclear Safety (SONS)

3.5.2 National Policy including any specific education and training in RWM Policy

Although no explicit long term strategy; no national incentives or special national funding provisions to provide, coordinate or improve RWM education and training exist, there is activity in this area. One purpose of the national initiative KYT (Finnish Research Programme on Nuclear Waste Management 2002-2005) is to maintain national competence in RWM. An expert group has been established which looks towards maintaining current levels of expertise in the nuclear energy field, and studies on general radiation protection training needs have been conducted.

3.5.3 Training Requirements

Currently minimal legal requirements for qualifications of RWM specialist staff are demanded and most organisations provide new staff with compulsory or optional in-house introductory training in RWM. A few formal courses are available however most training and learning takes place through national seminars, international conferences, and scientific publications. Applied training is obtained through the transfer of tacit knowledge and by practical work on projects or through hands on training. By the year 2012, when the national RWM organisation applies for the construction licence of the disposal facility, an E&T (or competence) strategy needs to be established as a part of the licence application preparation process. Several respondents externally source training in various complex modelling activities and in some cases education and training for highly specialised topics is found to be obtained abroad. The survey response does not identify a great demand for general education and training[4] and although training for performance assessment, material and manufacturing technology, geosciences and geotechnology are required, it is unclear if this is a gap in the market or due to subjectivity weaknesses of the survey.

3.5.4 Capabilities & Activities

Two non-university organisations provide irregular education and training dependent on demand where course structure is orientated towards specific customer requirements. The universities provide modules or elements of RWM as part of broader courses relating to Radiochemistry, Nuclear Engineering and Nuclear Waste Management. Most university courses do not involve partnership with industry and are generally wholly taught. Specific facilities available include various laboratories, computer codes, controlled atmosphere boxes, and measurement systems.

Summary: Overall, the number of younger RWM experts is falling due to the retirement of senior experts and the challenge for the next five years is the knowledge transfer and its modes from senior experts to personnel with less experience[5].

3.6 France

3.6.1 The National Nuclear Industry

Agence Nationale pour la Gestion des Déchets Radioactifs (ANDRA), a public industrial and commercial organisation operating independently of waste producers is responsible for the long-term management of radioactive waste produced in France. The Institute for Radiological Protection and Nuclear Safety (IRSN), a public establishment under the joint authority of the Ministers of Defence, the Environment, Industry, Research and Health carries out research, analysis and work within the fields of nuclear safety, protection against ionising rays, the control and protection of nuclear materials and protection against acts of malevolence. The Commissariat à l'énergie atomique (CEA) oversees management of long lived and high level activity nuclear waste. Institut National des Sciences et Techniques Nucléaires (INSTN) is a university type organisation that also provides continuous and professional training at all levels, originally created as a public organisation within CEA to disseminate CEA knowledge and

[4] National universities and polytechnics provide a good basic general education (M.Sc and B.Sc) in natural sciences, technology, and engineering, and thus there is no shortage of potential new-comers to the industry. The national education policy goal is that 70% of each age cohort shall have a higher education degree (to at least the Bachelor level).

[5] The number of younger experts is not falling, according to our knowledge, but in general the proposition of younger experts is to senior experts is small and when the senior experts retire, the percentage of younger experts will increase, but the number of experts in total will decline. The key issue here is, how to transfer knowledge.

know-how through education and training. COGEMA, a subsidiary of AREVA offers a wide range of services in the field of reprocessing and recycling. EDF is the national NPP operator. The waste "producers" and among them mainly COGEMA, EDF and CEA are legally bound to financially support ANDRA.

3.6.2 National Policy including any specific education and training in RWM Policy

Education and training in RWM and the long term strategy for nuclear education and training is coordinated through the INSTN Education and Training Council where all stakeholders (Universities, CEA, EDF, AREVA, ANDRA, governmental authorities) are represented.

3.6.3 Training Requirements

There is a need for RWM education and training related to the management of the geological disposal of HLW and LLW and spent fuel in geological formations. In the future ANDRA will need a maximum of 40 to 55 additional staff specialising in Radiation Protection & Safety Assessment (including Quality Assurance), Civil Engineering & Underground Construction and Waste Package Specification and Acceptance. In addition, a number of organisations (CEA, COGEMA, EDF, hospitals, other waste producers) anticipate recruitment of individuals who have a higher degree (i.e. MSc or PhD) in a relevant specialisation for the management of waste in operating facilities or facilities being dismantled.

3.6.4 Capabilities and activities

The survey data indicates that French RWM education and training is well coordinated. Andra provides in-house training for "non-specialists" (e.g. project management staff) requiring a good understanding of RWM disciplines and has set up two internal schemes (one for recruitment of young staff and one for more experiences staff) to provide education and training in RWM for specialist staff. This should provide most of the necessary future scientific staff. EDF and COGEMA provide in-house training for qualifications of RWM specialists (including specific practical training for professionals and workers). CEA's Nuclear Energy Division has developed a general internal nuclear training course for all new staff, young scientists and engineers engaged in the broad field of nuclear sciences, engineering and technologies. INSTN frequently organises courses for the IAEA or NEA regarding RWM, and provides many short RWM related courses where participants are generally professionals from CEA, nuclear companies (COGEMA, EDF) or governmental bodies.

A one year Masters degree is available with several universities including Université Joseph Fourier Grenoble, Institut National Polytechnique de Grenoble, Université Claude Bernard de Lyon and Institut National des Sciences et Techniques Nucléaires for national and international students. In addition, the PETRUS (Programme for Education, Training and Research on Underground Storage) initiative aims at developing both research and educational expertise in underground disposal.

Summary: Details regarding the age distribution of specialist staff are not known however there is a need for RWM education and training related to the management of geological disposal of HLW and LLW and spent fuel in geological formations.

3.7 Germany

3.7.1 The National Nuclear Industry

By law, the Federal Government has to ensure the safe disposal of radioactive waste by providing repositories. The Ministry for the Environment (BMU) is the responsible Federal Ministry and regulatory body. On behalf of BMU, the Federal Office for Radiation Protection (BfS) is responsible for the construction and operation of plants and installations for the disposal of radioactive waste. The Deutsche Gesellschaft zum Bau und Betrieb von Endlagern für Abfallstoffe mbH (DBE) currently fulfils this task and is partly owned by Gesellschaft für Nuklear Service (GNS), a nuclear industry company.

Regulatory and government advisory organisations are the Federal Institute for Geosciences and Natural Resources (BGR) and Gesellschaft für Anlagen und Reaktorsicherheit mbH (GRS) both of which are also organisations doing RTD work.

Additional organisations and companies involved in research, development and technology include institutes in the national research centres Karlsruhe (FZK); Jülich (FZJ) Neuherberg (GSF) and several private consultant or engineering firms.

Research, technology and development funds are provided by BMU for site-specific research, (funds for these tasks are provided by the utilities money based upon the "polluter-pays-principle") and the Ministry of Economics and Labour (BMWA) (non site-specific specific research, technology and development).

A RWM-organisation organised and financed and with a management structure for example like Nagra, SKB or comparable European institutions does not exist in Germany. Therefore, by definition, the survey does not address a "RWM-organisation" (most likely BfS might fulfil the profile).

3.7.2 National Policy including any specific education and training in RWM Policy

Nuclear phase-out is the objective of the Federal government. In June 2001 the agreement on nuclear phase-out was signed between government and utilities orderly termination of nuclear energy production. In Germany deep geologic disposal for all types of radioactive waste is obligatory. The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety demands one single repository for all kinds of radioactive waste. The target date for repository start-up is still 2030.

There are no national initiatives to coordinate education and training in RWM, nor does there exist a national strategy or any special national funding provisions to provide RWM education and training. However, the respective companies/institutions try to maintain current levels of expertise unsupported by government.

3.7.3 Training Requirements

There are some legal requirements for qualifications of RWM specialist staff working as experts for legal authorities. Most respondents answered that on-the-job training accompanied by special courses is the most useful way to develop staff. In-house training through practical work on projects is accompanied by internal and external training measures. External education and training is usually obtained through workshops; national and international seminars, international and national conferences, summer schools, practical training courses (e.g. radiation protection, radiochemistry, etc.) through participation in courses organised by specialised institutions like FTU in the Forschungszentrum Karlsruhe; or if necessary, at institutions abroad like ITC, Switzerland.

3.7.4 Capabilities and Activities

Universities provide modules or elements of RWM as part of broader courses related to reactor technology, nuclear engineering or chemistry. In fact, just one complete university course in RWM is identified but only one semester long and wholly taught. Some Universities of Applied Sciences cooperate with industry. Several facilities run various laboratories, hot cells with remote handling equipment, and analytical and measurement systems. Education and training in radiation protection is provided at different institutions (mostly research centres or universities) and is concentrated mainly at conveying job-specific knowledge to people from different branches (radiology, medicine, nuclear, etc).

Summary: Despite the uncertain situation concerning future strategy in waste disposal, there is demand for RWM education and training especially in order to further develop state-of-the-art expertise and to avoid the loss of competence in the several RWM related fields of research.

3.8 Hungary

3.8.1 The National Nuclear Industry

The national RWM organisation, the Public Agency for Radioactive Waste Management (PURAM) is responsible for radioactive waste management and decommissioning of nuclear facilities. PURAM performs this mission via contracts involving professional companies. The Hungarian Atomic Energy Authority's (HAEA) CNFF Technical Administration is the administrative body of the Central Nuclear Financial Fund (regulatory organisation), which

provides finance for radioactive waste disposal and the decommissioning of nuclear facilities. Others employing staff in RWM are not significant, as they are entitled to licensing or inspections in some adjoining territories of RWM only.

3.8.2 National Policy including any specific education and training in RWM Policy

There are currently no national incentives to coordinate or improve education and training in RWM, and there is no long term national strategy or special national funding provisions for RWM education and training in Hungary at this time.

3.8.3 Training requirements

As the Hungarian nation nuclear industry is small there exists low and occasional demand for education and training. However, it is anticipated that the number of PURAM specialist staff employed will increase by 23 employees from the start of the NPP decommissioning in 2011. HAEA is also anticipating a slight increase in specialist staff numbers but even though education and training is sourced externally, demand for training will continue to be minimal.

3.8.4 Capabilities & Activities

Details of non-university organisations providing education and training in RWM are not provided in the survey response however the University of Veszprém, Department of Radiochemistry and Budapest University of Technology and Economics (BUTE) both provide RWM modules within broader courses outside RWM. These courses involve cooperative working with industry but last just one semester.

Summary: In Hungary facilities are not available for RWM education and training at this time but in the future underground research laboratory facilities will be available. In-house training is not available thus education and training are externally sourced. There is low and occasional demand for RWM education and training, which is not expected to increase over the next five to ten years.

3.9 Italy

3.9.1 The National Nuclear Industry

Agenzia per la Protezione dell'Ambiente has both regulatory and government advisory responsibilities and the national RWM organisation (SoGIN) maintain close relations with the national research organisation (ENEA). Both ENEA and SoGIN own NUCLECO responsible for nuclear waste collection.

3.9.2 National Policy including any specific education and training in RWM Policy

There exists no explicit long term strategy; no national incentives or special national funding provisions to provide, coordinate or improve RWM education and training in Italy.

3.9.3 Training Requirements

There exist no national legal requirements for qualifications of specialists working in RWM, yet there is a high demand for RWM education and training. All RWM organisations in the country employ staff approaching retirement age and so there will be requirements for education and training of replacement staff. For example the organisation (SoGIN) responsible for the Dismantling and decommissioning of the Fuel Cycle Plants anticipate employing from 10 up to 20 graduate level recruits in the next 5 years requiring specific training in the broad field of RWM.

3.9.4 Capabilities & Activities

All RWM education and training capability is provided by universities only as there are no non-university courses available. RWM education and training is accessible as modules within numerous broader courses outside RWM. For example, three universities provide masters level courses containing RWM modules and a plethora of universities offering nuclear engineering courses at level I and II.

Summary: Overall, the RWM programme is in a period of growth and demand for education and

training is expected to increase over the next five to ten years.

3.10 Netherlands

3.10.1 The National Nuclear Industry

Centrale Organisatie Voor Radioactief Afval (COVRA NV) is the central facility for the collection, treatment and storage of radioactive waste in the Netherlands. Dutch regulatory and government advisory organisations include the Ministry of Housing, Spatial Planning and the Environment (VROM) (regulation and inspection of nuclear safety, radioactive waste management, transport and radiation protection), Nuclear Research & Consultancy Group (NRG) (centre of expertise on RWM and geological disposal) and the Netherlands Institute of Applied Geoscience (TNO-NITG). Others employing staff in RWM include NRG and Electricity Production Company (EPZ) which produce electricity with help from a nuclear plant. NV Gemeenschappelijke Kernenergiecentrale Nederland (GKN), the NPP in Dodewaard, is in the process of decommissioning and by June (amended) 2005 the building will enter the safe enclosure phase.

3.10.2 National Policy including any specific education and training in RWM Policy

There is a national strategy to increase the knowledge and expertise on RWM, specifically oriented at most aspects of geological disposal of radioactive waste where government funds are allocated for this task. The national program will run for a minimum of eight years and is a continuation of work in progress. The work to be carried out in the national program primarily involves research staff and does not include training of students at universities nor does it specifically address the issue of education and training in the form of training courses.

3.10.3 Training Requirements

It is found that most organisations require some qualification in radiation protection and although there are no legal requirements stated for training of specialist staff, on-the-job training is an essential education and training practice.

3.10.4 Capabilities and Activities

Although no specific training courses on RWM exist, generic training courses in radiation protection, reactor physics or other subjects relevant to RWM address the subject briefly in one or two modules. Courses are not linked to industry, accredited by universities or developed for distance learning. All new TNO-NITG staff participate in internal annual courses in applied geosciences.

Summary: There exists demand for RWM education and training in the next five to ten years for compensating the loss of expertise by natural turnover supported by national strategy to increase the knowledge and expertise on RWM that is specifically oriented at aspects of geological disposal of radioactive waste.

3.11 Portugal

3.11.1 The National Nuclear Industry

Instituto Tecnológico e Nuclear (ITN), Departamento de Protecção Radiológica e Segurança Nuclear (DPRSN) is the only nuclear industry organisation in the country as all activities related to RWM are the responsibility of the Portuguese Government.

3.11.2 National Policy including any specific education and training in RWM Policy

National Policies on RWM are a responsibility of the Instituto dos Resíduos, Ministério do Ambiente e do Ordenamento do Território (Institute of Wastes, Ministry of Environment). National policies related to RWM education and training are unknown.

3.11.3 Training requirements

ITN DPSRN requires specialists in the fields of Radiation Protection and Safety Assessment; Earth Sciences and Rock Engineering; Biological and Environmental Sciences; Law and Regulation; Civil Engineering and Underground Construction; Public Relations and Communications.

At ITN, training in RWM activities are voluntary but the transfer of knowledge between old and new staff is facilitated through practical work and hands on training. In the last few years, a broad training scheme in RWM has also been implemented for new staff however it has been observed to be far from satisfactory thus the organisation does not adequately cater for current RWM education and training.

3.11.4 Capabilities and Activities

ITN is the only non-university organisation providing education and training in RWM in Radiochemistry, Radiopharmaceutical Chemistry, Radiological protection and RWM under two Masters level courses established September 2004. The Institute collaborates with universities and research centres through conferences and tutorials; and provides training courses for the industrial and medical sectors, high schools, universities and governmental departments. The Instituto Superior Técnico, (IST)[6] runs a Masters degree in Radiological Protection in collaboration with Department of Radiological Protection and Nuclear Safety/ITN. The Inorganic and Radiopharmaceutical Chemistry Group of Chemistry Department/ITN is running a Masters course in Biomedical Inorganic Chemistry (Diagnostic and Therapeutic Applications) in collaboration with the University of Lisbon, Faculty of Sciences. This will involve experts from the DPRSN and Reactor Department of ITN and Physicians from the Nuclear Medicine Centres.

Summary: The future upgrading of the existing interim storage facility for radioactive waste located at ITN demands educated and trained technicians, researchers and regulators. Transfer of theoretical and practical knowledge should be enforced through increasing the number of the courses at all levels (high schools, universities, industrial and medical sectors). Enforcing teaching of Radiological Protection aspects is of paramount importance in forming highly skilled experts on RWM.

3.12 Romania

3.12.1 The National Nuclear Industry

The Romanian national RWM organisation, National Agency for Radioactive Waste Management (ANDRAD) is the national authority in charge with the national co-ordination of the safe management of spent fuel in radioactive waste, including the final disposal. CNCAN, Romanian Nuclear Regulatory Authority is the national competent authority in nuclear field exercising regulation, licensing and control competencies. The national nuclear industry is mainly composed of many other nuclear industry organisations such as Nuclearelectrica, SA National Company (SNN), responsible for the management of radioactive waste generated by its own activity; Uranium National Company (CNU), responsible for most of the RW arising in the front-end of Nuclear Fuel Cycle and Center of Technology and Engineering for Nuclear Projects (CITON), in charge with technical support (design, engineering and technology) for all RWM facilities in Romania. CITON assists the ministries in charge of energy production, research and development with strategies and programs in the nuclear field and their implementation.

3.12.2 National Policy including any specific education and training in RWM Policy

National policy and specifically education and training policy is not identified, however the Nuclear Agency is the specialised body of the central public administration which provides Romanian Government specialised technical assistance in elaborating nuclear national policies; promotes and monitors the nuclear activities; holds responsibility for setting up the National Strategy for the Development of Nuclear Field and the Action Plan and represents Romania in relationships with IAEA Vienna, European Commission and other international organisations in nuclear field.

3.12.3 Training Requirements

6 Technical University of Lisbon

Legislation generally demands some training which is generally sourced externally.

3.12.4 Capabilities & Activities

University education and training is provided by University Politehnica of Bucharest (UPB), Faculty of Power Engineering, Department of Nuclear Power Engineering (which provide 13 courses all worth between 2 and 12 ECTS points). University of Bucharest, Faculty of Physics provides a course on Environmental Radioactivity. The University of Bucharest, Faculty of Chemistry, Department of Physical Chemistry offers 7 courses all containing modules relevant to RWM.

3.13 Slovak Republic

3.13.1 The National Nuclear Industry[7]

Slovak Republic has no national RWM organisation established yet. Indeed the national infrastructure is currently dramatically changing in several ways. First, according to the new Act No. 541/2004 Coll. (Atomic Act; entering into force on 1 December 2004), the national organisation responsible for disposal of radioactive waste is to be established by the Ministry of Economy until January 1st, 2007. State-owned organisations still dominate the industry but, on the other hand, it is expected that transaction documents where the Slovak Government sells the controlling block of the Slovak Electric, Plc shares (including its branches producing the nuclear electricity) will be signed soon. According to recently published information, another branch of the Slovak Electric named as "Decommissioning of Nuclear Installations and Spent Fuel and Radioactive Waste Management (SE-VYZ)" is not included in the privatisation process. It is still unclear how these will impact on RWM infrastructure in the country. The State Fund of Decommissioning of Nuclear Power Facilities and the Spent Fuel and Radioactive Waste Management is responsible for preparation and proposal of the state fund budget and control of its withdrawal in compliance with approved projects. The Nuclear Regulatory Authority of the Slovak Republic (NRASP) has regulatory and surveillance responsibilities. It also participates, as a competent authority, on a governmental level, to the decision making processes concerning the decommissioning and radioactive waste and spent fuel management.

3.13.2 Training Requirements

Only declared demand of education and training in area of radioactive waste management for the near future is given by needs of training of SE-VYZ operational staff, according to the provisions of legislation. SE-VYZ trains its operational personnel in the authorised training centre (VUJE Trnava) as well as applying other training forms (in-house training).

There are two motivating aspects which should increase the interest for the training not only from the required operational point of view. First, a decision on untimely shut-down and decommissioning of NPP V-1 in Jaslovske Bohunice (i.e. need to retrain a part of the NPP operational staff). Second, legislatively required establishing of the national radioactive waste management organisation during next two years. It is expected that this organisation will have to also perform conceptual activities and activities leading to more long term results (including the development of geological disposal). The education and training needs for personnel involved in such activities, in specialisations listed in the questionnaires is now anticipated. Quantitative assessment of this need seems to be premature at the present time.

3.13.3 Capabilities & Activities

University education and training is provided by the Slovak University of Technology in Bratislava, Faculty of Electrical Engineering and Information Technology, Department of Nuclear Physics and Technology which makes available several opportunities to study RWM modules. The Comenius University in Bratislava, Faculty of Natural Sciences provides a two year wholly taught MSc course in Radiochemistry. Education and training on both faculties is performed frequently in partnership with Nuclear Power Plant, Jaslovske Bohunice.

With regard to non-university organisations, VÚJE Trnava Inc NPP Personnel Training Centre was set up to accommodate all training needs of nuclear facilities in the country as authorised by the Nuclear Regulatory Authority. Slovak Electric plc and its branches train employees

7 During collection and review of data large scale changes were taking place in Slovak Republic. Data for this national overview was provided November 2004.

according to corresponding legislative provisions although are more oriented to the needs of NPP operations. A course provided by NPPs Personnel Training Centre for SE-VYZ employees and inspectors of the regulatory authority is the only course in the country directly oriented to RWM.

Summary: Information provided by the NC has many inconsistencies as information is not kept under review within the nuclear industry and/or it is not freely accessible. At the time of writing, the National Correspondent verified the reorganisation of the personnel training system and further developments have been made with regard to privatisation of the nuclear industry. Thus, it was difficult to obtain reasonable and comparable information and, even more, to verify its correctness.

In January 2005, the National Correspondent anticipated an increase in RWM education and training for personnel involved in RWM activities.

3.14 Slovenia

3.14.1 The National Nuclear Industry

Slovenia maintains a small nuclear programme where regulatory and government organisations have numerous complementary RWM responsibilities. The Slovenian Nuclear Safety Administration (SNSA) is the national regulatory body and the Agency for Radioactive Waste Management (ARAO) is the national RWM organisation responsible for the disposal of radioactive waste and spent fuel and management of RW from small producers. The Jožef Stefan Institute and the Institute of Occupational Safety are technical support organisations authorised to oversee radiation protection practices and measurement and transport of sources of radioactive waste. Both institutes are involved in numerous RWM activities and have RWM education and training links within the industry and medicine. The only Nuclear Power Plant in Slovenia, NPP Krško, is responsible for processing RW and Rudnik Žirovski vrh (RZV) is currently in the process of decommissioning the Uranium Mine Žirovski Vrh and is expected to liquidise once remediation of the Uranium Mine is complete.

3.14.2 National Policy including any specific education and training in RWM Policy

The long-term policy adopted by the government and subsequently by the higher education institutions calls for coherence with the goals set forth by the Bologna Convention. Regarding nuclear education, in a broader sense, the nuclear component has been acknowledged as a viable option in the future electric supply mix. In this context nuclear science and engineering education has found its place predominantly in the postgraduate level taking into account the country specific needs and the size of the program. It is anticipated that higher education covering RWM issues will remain inside the wider nuclear engineering programmes. In continuation the institutions and companies associated with the RWM will provide for the more specific and practical supplementary training.

3.14.3 Training Requirements

New regulations regarding qualifications of specialist staff are expected to change current policy in which additional training is required only in the areas of radiation protection, NPP operation and repository operation. However, the industry does not anticipate large rises in new staff; therefore no significant rise in education and training needs is expected in the near future. Staff generally receives in-house training and basic training at the Nuclear Training Centre of the Jožef Stefan Institute. Specialist training is sourced abroad by some and most provide practical on-the-job training. Most organisations pay special attention to participation of specialists in training courses, seminars and workshops organised by the IAEA, EU through the PHARE/RAMG, OECD/NEA, US NRC and by other professional organisations and institutions.

Most organisations require specialist staff however they are found to be difficult to obtain in comparison with generalists to the extent that some recruit generalists as an alternative and provide RWM education and training internally or using available courses. Overall, the industry does not anticipate large rises in new staff.

3.14.4 Capabilities and Activities

As just over half of the work carried out by ARAO is sub-contracted and consultants

occasionally used, the Agency has recently begun to invest in education and training of such external staff. Nuclear Power Plant Krško's in-house training department provides numerous stand alone courses. Several are provided by an independent training centre under Jožef Stefan Institute and are linked to industry. This training centre provides several short courses in nuclear technology and radiation protection courses run numerous times a year. The University of Ljubljana provides RWM modules within a broader Nuclear Engineering Course.

Summary: The transfer of RWM expertise and skills to younger generations is a potential problem, as not many young professionals enter the field. Overall, the country is found to require approximately 25 RWM specialist staff in the next five years although no significant rise in education and training needs is expected.

3.15 Spain

3.15.1 The National Nuclear Industry

The Spanish Nuclear industry is composed of numerous national or private organisations (CIEMAT, TECNATOM, LAINSA, MONCASA etc), one regulatory body (CSN) and the national RWM organisation (ENRESA). CSN is responsible for nuclear safety and radiological protection; MONCASA for the management of radioactive waste in specific containers or recipients and ENRESA responsible for the external management of radioactive waste. CIEMAT, the former Spanish Nuclear Research Centre is both shareholder of ENRESA and supplies scientific and technical support.

3.15.2 National Policy including any specific education and training in RWM Policy

The are no national initiatives to coordinate education and training in RWM, nor does there exist a national strategy or any special national funding provisions to provide RWM education and training. However, the respective companies/institutions try to maintain current levels of expertise unsupported by government.

3.15.3 Training Requirements

Although legislation requires legal qualifications of key RWM personnel within most organisations, the survey data does not identify specific training requirements. In-house training requirements are generally fulfilled. Organisations such as CIEMAT have no particular training requirements as training is sourced locally (CIEMAT and Spanish Universities) and abroad (Foreign Regulatory bodies (mainly NRC), IAEA, European Commission EC, Nuclear Energy Agency (NEA) and private companies).

3.15.4 Capabilities and Activities

Most education and training is provided in-house, for example LAINSA has relevant departments providing training dependent on the topic areas to cover, however education and training on environmental issues are obtained externally. MONCASA provides basic radiation protection internally and specific radiation protection is taught by the owner of the facility.

Non-university RWM education and training is available from CIEMAT which has an active policy on nuclear training topics and provides education and training to CSN and ENRESA. TECNATOM provides training for operating personnel of industrial facilities.

Universidad Politécnica de Madrid runs two relevant courses; Nuclear Engineering Department, Course on Radioactive Waste Management (jointly organised with the Energy Studies Institute of CIEMAT and ENRESA) and Fuel and Chemist Engineering Department, course on Radioactive Waste Management (which maintains industrial partnership with ENRESA). This course is also offered by others Spanish universities.

Summary: Overall, the survey data indicates that in the short term, staff numbers for those involved in the decommissioning of nuclear facilities will increase, however organisations such as LAINSA involved in RWM and handing of nuclear facilities anticipate current staff number to remain the same. MONCASA predict a rise in staff numbers in the long term and although no timescale is defined, CSN plans to increase staff numbers involved in radioactive waste disposal.

3.16 Sweden

3.16.1 The National Nuclear Industry

Svensk Kärnbränslehantering AB - Swedish Nuclear Fuel and Waste Management Co, SKB, has the responsibility for the management of Sweden's radioactive waste and spent nuclear fuel. The company is owned by the nuclear power companies in Sweden. Eleven reactors are in operation (2005). SKB has developed a system for managing the radioactive waste. The system includes the central interim storage for spent nuclear fuel (Clab) and the final disposal for radioactive operational waste (SFR). All transportation of the waste and the spent fuel is done is done on sea by the ship Sigyn.

The deep repository is under development and siting is under way. Full-scale tests of the technologies are performed at the Äspö Hard Rock Laboratory and the Canister Laboratory. Two sites are performing comprehensive site investigations, in the municipalities of Östhammar and Oskarshamn.

There are two regulatory bodies in Sweden authorised to supervise spent fuel and radioactive waste management: The Swedish Nuclear Power Inspectorate (SKI) and The Swedish Radiation Protection Authority (SSI). The Swedish National Council for Nuclear Waste (KASAM) is the advisory body to the Swedish Government regarding issues related to nuclear waste management.

3.16.2 National Policy including any specific education and training in RWM Policy

The Nuclear Activities Act requires a programme for the comprehensive research and development and other measures that are required to manage and dispose of nuclear waste in a safe manner and to decommission and dismantle the nuclear power plants. To meet this requirement, SKB presents its Research and Development Programme every third year to the government. The regulatory authorities and the Government can clarify how they look upon different parts of the programme and stipulate guidelines for the future. Municipalities and other stakeholders can, after studying the programme, offer their viewpoints to SKB, the regulatory authorities or the Government.

3.16.3 Training Requirements

There are no national requirements for qualifications of specialists working in specific posts in RWM. SSI has the mandate to decide what requirements are needed however organisations such as SKB and SKI are very responsible and appreciate there is a need for specialist RWM staff to be properly qualified. Overall, training needs are identified on an individual basis and are obtained externally.

Generalists are found to be available on the market, only SKB find such staff difficult to obtain and usually need to supplement their education with specific RWM education and training. Generalists are used by respondents but are also supplemented by highly specialised staff such as consultants (in the case of SKB) or other current employees / specialist staff (as in the case of SKI). It is anticipated that current specialist staff numbers are expected to increase only slightly in the short term.

3.16.4 Capabilities and Activities

There are no non-university organisations providing education and training in RWM. KASAM does not provide education and training but organises a number of seminars, lectures and similar activities where regulatory organisations, representatives from local government concerned and other stakeholders and representatives from the industry such as SKB are invited. SKI relies on a mix of in-house training[8] and external national and international training courses and OKG training requirements are catered for by university courses (national and MIT), consultants and the KSU.

Chalmers University of Technology offers several nuclear chemistry courses which dedicate some time to nuclear waste. The Royal Institute of Technology (KTH), Nuclear Fuel Cycle course (chemistry) contains modules on the disposal of nuclear waste. The University of Kalmar, Department of Biology and Environmental Science focuses on the transport and distribution of environmental pollutants in and between rocks, soil and biosphere involving basic

8 Participation in research projects, international working groups etc. are also viewed as a mechanism for E&T

research in geosciences and applied research on distribution of pollutants from surface and rock deposit. The postgraduate school is funded by SKB, Oskarshamn municipality and the Faculty of Natural Science, Kalmar University.

Summary: Overall national demand for education and training in RWM is limited for the next five years and within the next 15 years SKB will require 20 new specialist staff all qualified to MSc or PhD level. SKB is currently in the process of making an assessment of future needs in terms of overall staff, specialists, consultants, contractors etc. In this context, the demand for education and training will be addressed.

3.17 Switzerland

3.17.1 National Nuclear Industry

Swiss electric power utilities (BKW FMB Energie AG, Bern; Kernkraftwerk Gösgen-Däniken AG, Däniken; Kernkraftwerk Leibstadt AG, Leibstadt; Nordostschweizerische Kraftwerke, Baden) operate five nuclear power plants providing 40% of the electric energy produced in Switzerland. The National Cooperative for the Disposal of Radioactive Waste (Nagra) is responsible for the development of projects for the disposal of radioactive waste in Switzerland. Other organisations employing staff in RWM include: Zwischenlager Würenlingen AG (ZWILAG) responsible for the Central Storage Facility in Würenlingen; Waste Management Laboratory (LES) at the Paul Scherrer Institute (PSI Villigen) carrying out research on waste management; and a few tens of private (national and foreign) companies providing engineering and consulting services for deep geological disposal, and technical support for field investigation activities.

On the governmental and regulatory level there is the Federal Council (Federal Government) which is the licensing authority for nuclear installations. The Federal Office of Energy (BFE – part of the Department for Environment, Transport, Energy and Communication UVEK) is the licensing authority for other licences (e.g. transport, trade, import and export of nuclear fuel and radioactive waste). BFE also conducts the licensing process for nuclear installations. The Federal Nuclear Safety Inspectorate (Hauptabteilung für die Sicherheit der Kernanlagen HSK) is the supervisory body of nuclear installations; HSK is the principal regulatory body, also in charge of supervising the preparations for the disposal of radioactive waste and the transport of radioactive material from and to nuclear installations. The Federal Office of Public Health (BAG – under the Department of Interior EDI) is the licensing authority for the handling of radioactive material in medical and research institutions and in other situations where the protection of the general public is the primary concern. The “Sektion Überwachung der Radioaktivität” (SUER, Department of Physics, University of Fribourg) is a specialised laboratory of the Department of Radiation Protection of BAG; SUER is the coordination office for the national monitoring programme on environmental radioactivity.

Within the federal administration, the following advisory bodies on radioactive waste management have been established: Federal Nuclear Safety Commission (KSA) comments on licence applications and on fundamental safety issues; Interdepartmental Working Group on Radioactive Waste Management (AGNEB) prepares technical documents for governmental decisions on RWM and Geological Commission on Radioactive Waste Disposal (KNE) advises BFE and HSK on geological aspects of waste disposal.

3.17.2 National Policy including any specific education and training in RWM Policy

Qualified (scientific and technical) personnel consist of scientists and engineers (mostly with university degree) in professional disciplines with particular relevance for the management of radioactive waste. Scientific and technical work areas which are defined by the phase-oriented disposal programme are basically “discipline” oriented and directly linked to specific specialist areas: Corresponding qualified personnel in e.g. geology, hydrogeology, physics, chemistry, civil engineering, material technology etc. is usually educated and trained at universities, polytechnics and other institutions, and later available on the world-wide labour market. Such personnel recruited by the RWM organisation, in accordance with i) the needs of the strategic programme and ii) the foreseeable needs implied by personnel changes (leaving, retirement). In addition, the available in-house workforce is supplemented by a well-established, actively maintained, international network of experts in specialised work areas.

A similar human resources policy is adopted by most organisations involved in the management of radioactive waste in Switzerland.

3.17.3 Training Requirements

The new "Nuclear Energy Law" (in force since 1st February 2005) and the corresponding "Nuclear Energy Ordinance" stipulate that an operating licence holder is responsible for the security of any nuclear installation and its operation. To this end, the license holder is obliged to "set up a suitable organisation and recruit a sufficient number of specialised staff". Provisions for education and training of specialised staff are laid down in the corresponding regulations of the Swiss Federal Council. The Federal Safety Authorities are obliged to support education and training of specialists in the areas of safety and security of nuclear installations, and also for nuclear disposal.

Legal requirements for education and training other than for the operation of the nuclear installations, nor for the handling and disposal of radioactive waste, are not specified.

3.17.4 Capabilities and Activities

Education and specialisation with respect to the organisation's needs in the field of radioactive waste management is done on-the-job by tuition within project teams that are allocated to specific work disciplines, e.g. waste characterisation, regional and local geology, field investigations, performance assessment etc. Depending on available options on-the-job tuition is supplemented by individual training sessions attained e.g. at national and international conferences, workshops, special training courses etc. Such opportunities are useful; however, they are not indispensable for the sake of human resources in radioactive waste management.

Education and training opportunities in the field of nuclear technology, radiation protection and waste disposal are offered in Switzerland, for instance, by School of Radiation Protection ("Strahlenschutzschule"), Paul Scherrer Institute (PSI, Villigen); School for licensed operators of nuclear power plants ("Reaktorschule", PSI Villigen); School of Underground Waste Storage and Disposal (ITC Innertkirchen); Postgraduate studies/courses in nuclear technology, Swiss Federal Institute of Technology, Zürich and Lausanne; Graduate and Postgraduate courses, University of Bern (geology, geochemistry) and University of Neuchâtel (hydrogeology); Periodic nuclear technology seminars, Swiss Nuclear Forum and Swiss Nuclear Society (Bern).

Practical experience in deep geological disposal of radioactive waste is obtainable through the participation in research activities carried out at the Grimsel Test Site (crystalline rock) and the Mont Terri Underground Research Laboratory (argillaceous rock).

Summary: In Switzerland ITC provides courses in RWM, also two Underground Research Laboratories are available for E&T. Further European wide opportunities for E&T are regarded as useful but are not indispensable for HR in RWM.

3.18 United Kingdom

3.18.1 The National Nuclear Industry

The National RWM Organisation, United Kingdom Nirex Ltd is charged with the mission "In support of Government Policy, develop and advise on safe, environmentally sound and publicly acceptable options for the long-term management of radioactive materials in the UK." It is to be independent of the nuclear industry, none of whose organisations employ staff to work on geological disposal of wastes although large numbers of scientists and engineers in such organisations work on the conditioning of wastes for possible future disposal. The majority of such work in the UK will become the responsibility of a newly-created Nuclear Decommissioning Authority in early 2005 which is expected to contract out the work of conditioning wastes.

The National Radiological Protection Board advises Government and the regulatory bodies on radiological protection in relation to all aspects of waste management. In the current absence of a policy of geological disposal, this represents keeping a watching brief on international developments. The Environment Agency, Nuclear Waste Assessment Team (NWAT) is the UK's regulatory body with the principal responsibility of oversight of Nirex's work on geological disposal options.

3.18.2 National Policy including any specific education and training in RWM Policy

There is no long-term national strategy for RWM education and training however a recent Government paper[9] announced the creation of what is now to be the Nuclear Decommissioning Authority, and proposes a targeted action plan.

Three national incentives exist to coordinate or improve RWM education and training; the COGENT Initiative was set up to establish a Sector Skills Council (an independent employer-led organisation to address skills needs in its sector) to become operational in early 2004. Project Dalton is also being established (by the New University of Manchester, the North West Development Agency and British Nuclear Fuels) to support the implementation of Government Policy for nuclear site clean up and energy generation by taking initiatives to help fill skills gaps. The Dalton Nuclear Institute is co-ordinating a proposed Nuclear Technology Education Consortium (NTEC) of universities. Finally, BNFL's University Alliance (currently with the Universities of Leeds, Sheffield, Manchester Victoria, and Manchester Institute of Science and Technology) proposes the development of training courses.

There are no special national funding provisions but the Nuclear Decommissioning Authority, to be funded by Government, will be expected to ensure that the necessary knowledge and skills are in place to deliver safe and cost-effective waste management.

3.18.3 Training Requirements

There exist legal requirements for the qualifications and experience of specialist staff however with the on-going national policy review, there is not a high demand envisaged for geological disposal education and training in the short term. If the Government identifies geological disposal as a policy option in 2007, there is likely to be a small increase in demand for education and training in relation to siting policy. In order for Nirex to provide education and training to specialist staff, a wide range of in-house training is required appropriate to the individual. At this time these requirements are being fulfilled by using in-house RWM expertise and external scientific or engineering specialist expertise. A similar position exists for The NWAT regulatory body.

3.18.4 Capabilities and Activities

There are no non-university organisations providing RWM education and training at present but proposals are being elaborated by RWE NUKEM and the British Nuclear Energy Society for pilot one-week intensive training course, including consideration of geological disposal of long-lived wastes. Only the University of Birmingham Physics and Astronomy Department (a prospective partner in NTEC) runs a course in Radioactive Waste and Decommissioning involving industrial partnership with UKAEA, BNFL, British Energy, and Atkins.

With the ongoing national policy review, there is not a high demand envisaged for geological disposal education and training in the short term. If the government identifies geological disposal as a policy option in 2007, there is likely to be a small increase in demand for education and training in relation to siting policy.

[9] White Paper, "Managing the Nuclear Legacy"

CHAPTER 4: RESULTS AND ANALYSIS

4.1. Training Needs

This chapter reviews the education and training needs of the three categories of organisations employing staff in radioactive waste management:

- National RWM Organisations
- Other Nuclear Industry Organisations employing staff in RWM
- Regulatory and Government Advisory Organisations employing staff in RWM

4.1.1 National RWM Organisations

In line with the development of the European nuclear industry, national RWM organisations were found to be established in all CETRAD participating countries with the exceptions of Germany and the Slovak Republic (it is only now that progress is being made towards the establishment of a national RWM organisation in Slovak Republic). Portugal's national RWM organisation was the first to be established in 1961 and in the 1970s and 1980s Sweden, Switzerland, Belgium, the UK and Netherlands had also established such organisations. The most recently set up are those of Bulgaria and Romania (2004). Table 1 identifies national RWM organisations and the number of specialist staff employed.

Table 1: National RWM Organisations

Country	**National RWM Organisation**	**Specialist staff[10] employed (status: end of 2004?)**
Belgium	ONDRAF/NIRAS Belgian Agency for Radioactive Waste and Enriched Fissile Materials	34
Bulgaria	State Facility for Radioactive Waste Management	147
Czech Republic	Radioactive Waste Repository Authority (RAWRA)	18
Finland	POSIVA Oy	32
France	Agence Nationale pour la gestion des Déchets Radioactifs (Andra)	195
Germany	None see page 14 for explanation	---
Hungary	Public Agency for Radioactive Waste Management (PURAM)	13
Italy	Società Gestione Impianti Nucleari (SoGIN)	260
Netherlands	COVRA NV	39
Portugal	Instituto Tecnologico e Nuclear (ITN), Departamento de Proteccao Radiologica e Seguranca Nuclear (DPRSN)	5
Romania	National Agency for Radioactive Waste Management (ANDRAD)	15
Slovak Republic	Slovac Electric Plc, NPP Decommissioning and Radioactive Waste and Spent Fuel Management Branch SE-VYZ	85
Slovenia	Agency for Radwaste Management (ARAO)	13
Spain	ENRESA	110
Sweden	Svensk Kärnbränslehantering AB (SKB)	85
Switzerland	National Cooperative for the Disposal of Radioactive Waste (Nagra)	49
United Kingdom	Nirex Limited	39

National RWM organisations employ an average of 60 specialist staff per country. Of the participating countries, France employs the most specialist staff (195) whilst Portugal employs just 5. It must be noted that these examples are the extreme.

With regard to the qualification profile of specialists employed, most national RWM organisations employ greater numbers of engineers, PhD, MSc and licentiate qualified staff than any other qualification level. Some staff are first degree scientists, lawyers, social scientists and economists, but the numbers of specialist staff possessing such qualifications are not as great.

10 The term "specialist staff" generally refers to all RWM staff excluding administrative and support staff.

A full set of specialist staff numbers year-by-year since establishment of national RWM organisations were not received however from the sample obtained, most countries (Bulgaria, Czech, Finland, Slovenia, Hungary, Switzerland) currently employ more specialist staff now than they have done in the past. Belgium, the Netherlands and Slovak Republic currently employ more specialist staff now than for the last several years.

With regard to the age distribution of specialist staff, a sample reveals there to be more specialist staff within the age groups of 30-40 years and 40-50 years. Table 2 summarises the data available related to the age distribution of staff.

Table 2: Age Distribution of Specialist Staff

Age 30 and below	There does exist a large gap between this age group and those of 30-40 however this is attributed to the career development of specialist staff as those under 30 years old are generally still developing expertise and experience to become specialists.
Age 30 to 40	This is the age group recognised as having acquired specialist expertise. In the cases of Finland Hungary, Slovak and the UK the data provided confirms the shortage in specialists as identified by the International Atomic Energy Agency11. Only Bulgaria and Sweden do not seem to be experiencing this where this age category is made up of the greatest number of specialist staff.[12]
Age 40 to 50	With the exception of Bulgaria and Sweden, this is the age group containing the greatest number of specialist staff.
Age 50 to 60	This age group does contain fewer specialist staff than age category 40-50 but the figure is not as low as the under 30 category and it must be noted that in Slovak Republic figures for this age group are only very slightly lower.
Age 60 and above	There does exist a large gap between this age group and those of 40-50 and 50-60. This is due to retirement, and numbers of staff originally involved with the inception of nuclear technology in 1940s would have been low.

Future anticipated staff numbers of national RWM organisations are not expected to increase significantly as most respondents expect future specialist staff numbers to remain as they are or increase a little depending on the phased implementation steps of the national programmes and the large uncertainties involved. The creation of underground research laboratories and geological repositories may positively impact employment figures due to increased demand for specialist staff. Consideration of potential future demand at a European level is given in Table 9.

The survey indicates that that National RWM Organisations employ a majority of staff specialising in:

- nuclear and chemical engineering,
- radiation protection and safety assessment,
- earth sciences and rock engineering.

Any anticipated increases in the number of specialist staff will be within the above areas plus a few in public relations and communications.

Most national RWM organisations have legally imposed national qualification requirements for specialists working in specific posts related to RWM. In all cases, provision for training is in place to fulfil such legal requirements and where there is no such requirement, company policy demands professional competence.

Broad training in RWM for new specialist staff is usually demanded by company policy within a short period of recruitment, and when this is the case (i.e. UK, Slovenia, Finland, Hungary and Spain) training is compulsory or part of the working agenda. The Portuguese response indicates that such training is compulsory but the quality of training currently provided is far from satisfactory.

Continued or supplementary specialist training methods utilised by National RWM organisations include;

11 IAEA Annual Report 2003, http://www.iaea.org/Publications/Reports/Anrep2003/index.html

[12] The number of specialists in Finland is not declining in this age cohort, there simply are not specialists in this age category! And if one looks at the past events, the potential new comers would have chosen their career during the years of 1982-1995, when there was the Tsernobyl accident, lack of nuclear plant construction (stagnated period in the industry), and the establishment of green parties opposing nuclear energy, which lead to the situation that there was no desire to enter the industry. This is the situation that the RWM organisations need prevent from repeating itself.

- on-the-job training,
- conferences,
- seminars and international technical collaborative meetings.

Education and training is generally provided through the use of both in-house capability and external training providers;

- Internal training is found to involve on-the-job training, the use of internal experts and some national RWM organisations have formal structured courses provided by internal personnel/human resources or consultants.
- External education and training is provided by one or more organisations in the Netherlands, Portugal, Slovenia, Czech Republic and Switzerland.

Both internal and external training in general (not all specifically identified the education and training tools used) involves on-the-job training, lectures, workshops and conferences.

Table 3 details the topics identified as being used by both internally and externally sourced courses.

Table 3: Sample of topics taught

• Design & construction of URL and repository	• Collection & classification of wastes
• New radioactive waste treatment techniques for solids and liquids (aqueous & organic)	• Radiation protection
• Use of equipment to monitor radiation/contamination	• Segregation & conditioning in cement matrices of solid radioactive waste
• Waste characterisation	• Site selection
• Law, regulation and standards	• Quality Assurance
• Radiation protection at NPP	• Work safety
• RTD programs	• Quality Assessment
• Environmental protection	• Safety

Summary

The survey has identified national RWM organisations to be well established in Europe, employing an average of 60 specialist staff per organisation and a total of 679 (as at 2004) across the participating countries. The majority of specialist staff are qualified to MSc and PhD level and are between 30 and 50 years old. Broad RWM training for new specialist staff is generally required involving a wide variety of subjects both directly and indirectly applicable to RWM and geological disposal and where in-house training is provided through on-the-job training. Employment of specialist staff is currently at a peak but is not expected to increase significantly.

4.1.2 Other Nuclear Industry Organisations employing staff in RWM

Other Nuclear Industry organisations generally play key roles in the national industry and are closely linked to National RWM Organisations. The RWM responsibilities of Other Nuclear Industry Organisations are varied in that they provide consulting and commissioned work to National RWM Organisations, are involved in transport, treatment, processing and storage of waste, assist in decommissioning activities and participate in radioactive waste projects such as research of engineering barriers.

Table 4 identifies those falling into the category of Other Nuclear Industry Organisations specifying the number of specialist staff currently employed.

Table 4: Other Nuclear Industry Organisations employing staff in RWM

Country	Other Nuclear Industry Organisations employing staff in RWM	Specialist staff employed
Belgium	Belgian Nuclear Research Centre (SCK·CEN)	55
	Belgoprocess	
	IRE	
Bulgaria	Institute for Nuclear Research and Nuclear Energy	30
	Kozloduy NPP Plc.	5007[13] (confirmed specialist staff employed is 50)
Czech Republic	Nuclear Research Institute Rez plc	15
Finland	TVO Teollisuuden Voima OY	1
	Fortum Power & Heat Oy (FPH) including Fortum Nuclear Services (Ltd)	21
	Saanio & Riekkola Consulting Engineers	17
	Jaakko Pöyry Infra including JP-Fintact and JP-Suoraplan	12
	Fracom Ltd	8
France	Commissariat à l'énergie Atomique (CEA)	400
Germany	Federal Office for Radiation Protection (BfS)	50
	Federal Institute for Geosciences and Natural Resources (BGR)	100
	DBE Technology	15
	Institut für Sicherheitstechnologie, ISTec	10
	Deutsche Gesellschaft zum Bau und Betrieb von Endlagern für Abfallstoffe mbH (DBE)	250
	Forschungszentrum Karlsruhe (FZK), Institut für Nukleare Entsorgung (INE)	41
	Forschungszentrum Jülich (FZJ), Institut für Sicherheitsforschung und Reaktortechnik (ISR)	30
	Forschungszentrum Rossendorf (FZR), Institut für Radiochemie	12
	Öko-Institut e.V. (Institute for Applied Ecology)	10
	National Research Centre for Environment and Health (GSF), Institute for Radiation Protection (ISS)	2
	European Institute for Transuranium Elements (ITU)	10
Hungary	None	---
Italy	Ente per le Nuove tecnologie l'Energia e l'Ambiente (ENEA)	95
	NUCLECO S.p.A.	30
Netherlands	Nuclear Research & Consultancy Group (NRG)	53
	Electrical Production Company South Netherlands (EPZ)	6
	Gemeenschappelijke Kernenergiecentrale Nederland (GKN)	
	Urenco	
Portugal	None[14]	
Romania	Nuclearelectrica, SA National Company (SNN)	
	Uranium National Company (CNU)	250
	Center of Technology and Engineering for Nuclear Projects (CITON)	50
	Institute for Nuclear Research (ICN)	55
	R&D National Institute for Radioactive Metals and Resources (ICPMRR)	
	HORIA HULUBEI National Institute of Physics and Nuclear Engineering, IFIN-HH	75
	Institute for Geotechnical and Geophysical Studies Ltd (GEOTEC Ltd)	
	(ICIM), The National Research and Development Institute for Environmental Protection	50
Slovak Republic	Slovak Electric Plc	28

13 (Bulgaria) This represents all specialists employed at a particular facility and it is assumed that a maximum of 10% of this figure are RWM specialist staff.
14 (Hungary) all activities related to RWM are under the responsibility of the Portuguese Government and no Other Nuclear Industry Organisations exist

Slovenia	Nuklearna elektrarna Krško	9
	Rudnik Žirovski vrh, d.o.o.	9
Spain	Centro de Investigaciones Energéticas Medioambientales y Tecnologicas (CIEMAT)	37
	TECNATOM S.A.	3
	Logistica y Acondicionamientos Industrialies S.A. (Lainsa)	80
	Moncobra S.A. (Moncasa)	25
	Iberdrola Ingenieria y Consultoria S.A.U. (IBERINCO)	7
	Framatome ANP	1
Sweden	OKG AB	82
Switzerland	Zwischenlager Würenlingen AG (ZWILAG)	
	Paul Scherrer Institutem (PSI), Waste Management Research Laboratory	
	Several engineering and consulting companies	
United Kingdom	Nuclear Decommissioning Authority (NDA)	250

It is found that in general, specialist staff make up a large majority of all staff within this category however the level of education of specialist staff is varied. In Finland, only those qualified to above post graduate level are considered "specialist staff" and are found to posses PhD, MSc, licentiate, legal and engineering qualifications. Similarly, in Germany all specialists have, at minimum, a first degree. These observations highlight subjectivity gaps in the survey as the definition of 'specialist staff' varies from country to country.

More staff with technical qualifications are employed than those with PhD level qualifications. For example, OKB of Sweden employs a vast majority of specialist staff with technical degrees and at CEA France; half of specialist staff (around 200) have a technical degree qualification. It is suggested that this is due to general labour market trends (i.e. fewer people continue to further education). Such findings indicate a need for education and training at all levels particularly during employment.

Most organisations do have legal requirements for qualifications of specialists working in specific posts in RWM although these are generally particular to nuclear safety and radiation protection. Finland, the Netherlands and Belgium have none imposed yet require some qualification in radiation protection and internal training. Regulations do not impose set levels of education and training.

As with National RWM organisations, respondents found it difficult to provide a breakdown, as a function of time, of current and anticipated future RWM staff areas of specialisation and were not able to provide current or anticipated future staff specialisation data in the original questionnaire. However for those that did the following representative data was available:

- The Bulgarian Institute for Nuclear Research and Nuclear Energy anticipates 2 additional specialist in Monitoring Occupational Safety, 4 extra in 'others' (not specified) and one in each of the following Radiation Protection & Safety Assessment, Law & Regulation, Physics, and Chemistry and Material Science in the medium term (not defined).
- Fracom Ltd (Finland) currently employs 7 specialist staff part time, and one (Lic Tech) full time. Earth Sciences & Rock Engineering specialists will increase from 5 to 6 staff and an increase from 3 to 4 specialist staff in Civil Engineering and Underground Construction and Mining both after three years.
- CEA (France) was able to provide detailed data. A total of 400 current specialist staff are employed however this is expected to be cut to 265 in the short term (2008) decreasing in the field of R&D on RWM and increasing in the field of nuclear engineering for future reactors & advanced fuel. A slight increase is expected in Earth Sciences and Rock Engineering and slight decrease in Civil Engineering and Underground Construction and Mining. In the medium term (2012) approximately eight economics specialists will be employed.
- Moncasa (Spain) anticipate between 5 and 10 new specialist staff in the long term.
- In Germany broad RWM training for specialist staff is not required as analysis of Q.1.10

(Appendix A) found. German specialist staff to posses a minimum of a first degree and thus are considered to already have grounding in RWM.

- NRG (Netherlands) compulsory training is provided within one year of recruitment where staff participate in annual courses on nuclear technology in which RWM and decommissioning topics are addressed. In addition, most specialists participate in special courses on health physics and radiation protection.
- Similarly, at EPZ (Netherlands) all new staff receive training (internal practical training within one year of recruitment), and all new employees working in nuclear areas are expected to participate in the annual course on radiation protection.
- At Kozloduy NPP (Bulgaria) staff receive training on the basic principles of radioactive waste manipulation.
- At OKG (Sweden) there is no special need for new specialist training as education and training requirements are identified individually.
- CEA (France) has developed a specific general basic nuclear training course intended for all new staff, young scientists & engineers engaged in the broad field of nuclear sciences, engineering & technologies.
- Moncassa (Spain) all new RWM specialist staff require basic and specific radiological protection training which requires periodical retraining (basic training provided biannually, specific course annually).

On the whole new specialist staff are required to have a broad understanding of RWM and given the broad and numerous functions of Other Nuclear Industry Organisations it is clear that education and training is developed to organisational requirements. As considered above, the subjective nature of the question may contribute to the mixed and unspecific survey response received. However, an alternative or additional contributing factor may be the ways in which organisations utilise resources and opportunities within their individual business environments. It may be suggested that a further influential factor is the lack of a broad European Union Framework in this area.

In general, the survey indicates Other Nuclear Industry Organisations to currently employ a majority of staff specialising in the same specialist areas as identified for National RWM organisations:

- nuclear and chemical engineering,
- radiation protection and safety assessment,
- earth sciences and rock engineering.

Some Other Nuclear Industry Organisations cater for training requirements in-house (i.e. Fracom of Finland, CIEMAT and TECNATOM of Spain and SCK·CEN Belgium) or through on-the-job training (i.e. NRG of Netherlands, all German Other Nuclear Industry Organisations and Slovak Electric of the Slovak Republic). Others utilise international conferences, scientific publications (i.e. Jaakko Pöyry Infra of Finland); professional training courses (ie. FPH Fortum Power & Heat Oy of Finland) and University courses and consultants (i.e. OKG of Sweden).

Table 5 details the topics identified as being used by both internally and externally sourced courses.

Table 5: Examples of topics taught include:

• Radiological Protection	• Economics
• Decommissioning Techniques	• Communication
• Environmental Effects	• Environmental Effects
• Measuring Techniques	• Radiological Protection
• SA, Decommissioning, Nuclear Engineering	• Advanced Courses on Ethics, Sociology, Philosophy
• Health Physics	• New Technologies For Reduction of Radioactive Waste
• RWM & Geological Disposal	• Nuclear Waste Systems
• Safety Training	• Supervision Of Radioactive Facilities

Summary

Other Nuclear Industry organisations are numerous and are closely linked to National RWM Organisations. Specialist staff make up the majority of all staff within Other Nuclear Industry organisations, employing a total of approximately 6960 RWM specialist staff, most of whom possess technical degrees and qualifications. Education and training is typically developed in an ad-hoc manner through on-the-job training, attendance at conferences and according to organisational requirements.

4.1.3 Regulatory & Government Advisory Organisations employing staff in RWM

Most countries have at least one regulatory body and one or more government advisory organisation. Many government advisory organisations also have some research capacity.

Table 6 identifies the Regulatory and Government Advisory Organisations employing staff in RWM, specifies regulatory or advisory functions and presents the number of specialist staff employed.

Table 6: Regulatory and Government Advisory Organisations

Country	Organisation Name	Function	Specialist Staff (status: end of 2004)
Belgium	Federal Agency for Nuclear Control (FANC – AFCN)	Regulatory	5
Bulgaria	Nuclear Regulatory Agency	Regulatory	6
Czech Republic	State Office for Nuclear Safety (SUJB)	Regulatory	4
Finland	KTM Ministry of Trade and Industry, Helsinki Energy Department, Nuclear Energy Section	Regulatory	3
	Radiation and Nuclear Safety Authority (STUK)	Regulatory	9
	VTT Industrial Systems (VTT TUO)	Advisory	19
	VTT Processes (VTT PRO)	Advisory	23
	VTT Building and Transport (VTT RTE)	Advisory	5
	Geological Survey of Finland (GTK or GSF)	Advisory	13
	University of Helsinki, Department of Chemistry, Laboratory of Radiochemistry (HYRL)	Advisory	9
	HUT/AES	Advisory	3
	Helsinki University of Technology (HUT), Institute of Mathematics	Advisory	3
	LUT	Advisory	12
France	The Institute for Radiological Protection and Nuclear Safety (IRSN)	---	
Germany*	Federal Institute for Geosciences and Natural Resources (BGR)	Advisory	100
Institutions do not have only advisory status but are also R&D-institutions (multiple tasks), staff also involved in R&D	Gesellschaft für Anlagen und Reaktorsicherheit mbH (GRS)	Advisory	50
	Institut für Sicherheitstechnologie (ISTec)	Advisory	10
	National Research Centre for Environment and Health (GSF), Institute for Radiation Protection (ISS)	Advisory	24
	Öko-Institut e.V. (Institute for Applied Ecology),	Advisory	10
Hungary	HAEA Hungary Atomic Energy Authority, CNFF Central Nuclear Financial Fund (Technical Administration)	Regulatory	7
Italy	Agenzia per la Protezione dell'Ambiente (APAT)	Advisory & Regulatory	30
Netherlands	VROM Ministry of Housing, Spatial Planning and the Environment	Regulatory	2.5
	NRG[15]	---	---
	TNO-NITG Netherlands Institute of Applied Geoscience - National Geological Survey	Advisory	15

15 Netherlands, NRG identified as 'Other national RWM organisation' and analysed in section 4.1.2

Portugal	Ministry for Science & Nuclear & Technological Institute (ITN)	Unknown	
	Instituto Nacional de Residuos	Unknown	
Romania	National Commission for Nuclear Activities Control (CNCAN)	Unknown	35
	Nuclear Agency (AN)	Unknown	5
Slovak Republic	Nuclear Regulatory Authority of the Slovak Republic	Regulatory	7
	State Fund of Decommissioning of Nuclear Power Facilities and the spent fuel and radioactive waste management	Regulatory	4
Slovenia	Ministry of the Environment, Spatial Planning and Energy, Slovenian Nuclear Safety Administration (SNSA)	Regulatory	2.5
	Institute of Occupational Safety	Advisory	7
	Jožef Stefan Institute	Advisory	60
Spain	Consejo de Seguridad Nuclear (CSN)	Regulatory	32
Sweden	Swedish Nuclear Power Inspectorate (SKI)	Regulatory	14
	Swedish Radiation Protection Authority (SSI)	Regulatory	23
	Swedish National Council for Nuclear Waste (KASAM), Ministry for Sustainable development	Advisory	
Switzerland	Swiss Federal Nuclear Safety Inspectorate (HSK)	Regulatory	10
	Federal Office of Public Health (BAG)	Regulatory	
	Swiss Federal Nuclear Safety Commission (KSA)	Advisory	
	Arbeitsgruppe des Bundes für die nukleare Entsorgung (AGNEB)	Advisory	
	Kommission Nukleare Entsorgung (KNE)	Advisory	
UK	Nuclear Waste Assessment Team (NWAT), Environment Agency	Regulatory	4

Specialist staff are found to posses PhD and MSc qualifications and few holding technical degrees or below, however as noted previously the interpretation of respondents definition of "specialist" may be an influential factor.

With the exceptions of Czech Republic and Bulgaria, responses indicate no national legal requirements specifically for RWM specialists of regulatory and government advisory organisations. A few (Netherlands, Slovenia) require personal safety and / or radiation protection training or qualifications. Overall legislation does not demand extensive education and training for specialists within this area.

Respondents found it difficult to provide current or anticipated future staff specialisation data in the original survey. As previously identified with National RWM organisations and Other Nuclear Industry Organisations, the survey indicates the main areas which specialist staff specialise in are;

- Nuclear & chemical engineering,
- Radiation protection & safety assessment
- Earth sciences & rock engineering.

Most specialist staff, particularly new specialist staff, require broad training in RWM, for example;

- In SKI of Sweden new specialist staff training is essential and based on individual needs,
- New staff of TNO-NITG (Netherlands) participate in internal annual courses in applied geoscience and special RWM training is led by senior scientists, usually on-the-job,
- In Germany all new specialist staff receive broad RWM training,
- In Switzerland, RWM training of new specialist staff is considered to be of advantage.

Half of respondents identify training as compulsory and half optional. The Geological Survey of Finland identify the need for supplementary training on a case by case basis, and at CSN Spain, annual training is optional but recommended.

Due to the diversity of respondents, training topics and methods of training provision are varied. In-house training topics are found to be broad or introductory including RWM subjects and surrounding topics such as; basics of nuclear technology, safety and radiation protection (Jožef Stefan Institute, Slovenia), basics of RWM (STUK, Finland; Geological Survey of Finland; CSN Spain) and legislation and administration (KTM, Finland). Although broad introductory training is sometimes obtained externally it is noted that in general specialised or focused training is usually obtained externally *and introductory training internally*.

Table 7: Examples of specialised topics covered by externally sourced courses

• Advanced radiation protection	• Reactor Physics
• Focused legal, legislative and administrative topics	• Specialist computer modelling
• Advanced performance assessment	• Material and manufacturing technology
• Advanced geosciences and geotechnology	• Geochemical modelling
• Hydrogeological modelling	• Earth sciences and rock engineering
• Decommissioning	• Risk Analysis
• Site selection design and construction	• Safety Assessment of repositories

On-the-job training is used by many. For example, VTT TUO, Finland fulfils specific education and training needs through a hands-on approach where participation in research projects forms the learning experience.

Education and training is also noted to be obtained from overseas organisations. Those specified include:

- PHARE (a European pre-accession instrument)
- Decovalex III and Decovalex THMC (Helsinki University of Technology)
- U.S. Nuclear Regulatory Commission
- International Atomic Energy Authority

Conferences, seminars, workshops and summer schools organised by various organisations within the national industry are utilised to some extent as part of education and training.

Summary

The survey has identified there to be Regulatory and Government Advisory Organisations in each country employing staff in RWM. Approximately 630 specialist staff are employed generally possessing PhD and MSc level qualifications. Although new specialist staff require broad training in RWM, legislation does not demand extensive education and training for specialists in this area and on-the-job training is a key component of staff development. Where training is provided in-house training topics are found to be broad or introductory and specialised or focused training is usually obtained externally. Overall, Regulatory and Government Advisory Organisations anticipate little change in the numbers of specialist staff employed in both the short and medium term.

4.2. Capabilities and Activities

The capability and activities of universities and non-university organisations are now considered to identify ability to supply current demands of National RWM organisations, Regulatory and Government Advisory Organisations and Other Nuclear Industry Organisations.

4.2.1 Non-University organisations providing education and training in RWM

Both private and state owned non-university organisations provide RWM education and training in most participating countries. Those without include the UK (although plans are currently underway), the Czech Republic and Sweden. The majority of non-university organisations are state owned including Slovenia, Belgium, Bulgaria, and Spain. Finland has two non-university organisations providing education and training in RWM, one public and one private firm. Most participating countries have a training centre that provides the majority of national industry non-university training requirements.

In all, eighteen non university organisations are identified as providing education and training in this area. Non-university provision is generally broad, at various levels and provided in the form of short, stand alone courses. RWM education and training includes:

- SCK•CEN/isRP (Belgium) provides courses for all levels (beginners, intermediates and advanced) on a wide variety of subjects, which are all associated with radiological protection and nuclear science and technology, thus also RWM related subjects. Content, structure, frequency and nature of course teaching are all demand dependent.
- NRG (Netherlands) makes available courses related to RWM and geological disposal as part of a series of nuclear technology courses. RWM and decommissioning courses are presented once or twice a year. Radiation protection courses of various levels are organised several times a year.
- ITN (Portugal) have recently established a Masters course on Biomedical Inorganic chemistry in collaboration with University of Lisbon.
- Jozef Stefan Institute (Slovenia) provides standard, introductory and refreshment short courses. NPP Krsko training department provides general and short courses for employee training and on-the-job training. NPP Krsko also uses the Jozef Stefan Institute for initial staff training.
- FTU of FZK (Germany) provide several short stand-alone courses on radiation protection.
- Training Centre, Kozloduy NPP (Bulgaria) operates several general introductory short courses covering the main aspects of RWM.
- JP-Fintact and JP-Suoraplan (Finland) provide very flexible courses according to client needs. Frequency is dependent on demand. VTT Processes has recently established an annual course for new staff of the National RWM organisation.
- NPP Personnel training centre VUJE (Slovak Republic) operates stand alone courses linked to industry taught through lectures and on-the-job training on operation and maintenance of nuclear facilities. Such courses include recognised qualifications and the training centre provides nuclear industry suppliers with training when legislation requires.
- ITC School (Switzerland) is the only organisation dedicated entirely to providing training in RWM. It provides several short courses a year on demand of its member organisations. Short courses (one to three weeks long) are conducted irregularly and are taught by highly qualified internationally recognised specialists. ITC is the only international provider.
- School of Radiation Protection ("Strahlenschutzschule"), Paul Scherrer Institute (PSI, Villigen) offers a wide spectrum of basic courses and training opportunities for professionals working with ionising radiation and radioactive materials (e.g. staff from universities and technical colleges, radiation protection personnel in nuclear facilities, medical professions, emergency organisations); these courses fulfil the legal requirements stipulated in the Swiss Radiation Protection Ordinance.
- School for licensed operators of nuclear power plants ("Reaktorschule", PSI Villigen) is a higher level technical institute offering recognised qualifications (diploma) for operating personnel of nuclear power plants. Additional courses are dedicated to basic training in nuclear technology and the design of nuclear power plants.
- INSTN (France) provides numerous courses including courses on demand, a Masters in collaboration with universities and courses aimed at obtaining regulatory qualifications. However this is a university type organisation providing continuous and professional training supervised by the Ministry of Education.
- CIEMAT (Spain) provides postgraduate and PhD courses every two years.

It must be noted that the survey does not identify any distance learning courses in this area.

Average participant numbers for non-university courses range from 5 to 30 (where 5 participants per course are deemed low and 30 is high) but unfortunately this figure does not provide age distribution data of participants or career development following course participation. There are non-university courses attracting greater numbers such as the three introductory / refresher courses provided by Nuclear Training Centre of Jozef Stefan Institute,

Slovenia which have up to 300 participants yearly that come from a wide range of institutions (industry, research, hospitals, government etc) generally from Slovenia but also attracting larger numbers of international participants for the radiation protection courses (run twice every three years) and specialist courses (run once every five years). The NPP Personnel training Centre VUJE, Slovak Republic also receives large numbers (yet not to the extent of Jozef Stefan Institute). It is assumed such high demand is due to the regulatory requirements of specialist qualifications as participants in this case are from Slovak Republic only.

Qualifications for acceptance for course participation are required by most but are varied where some require no specific qualifications and others require high school degrees, academic degrees, a technical, engineering or natural science background. Respondents have not provided details of problems encountered. This may be because no particular problems have been noted or because National Correspondents have not been able to access this information.

Non-university RWM education and training facilities available include:

- SCK·CEN labs (characterisation of radioactive waste) & underground research facility (in Mol) for long-term disposal of HLW.
- Grimsel Test Site (and possibly Mt. Terri URL) for ITC practical courses.
- Fully equipped class rooms & conference halls, computer laboratory, radiation protection laboratory with specific equipment, on-the-job training facilities in State Facility of RWM, full-scope & multifunctional simulators.
- INSTN active radiochemistry laboratory for practical work of students & trainees, but no facility or equipment devoted to HLW or long-lived waste management.
- Teaching resource materials – the document library of the isRP contains basic modules on radiological protection open for the general public.

Summary

Both private and state owned non-university organisations provide RWM education and training in most participating countries and many have a training centre that provides the majority of national industry non-university training requirements. Generally, non-university courses are broad, targeted at various levels and focus on the provision of professional training through stand alone courses but some are noted to work with universities (for example, Portugal, Switzerland, France and Spain) or are somehow linked to industry (for example through sharing of facilities). Non-university courses are identified as dependent on demand and have the freedom (unless contractual or legislative agreements to supply have been made) to be flexible customising services to meet client needs with various training material, classroom and laboratory facilities available. Average participant numbers range per course from 5 to 30. Overall, non-university education and training in RWM provision is uncoordinated and disjointed.

4.2.2 University courses

Of the 66 university courses involving RWM identified, there are no courses that provide a qualification in RWM. RWM modules are available within a number of courses including various streams of chemistry, geosciences, earth sciences, applied sciences, engineering (power, civil, chemical) energy and environmental technology / science.

Many university courses include laboratory teaching, visits to facilities, attendance at conferences, and project work in addition to lecture or classroom teaching. Geoenvironmental distance learning courses are not identified within the survey data and issues regarding quality of provision have not been addressed although university courses are accredited to national standards under the Bologna process. Data was not available to identify if course participants obtain employment in RWM areas following graduation, this may be because such data is difficult to obtain or because Universities do not monitor graduate progression into employment.

Table 8: Examples of typical university courses available

Country	Provider	Course Name / Credits
Belgium	BNEN Belgian Nuclear Higher Education Network	Interuniversity programme in Nuclear Engineering / University degree for the complete BNEN course (in total: 60 credits)
Portugal	Physics Department of IST Instituto Superior Técnico, Technical University of Lisbon	Master Course in Radiological Protection
Slovenia	University of Ljubljana, Faculty of Mathematics & Physics, Ljubljana	Graduate programme in Nuclear Engineering / Master degree in Nuclear Engineering / 120 ECTS
Germany	Technical University Clausthal (Lower Saxony), Institute of Mining, (Earth Sciences, Mining and Economic Sciences	Lecture: Long-term safety of waste repositories Lecture: Disposal of hazardous waste / diploma level, ECTS credits: 3
Bulgaria	Technical University of Sofia, Faculty of Power Engineering & Power Machines, Department of Thermal & Nuclear Power Engineering as well as Joint Technical College	Modules in 2 courses (Radiation Protection, Nuclear Safety) / BSc. in Thermal & Nuclear Power Engineering
Czech Republic	Czech Technical University, Prague, Faculty of Civil Engineering	Experimental Research of Nuclear Waste Disposal
Finland	University of Helsinki, Department of Chemistry, Laboratory of Radiochemistry	i) Radiochemistry basic II ii) Chemistry of Nuclear Fuel Cycling iii) Natural radioactive decay series in environmental studies / 2 % of MSc., 5 % PhD
Sweden	Chalmers University of Technology, Chemical Engineering Göteborg	Nuclear Chemistry (within course of 3 lectures, 2 hours are about nuclear waste PhD courses are given that contain 4 weeks of lectures in SA in geological repositories + project work
Switzerland	Federal Institutes of Technology in Zürich and Lausanne	Graduate / Postgraduate courses in nuclear technology

Overall participating countries consider it possible to teach a universal course in English, BNEN teaches in English as standard. In Belgium tuition and material is generally in French and or Flemish but Belgian specialist staff are generally fluent in English and in Slovenia only specialist courses are taught in English (usually conducted in Slovenian) and respondents consider it possible to convert to English. In Germany some special courses are provided in English and English as the course language is considered achievable although this is dependent on supply and demand. The Swiss already teach in English and the Hungarians in Hungarian and English. In the Czech Republic classes are taught in English which is the preferred language.

A sample of university facilities available includes laboratories with analytical equipment, computer codes, simulators and detectors. External practical training with industrial facilities such as opportunities to visit NPPs, radioactive waste sites and access to repositories are also available to course participants.

Total and average participation numbers are higher than non-university organisations, generally between 5 (low) and 45 (high) participants per course.

Summary

There are no courses that provide a qualification in RWM, yet each country has RWM modules or lectures available. Across the participating countries, a number of courses are considered by a wealth of disciplines which include elements of RWM teaching. Teaching and external practical training facilities are available and most participating countries consider it feasible to teach a universal course in English if not already doing so. Participation numbers are higher than those of non-university courses and university courses are accredited under the Bologna process by default.

4.3 Supplementary Reporting on European Education and Training in RWM

Results and analysis of the data obtained from the supplementary questions (intended to address identified gaps and weaknesses in previously obtained data) are considered below. This includes anticipated future recruitment for specialist staff, development toward the creation of Underground Research Laboratories and Underground Geological Repositories, national levels of demand for RWM education and training courses, involvement in social acceptance of RWM issues, and availability of facilities.

4.3.1 Demand for specialist staff and education and training in RWM

When answering the initial questionnaire, respondents found it very difficult to provide data regarding additional staff to be required in the future. However, data from the supplementary questions reveals that approximately 200 specialist staff educated to MSc level or higher in a number of areas will be required in minimum over the next five years. The specialist areas in greatest demand are Radiation Protection and Safety Assessment, Nuclear and Chemical Engineering and Earth Sciences and Rock Engineering. Table 9 provides details at a national level of the anticipated requirements.

Additional recruitment and natural replacement of specialist staff is considered by National Correspondents to be dependent on unforeseeable factors such as internal company strategy, political developments and decisions, development of research and development budgets and economic progress. Although the uncertain nature of national RWM programmes makes it difficult to predict recruitment levels, potential future demand for specialist staff in RWM and geological disposal can to some degree be estimated through the identification of important milestones such as anticipated dates for the creation of Underground Research Laboratories and Underground Geological Repositories (these are shown in Table 10). As can be observed, most countries have a timescale for an Underground Repository agreed. However, it should be noted that few have a timescale agreed for construction of Underground Research Laboratories which are often seen as a precursor to the actual repository.

The gap in expertise between generations (acknowledged by IAEA) is supported by findings within this survey. Findings reveal that on-the-job training and continuous professional development training are ways in which organisations attempt to manage this potential problem.

All organisations reviewed in section 1 of the survey provide some element of in-house training and many rely on several continued or supplementary training methods based on a mixture of internal and externally sourced provision. In Hungary and the Czech Republic, in-house provision is not required, but in most countries in-house training is used and needs are fulfilled or training obtained externally.

Table 11 presents national levels of demand for RWM education and training courses available where on average providers record 25 participants per course or more (high), between 15 and 25 participants (medium), between 5 and 10 participants per course (low). Where there are less than 5 participants or costs outweigh income or benefits gained, demand is acknowledged as none.

It is acknowledged that the stagnation of the nuclear industry has some negative impact on students interest for academic qualification, however a number of academic courses are currently available in the participating countries involving an element of RWM generally in the form of a module or seminars and an increasingly positive public perception may improve levels of demand.

Table 9: Additional recruitment (new staff and any natural replacement specified*) over the next five years.

Country	Numbers of staff	Qualification level	Nuclear & Chemical engineering	Radiation protection & SA	Earth sciences & Rock engineering	Civil engineering & underground construction & mining	Biological & Environmental sciences	Law & Regulation	PR & communications	Others
NEW STAFF & NATURAL REPLACEMENT										
Bulgaria	20									
Czech Republic	8	MSc		×	×	×	×	×	×	
		MSc or higher								
Finland	30	For civil/rock engineering also B.Sc. qualification is foreseen			×	×				not specified
France	40-55			×		×				Waste package specification & acceptance
Italy	40	Engineering	×	×	×					
Netherlands	2	MSc							×	Geohydrology
Portugal	7		×	×	×			×	×	
Slovak Republic	3	MSc								
Spain	5-10 +	Not identified		×				×		Management of radioactive wastes & Radioactive waste disposal
Sweden	7.5 (23 over 15 years)	MSc	×	×		×				Safety assessment, social sciences
Switzerland	10	MSc or higher			×	×	×		×	Environmental impact assessment, land use planning
UK	6	MSc minimum		×	×					Material science
NATURAL REPLACEMENT										
Czech Republic	18	PhD & MSc	×	×	×				×	Economics
Slovenia	20	University Diploma	×	×			×			Gammaspectrometry specialists, physics, mechanical & electrical engineering
ESTIMATED TOTAL	**201.5 – 221.5**									

* The survey did not specifically request the identification of numbers of staff for natural replacement

Table 10: Agreed timescales for the creation of Underground Research Laboratory and Underground Geological Repository

Country	Underground Research Laboratory (Year)	Underground Geological Repository (Year) (creation of)
Belgium	Present	
Bulgaria	No agreed timescale	No agreed timescale
Czech Republic		2065
Finland[16]	2004-2010	Construction 2015-2018
France	Present (2004)	No agreed timescale
Germany	No agreed timescale	2030
Hungary	2013	2033-2046
Italy	No agreed timescale	2008 (date under review)
Netherlands	No intentions to construct	Not known
Portugal	Timescale not known	Not known
Slovak Republic	No agreed timescale	2006-2037
Slovenia	No intentions to construct	2066
Spain	No intentions to construct	Postponed
Sweden	Present	2017
Switzerland	Present	2010-2040
UK	No intentions to construct	No agreed timescale

Table 11: Levels of demand for RWM education and training courses available

Country	Level of demand
Czech Republic	High
Spain	High
Finland	High to medium
France	Medium
Netherlands	Medium to low
United Kingdom	Medium
Switzerland	Medium to low
Slovenia	Medium to low
Portugal	Medium to low
Belgium	Medium to low
Bulgaria	Medium to low
Hungary	Low

Table 12: Social inclusion issues required in RWM education and training

- public perception of risk
- importance of social competence of involved staff
- communication under special circumstances
- perception of environmental impact of construction and operation
- public involvement in the long-time development projects in RWM area
- economic impact
- communicating and dealing with the media
- perception of socio-economical aspects (land value)
- opinion of the public regarding nuclear especially nuclear waste
- gaining of public acceptance of the local solutions of regional (more global) problems, particularly the geological disposal of radioactive waste and spent fuel.

Comment: Slovenia emphasised the need for careful consideration and a case dependent approach to social issues to be included in RWM education and training.

[16] The construction is for an Underground Rock Characterisation Facility (URCF), which locates on the selected repository site, not an URL. URCF Construction takes place during 2004-2010.

4.3.2 Public Opinion and Social Inclusion

Development of positive public opinion in RWM may be facilitated by improved public relations and communications with stakeholders. The survey has found organisations to be increasingly involved in this area with demand for staff specialising in public relations and communications. During the initial project stages little consideration was given to social inclusion issues surrounding geological disposal however supplementary questions attempted to address this through the identification of demand for RWM education and training to include the surrounding social issues (such as social and political acceptability of the geological disposal of high level nuclear waste). Social inclusion issues were found to be of great importance and generally accepted as part of a procedure for achieving social and political acceptability. In particular, the Slovak Republic has acknowledged the impact of social acceptance on the siting process which has been interrupted due to public objection. Sweden, Belgium, Spain and Switzerland identified programmes already established to address these issues in various ways. Table 12 presents social inclusion issues to be included in any education and training in RWM provided.

4.3.3 Facilities available for education and training in RWM

Numerous specific facilities, equipment and tools are identified as being available for RWM education and training by universities and non university training providers. There is sufficient RWM education and training facilities available in Europe for those in the industry and future needs are somewhat dependent on political decisions to be taken, for example, in the UK, if geological disposal is selected as a policy option, access to underground research laboratory facilities, research sites and drilling sites will be required. Some countries have sharing schemes, for example, the United Kingdom, Netherlands, Sweden, Belgium, Switzerland access and make use of education and training facilities abroad and make facilities available for use by third parties in return. The Czech Republic and Hungary have no special facilities available for RWM education and training but expect underground research laboratories and facilities to be available in the future. France, Italy, Slovenia, Belgium and Sweden have sufficient education and training facilities to meet present needs. French, Belgian and Italian facilities are available to third parties, in particular France promotes sharing facilities within Europe as CEA and ANDRA are involved in such European programmes.

Summary

The supplementary questions enabled the identification of demand for at least 200 specialist staff educated to MSc level in a number of areas over the next five years to fulfil additional recruitment and natural replacement needs. The survey has revealed modest levels of demand for courses available despite difficulties in predicting future recruitment as a consequence of uncertain national RWM programmes. Potential future demand for specialist staff in RWM and geological disposal can to some degree be estimated through the identification of anticipated dates for the creation of Underground Research Laboratories and Underground Geological Repositories.

Social and political acceptability is considered important to the development of the industry, thus specific social inclusion issues are required to be included in education and training courses. There is sufficient RWM education and training facilities available in Europe for those in the industry and future sharing schemes make facilities available to third parties. Gaps in expertise between generations are currently being addressed through on-the-job training and continuous professional development training.

This chapter has given consideration to the training needs of all nuclear industry organisations employing staff in RWM, the capabilities and activities of academic and professional education and training providers and European education and training needs in RWM providing a comprehensive review of educational and training needs. Survey conclusions are presented in chapter 5.

CHAPTER 5: SURVEY CONCLUSIONS

5.1 Introduction

Consideration has been given to the national context of each participating country and results and analysis of training needs and capabilities identified in the preceding two chapters. This chapter presents conclusions of the review of educational and training needs in Radioactive Waste Management focusing in particular on geological disposal identifying demand for specialist staff and their education and training needs, and capabilities and activities of education and training providers. The conclusions made are based on the factual findings of the survey and as such are dependent on the information provided by each of the National Correspondents.

5.2 Education and Training Requirements

5.2.1 General Observations

The survey has identified that in all, 3600 specialist staff are currently employed by i) national RWM organisations, ii) other nuclear industry organisations and iii) regulatory and government advisory organisations employing staff in RWM within the 17 CETRAD participating countries. These organisations expect to recruit, as a minimum requirement, 200 new and replacement specialist staff over the next five years.

Considering the current numbers of specialist, this is a very modest figure and would seem to indicate a future decline in overall numbers. However, the uncertain nature of some of the national radioactive waste management programmes affects the accurate projection of recruitment figures. Sharp upturns in numbers, as yet not quantified, are expected when the milestones of URL construction and repository construction are approached.

The survey also confirms previously identified shortfalls in the number of developing specialists (under 30 years old) within the European radioactive waste management industry. The age at which individuals obtain 'specialist' status is found to be between 30 and 40 years old and several national correspondents confirmed a decline in specialists of this age group. These findings support the identification of a gap between generations as highlighted by the International Atomic Energy Agency[17] and further reinforce the need for education and training to ensure that the knowledge skills and abilities from the current generation of experienced nuclear professionals are transferred effectively to the workforce of the future.

Most radioactive waste management organisations have no legal national qualification requirements imposed for specialists working in RWM, except for nuclear safety and radiation protection. Yet there are no strong drivers for education and training in radioactive waste management as there are in other areas of the nuclear industry such as radiation protection. Organisations that do not have such national qualification requirements tend to make broad introductory training in RWM compulsory or highly recommended as company policy. On the whole a relevant qualification is required to demonstrate ability. European Commission Directives may influence levels of demand for education and training in radioactive waste management.

5.2.2 Education Requirements

The educational qualification profile of specialist staff currently employed ranges across all levels, from highly specialist qualifications (i.e. PhD and Licentiate) to those educated to below university level. Across the various qualification profiles and different categories of organisations employing staff in RWM, the survey indicates staff with expertise in the following scientific disciplines to be currently employed:

- Earth sciences & rock engineering.
- Civil engineering & underground construction & mining.
- Nuclear & chemical engineering.

[17] IAEA Annual Report 2003, http://www.iaea.org/Publications/Reports/Anrep2003/index.html

- Radiation protection & safety assessment.

Future demand will continue to require staff in these areas.

Also, public relations, communication and social sciences are found to be a growing area, with the general acknowledgement that social acceptability and inclusion issues have an increasingly important role to play in RWM.

New and replacement staff are generally required to be educated to higher degree level (typically either MSc or PhD). Organisations that look to employ future specialist with an education, to MSc degree level, identify the areas listed above as being required, although it should be noted that these general courses often contain specific modules in RWM. Furthermore it should be recognised that this policy, in terms of the expected subject of a higher degree, will be strongly affected by the fact that historically specialist higher degrees (MScs) in RWM have not been available. In other words, organisations have historically employed people with MScs in these areas. They therefore naturally look to do so in future. This, however, does not preclude the possibility that if individuals with an MSc in RWM appeared on the job market that these same organisations may alter their position and favour such candidates. A European level MSc in this area, based on European Centres of Excellence, is worthy of further consideration.

In the case of PhDs this issue is not relevant as they are by their very nature specialised and focused. It should be noted however that the indicated demand for individuals with this background is not high. The survey identified a current demand for some 11 staff educated to PhD level over the next five years (based on returned questionnaires).

5.2.3 Training Requirements

All organisations reviewed in the survey stated a requirement for training to develop and maintain their specialist staffs knowledge and expertise. Training provision is achieved via i) on-the-job training, ii) courses that are internal to employer organisations, iii) external courses iv) conferences and seminars. Most organisations rely on a combination of several supplementary training methods based on a mixture of internal and externally sourced provision.

Individual needs (depending on past experience) and the job profile are the predominant criteria to define RWM training requirements for employed staff.

On-the-job training has been found to be a common practice and considered a key component of specialist RWM training enabling the transfer of tacit knowledge and experience of older generations.

Regulatory and government advisory organisations were found to provide broad or introductory RWM subjects internally and source focused and specialist training externally.

Specific geological disposal training requirements identified by the survey (specifically regulatory and government advisory organisations) include:

- Fundamentals of radioactive waste management and geological disposal.
- Geochemical modelling.
- Hydrogeological modelling.
- Advanced geosciences.
- Geotechnology.
- Safety assessment

Each of the 160 various organisations surveyed considers training to be required for specialist staff.

It is clear that there is a strong need for the provision of training in the area of RWM to ensure that staff receive appropriate continuous professional training throughout their careers. It has been identified that there are a number of methods used to address this need which includes both in-house and external training courses and in-house on-the-job training. It is apparent that most organisations use some combination of each of these methods.

5.3 Capabilities and Activities of Education and Training Providers

The survey has considered two main types of education and training providers; universities and non-university organisations. There are 66 universities providing education in RWM via higher level degrees with a combination of MSc and PhD programmes. Training needs are met via the non-university organisations with 18 such organisations providing training typically via short courses. With respect to education and training facilities it is apparent that there are sufficient RWM facilities available in Europe although future needs are dependent on political decisions to be taken regarding national RWM programmes.

5.3.1 Education Capability and Activity

66 Universities provide MSc level training. RWM is typically addressed by individual modules within these broader courses. Average participant numbers per university course range between a low of 5 to a high of 45 participants per course.

Currently there are no specific MSc level courses in RWM. However a specific course is planned to commence in late 2005 based in Germany (Clausthal University).

In terms of recognition and accreditation of University courses, all are by default accredited to national standards and will all fall under the Bologna process[18]. However there is no mechanism for courses to be recognised as providing education specifically related to RWM, in comparison to the ENEN type mechanism (considered in chapter 1) in other areas of education in the nuclear field.

Numerous universities have PhD programmes with candidates who undertake research training and research in areas specifically related to RWM. However the survey did not present large amounts of data related to these activities. It is thought that these activities are market driven with national funding bodies or industry organisations funding research in areas of need and PhD studies being a natural part of these activities. Also initiatives such a PETRUS have identified issues related to attracting high quality individuals to these areas as a bar to ensuring adequate provision of individuals with this level of education

The main feature absent from the provision of education is the co-ordination of education needs and provision at a European level. This factor inhibits cross national use of existing education provision.

5.3.2 Training Capability and Activity

There exist both private and state owned non-university organisations supplying RWM training in most participating countries at various levels (i.e. both in general, such as project management, and specialist areas) and typically provided in the form of short courses. Through these various organisations training material, teaching facilities and laboratories are available across Europe. Many of the courses provided are stand alone but some involve collaboration with universities or through sharing of facilities and are linked to industry. Although most participating countries have a training centre that provides the majority of national industry non-university training requirements, non-university course structure, content, frequency and nature of teaching is generally demand dependent and thus irregular (unless contractual or legislative agreements to supply have been made). This does though enable flexibility to meet individual client specific needs.

External courses are provided by 18 non-university organisations. Average participant numbers per non-university course range from 5 to 30 (where 5 participants per course is deemed low and 30 is high). However in the cases of Slovenia and the Slovak Republic much larger average figures are obtained. Such high participation is found to be due to several factors including;

- Regulatory requirements.
- Attracting participants from a wide range of institutions.
- Attracting participants both nationally and from abroad.
- Longer periods between course provision.

If the upturn in activity in this area occurs and training requirements greatly increase, further provision will obviously be demanded.

18 http://www.bologna-bergen2005.no/

The main features absent from the provision of training are;

- co-ordination of training needs and provision at a European level and
- mechanisms to allow recognition and accreditation of the training provided.

Both of these factors inhibit cross national use of existing training provision.

CHAPTER 6: OVERALL CONCLUSIONS

6.1 Introduction

This chapter presents a summary of the method of review and the conclusions made from the review of educational and training needs.

6.2 Method of Review

This review of educational and training needs in geological disposal aspects of radioactive waste management has been carried out with questionnaires distributed by the National Correspondents in each country, responsible for gathering national information. The survey has provided detailed insight into the current education and training requirements of participating countries through the provision of national overviews, a European level analysis of training needs, capabilities and activities and a summary of survey findings. Gaps and weaknesses within the data have been addressed through the distribution of further questionnaires and dialogue with National Correspondents providing clarification regarding interpretation.

6.3 Summary of Findings

In summary, the survey has found:

6.3.1 General

- 3600 RWM specialist staff are currently employed across the 17 countries covered.
- It appears that a minimum of 200 specialist staff are to be recruited in the next five years.
- However, if national RWM programmes are activated, the numbers of staff required will sharply increase.
- The survey confirms the emergence of a generation gap. Clearly this is an issue of concern.
- There are no strong legislative drivers for education and training in RWM (as there are in radiation protection).

6.3.2 Education Requirements

- Staff with expertise in i) earth sciences and rock engineering, ii) civil engineering and underground construction and mining, iii) nuclear and chemical engineering, iv) radiation protection and safety assessment are currently utilised and will continue to be required.
- Public relations and communication is a growth area as social acceptability has an increasingly important role in RWM.
- New and replacement staff educated to MSc and PhD level in the areas listed above are required to meet the target of 200 new staff listed above.
- However, if the upturn mentioned above takes place, these numbers will increase significantly.

6.3.3 Training Requirements

- There is a strong demand for internally and externally sourced training provision which is experience and role dependant.
- On-the-job training is common practice enabling the transfer of tacit knowledge and experience of older generations.

6.3.4 Education Provision

- Education in terms of graduate and postgraduate courses in RWM is predominantly provided by a large number of Universities based on information received from 66 universities across the countries participating in the CETRAD project. This is achieved at MSc level, via modules of more general courses, where accreditation falls under the Bologna process, and at PhD level via research programmes.
- There is just one MSc course dedicated to RWM planned for 2005 in Germany (none available at present) and PhD studies are market driven by research investors.
- A European level MSc in this area, based on European Centres of Excellence, is worthy of further consideration.
- With respect to education facilities it is apparent that there are sufficient facilities available in Europe.
- The main feature absent from the provision of education is the co-ordination of education needs and provision at a European level.

6.3.5 Training Provision

- Training provision is achieved via i) on-the-job training, ii) courses that are internal to employer organisations, iii) external courses iv) conferences and seminars.
- External courses are provided by 18 non-university organisations. External training needs are currently met by this mechanism.
- If the upturn in activity in this area occurs and training requirements greatly increase, further provision will obviously be demanded.
- Mechanisms to allow recognition and accreditation of the training provided are absent.
- Co-ordination of training needs and provision at a European level is also absent.

6.4 Recommendations

The key recommendations of this study are:

- The introduction of a mechanism to co-ordinate education needs and provision at a European level.
- The introduction of mechanisms to:

    i) Allow recognition and accreditation of the training provided.

    ii) Co-ordinate at a European level training needs and provision.

Appendices