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The Role of Education in Knowledge Management

TRAINING AS A TOOL FOR IMPROVING MOTIVATION AND EFFICIENCY IN NUCLEAR SAFEGUARDS

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This paper argues that in order to bridge the existing and future skills-gap in nuclear safeguards training focus must shift from the traditional provision of technical training to professionals to a more global approach, in which the organisation itself and the transfer of knowledge is viewed as the focal point for the establishment and the development of safeguards training.

It puts forward that the transfer of knowledge between generations of nuclear Safeguard workers in order to bridge the lack of formal skills is possible but it depends on a sound analysis of the situation which combines new analytical methods and a new framework approach.

Finally, the paper gives some examples of measures already undertaken in Euratom Safeguard training which can be taken as an embryo for further development.

1. Introduction

In terms of knowledge based management, nuclear safeguards training has always taken a techno-centric approach focusing on technology-based training to enhance knowledge sharing and growth. In the past, this has been sufficient to cater for training needs given the rather homogeneous population whose needs it has catered for.

Taking into account two major factors of change, one demographic and one linked to the difficulty of finding staff with necessary background qualifications, this paper advocates the need to switch our focus to a more organisational-based training that comprises of the organisation as a catalyst for facilitating knowledge, with the transfer of knowledge between peers as the key element.

The first part will therefore focus on the current situation and the challenges ahead. The second part will discuss conclusions and suggested solutions to solve these composite issues.

2. Current Situation

Nuclear Safeguards training has a more than 20 year old long tradition. It is the oldest training cell within the European Commission under the same framework. Traditionally, the focus has been on providing technical specialised training covering the needs of specialists in the field. This type of training has served well during its existence aiding above all new inspectors to acquire the necessary skills relatively quickly.

However, for the past 5 years, this form of institutionalised technical training has not met current demands and needs for the following number of reasons;

The first cause for concern is a demographic determinant. The European Commission has in its communication on the demographic future of Europe estimated that the European labour market will lose almost 50 million people up until 2050.

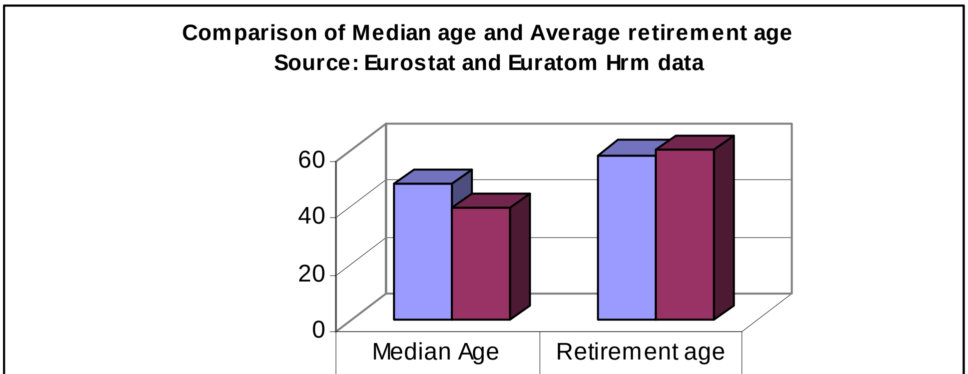
Another demographic effect is the ageing of the available work force. The final factor to take into account is the decline in nuclear literacy as a result of the low priority this topic is given in many European universities.

It should also be noted that performing nuclear Safeguards as defined in the Euratom Treaty is a very complex task ranging from verifying operators´ declarations, executing complicated measurements and representing the Commission (often alone) in relationships with member states and the IAEA. All these roles require technical skills, numerical skills, diplomatic skills, negotiation skills, social skills and other behaviouristic skills to ensure maximised efficiency with the lowest possible level of friction.

If you apply these factors to our concrete topic it soon becomes clear that we can no longer ensure that we will have nuclear expertise to recruit from, especially since salaries will probably increase in the nuclear industry depending on the scarcity of getting qualified staff, while the salaries within the EC are not business cycle related and remains less competitive.

Therefore, the main concern for training will be above all to focus on the transfer of knowledge (Argote, Ingram, Levine and Richard L. Moreland: Knowledge Transfer in Organizations) between experienced and less experienced inspectors. A second challenge will then be to adapt training to a cadre of people who do not necessarily possess background knowledge of the nuclear industry and, finally, safeguards training will also have to be adapted to meet the requirements of experienced inspectors and to train them as proficient mentors.

Graph 1: Average age and average exit rate of employees in Euratom and the EU



	Median Age	Retirement age
Euratom inspectors	48	58
EU average	39,5	60

As seen from the above graph, the median age of a nuclear inspector (permanent officials working as nuclear Safeguards inspectors) in Euratom is 48 years of age (internal data). This is a very high median age compared to the workforce as a whole in the EU which stands at 39.5 years of age at present (Eurostat, 2001 fig,). Furthermore a final factor is the average exit age into retirement which currently in the EU is 59.9 years of age (Eurostat, 2001 fig,) a figure similar to that of Euratom although our inspectors tend to retire somewhat earlier. Although these figures are not directly comparable, broader conclusions can still be drawn. It is likely, given that the current safeguard policy prevails, that during the next 10 years considerable investment is needed in human resources, ranging from competitions, recruitment and provision of introductory training for new inspectors.

In conclusion and as a result of the above factors it is clear that although the overall problem is complex and involves numerous factors, the main focus of change can be centred on three major areas, formulated as questions:

- How do we guarantee qualified, competent and well trained staff for future Safeguards?
- How do we solve the knowledge gap and ensure a system which allows for a good natural transfer of knowledge between our inspectors?
- How do we meet new demands if more fundamental background training is required?

2.1 The starting point

A switch from a techno-centric approach to training to an organisational-based training taking into account social networks and lifelong learning strategies would first of all require a very sound analysis of the current situation.

This analysis would cover three major initiatives. Firstly a sound analysis of the actual skills of the current inspectors is needed. This should be done by interviews in combination with statistical data gathering. This should give us supporting data on the current skill levels of our clients (Tomas Olsson: Larande organisationer)

Secondly, there would be a need to review the current formalised training system. Is it adapted to the present and future needs? What do we need to change in order to better meet the demands?

Finally an analysis of the organisation itself would need to be performed. Such an analysis covering the directorate of nuclear Safeguards inspectors would facilitate and enhance our knowledge about the communication networks of our clients. This kind of analysis is a key element in introducing an organisational based learning: instead of focusing on **what** we learn, our assumption here is instead **how** we learn (Bandura, Social learning theory).

How well does the process of informal learning work? How useful is the current network to its individuals? Is the present network stimulating and encouraging exchange of knowledge between peers?

2.2 Interpreting the initial results - basic assumptions

Although premature, some preliminary results gathered from the initial set of statistical fact finding and skill-assessment can be extracted.

Firstly it is clear that Safeguards training in Euratom has not evolved with time since its inauguration more than 20 years ago. This is particularly true for the technical training which has remained static both in pedagogical terms as well as in a relative content term.

The result is that technical training for experienced inspectors is not adapted to their needs. Another interpretation of the data also suggests a very rigid learning culture based on traditional theoretical and practical exercises not taking into account the need of the individual or the organisation.

Secondly, preliminary results also indicate that basic training is increasing in importance. As discussed above, the low priority of nuclear training in Europe combined with demographic changes make it evident that the new inspectors recruited for Nuclear Safeguards do not necessarily possess a relevant background for their position. Therefore induction training courses, rudimentary tuition and guidance is needed to a much larger extent that before (OECD study in 2000, ‘Nuclear Education and Training: Cause for Concern).

The third main finding is that there is a need to develop new training, reflecting on more non technical competences. Given the complexities of nuclear Safeguards inspections and the necessity for the individual inspector to represent Euratom in conjunction with both Member States and the IAEA more competences are required than just technical skills.

On the final point covering the organisation and its networks, the basic assumption would be that the shape of the social network helps determine the networks´ usefulness to its individuals. Smaller tighter networks tend to be less useful and efficient than larger more open networks with many weak ties to individuals outside this network (Wasserman, Stanley, & Faust, Katherine. (1994). Social Networks Analysis: Methods and Applications. Cambridge: Cambridge University Press).

Such larger social connections are more likely to introduce new ideas and becoming more efficient than the other form of network. Tight-knit groups on the other hand have rather homogeneous opinions and share common traits which in fact can hinder both creativity and efficiency.

This kind of analysis is very important in order to improve informal learning structures and this type of learning. In concrete terms, an older experienced inspector will feel motivated, if his experience is recognised as an incremental part of learning while the new inspector will have a day-to-day training of high quality.

3. Conclusions

As seen from above argumentation and discussions our work has yet to be finalised. Nevertheless, tentative conclusions have been drawn and basic measures have already been taken in order to revitalise our training along the lines discussed above

First of all we have adapted and strengthened the introductory training for nuclear safeguards inspectors. In order to facilitate the transfer of knowledge most of these training sessions are given by very experienced inspectors. Discussions are actively encouraged via the use of case studies and the creation of an open informal environment. The structure of the training is also modular, meaning that primarily 1 day sessions are mixed with introductory work via a mentor in each unit.

This pedagogical process also ensures that each new employee is given the time to absorb and consolidate each theoretical workshop before he takes part in the next one. Usually these modules are also actively inviting more experienced inspectors who for one reason or another might need a refresher. Their active contribution further enhances and facilitates this transfer of knowledge.

In addition to the above, the length and level of detail of our basic training has increased from traditionally a two week basic course to its present length of almost 7 full time weeks, spread over the first 20-30 weeks of employment.

Secondly and in order to further develop the technical training we are developing in-house competences which provide technical training at a facility. This type of basic training is essential for our work and will entail a theoretical framework given at HQ followed by real inspection work training in various nuclear facilities across Europe. At the date of writing one such training session has been given and two more are planned for this year.

Thirdly in order to cater for the more experienced inspector, transfer of knowledge is ensured via ad-hoc related in house training courses. These courses cover most fields relating to nuclear Safeguards and reflect upon new tasks, additional tasks and changed responsibilities. At present around 10-15 courses a year are run on this basis.

In addition to the above, new types of training are envisaged taking into account other aspects of the qualified inspector's work. This training mainly focuses on relationships with operators and third parties in order to ensure increased efficiency while maintaining the lowest possible level of friction. For example this training is related to basic human behaviour like negotiation and communication techniques just to name a few topics. The first set of courses is running during the month of March and more are to be added for autumn 2008.

Finally and lastly a note on the last steps of development towards an organisational based training system. When we have our final results, we will be in a position to better identify global and individual training needs. Moreover such an analysis will give us access to information needed in order to identify and professionalise a cadre of trainers willing to work on further improving the quality of the delivery. These identified lecturers will be trained in pedagogies and other skills in order to facilitate this transfer of knowledge.

This would form an embryonary approach towards the long term goal of creating a Safeguards Training Academy. Such an academy would bridge the gap between formal and informal learning. The scope of Safeguards training however needs to be broadened and additional services and training provided should be offered to other international actors, Member States and nuclear operators.

An overall framework would be the final step towards a training organisation where the transfer of knowledge is done both informally and formally with all actors involved in nuclear safeguards. Such a body could or perhaps should be semi-dependant from its origin and would also work conceptually on issues such as quality assurance, accreditation and vocational training support structures (vocational guidance, training advice, skills mapping etc.). This would also make sense in relation to costs. The nuclear safeguard community is small, training is costly and specialised. A common effort from all actors and the pooling of resources would free funds and make them available for other urgent needs.

It is obvious that the above mentioned development requires experience to work. This means that the experienced Safeguards worker regardless of his position and origin remains a core feature as the main deliverer of training. This is a fundamental switch of focus and requires above all patience and a long-term strategy.

In addition, the positive side-effects of such a longer term strategy and conceptual change should not be neglected. Transfer of knowledge in a correct manner also helps actors to understand their independent roles and their overall situation in the Safeguards framework. A mutual understanding would facilitate and increase the efficiency of inspection work.

Moreover, on a detailed level, since training is based on transfer of knowledge rather than having a technical formalistic approach, it is likely that the status and motivation of the experienced safeguards worker will increase. This would subsequently have a secondary impact on work performance and output.

Given the demographic changes and the low priority of nuclear training described under part 2, the median age will increase even further during the coming 10-15 years. The present nuclear Safeguards worker will work longer than before and his experience should not be underestimated as a source of know-how.

It is our belief that in order to bridge the knowledge gap and to ensure competent future nuclear safeguard workers this is the only feasible way forward until nuclear training is restored as a part of the curriculum of European universities.

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DEFINING QUALIFICATIONS AND COMPETENCE FOR PERSONNEL IN A SMALL WASTE MANAGEMENT ORGANISATION THE CASE OF POSIVA

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ABSTRACT

In 2000, the Finnish Parliament ratified a Decision-in Principle enabling Posiva to carry out confirming site investigations at Olkiluoto in Eurajoki. Posiva became the first organisation in Europe to select the site for a spent fuel repository. The construction of an underground rock characterisation facility, ONKALO, started in 2004 on the chosen site. This facility is constructed according to the safety requirements of a repository. Posiva's aim is to include ONKALO as a part of the deep repository in the licensing application, which is scheduled for submission by the end of 2012. Becoming a license holder and an operator of a nuclear facility requires qualified and competent personnel. Posiva, like many other organisations in the industry, needs to cross the generation gap, as its experienced specialists will retire before the disposal operations start. Since the licensing process will be one of the first of its kind, also new competencies of personnel are required. Posiva's systematic approach to develop the competence of Posiva's personnel to meet the requirements of the next stages of the disposal project is described.

1. Introduction to POSIVA

The first studies for the management of spent fuel started in Finland at the end of the 1970's. The government decided as early as in 1983 on the goal of disposing of the spent fuel starting 2020. In 1995, the national legislation, which bans the import or export of spent fuel, came into force. The same year Posiva Oy (Posiva) was established to carry out the RTD work and implementation of the spent fuel disposal programme for its owner's Teollisuuden Voima and Fortum Power and Heat. In 2000, the Finnish Parliament ratified a Decision-in Principle enabling Posiva to carry out confirming site investigations at Olkiluoto in Eurajoki municipality. Thus, Posiva became the first organisation in Europe to select the site for a high-level nuclear waste repository. The construction of an underground rock characterisation facility, ONKALO, started in 2004 on the final disposal site. The facility is constructed according to the safety requirements of a repository, because the aim is to include it as a part of the non-controlled area of the deep repository in the licensing application. The submission of the application is scheduled to take place by the end of 2012.

2. Need to define and develop competencies required for a repository licensing process

Becoming a license holder and an operator of a nuclear facility requires qualified and competent personnel. New competence is required from the personnel for the licensing process of a disposal facility, since the process will be one of the first of its kind. At the current project stage, the competencies needed for the licensing and also for operations' start are at the focal point of Posiva's competence development.

Posiva's personnel has been steadily growing over the years from about 20 persons employed by the company in the beginning to today's 70 employees. The resource planning for the disposal facility operations has defined a need of about 110-120 employees in total for the year 2020 and onwards when the disposal operations are scheduled to begin. In addition, Posiva uses many researchers, consultants and contractors from various universities, research organisations, and companies in carrying out the RD&D work and construction.

Posiva's organisation can be defined in organisational terms as encompassing the features of a professional bureaucracy (according to Minzberg in Karlöf 1995, 310-311) and also as a focal point of a subcontracting network (Anttila & al. 2002, 2) or a virtual project organisation. This influences the description of Posiva's current business processes, where a key core process is the overall steering of the RD&D work aiming at the license application in 2012 and the start of disposal operations in 2020.

Posiva, too, like many other organisations in the industry, needs to cross the generation gap, as its experienced specialists will retire before the disposal operations start. The company's employees' age structure resembles the overall age structure in the industry (CETRAD 2005, 27): 54% of the personnel are between the age of 20-39 and 33% are over 50 years of age (Posiva 2007).

3. Setting up internal training courses and networking with training providers

In 2002, the company's domicile was moved from Helsinki to Eurajoki municipality and the company's personnel rapidly doubled. As gaining high-level expertise in geological disposal takes tens of years, systematic approaches to define competence and needs for personnel's training are a must.

In 2003, Posiva contracted VTT (State Research Centre) to carry out a course for the new personnel in the scientific fundamentals of safety in geological disposal of spent fuel. The training course was five days long and was rerun in 2004 and 2005 with further development in 2005. From 2006 onwards, the course was now carried out in two course modules each four days long (Palmu & Hansen 2006, 20-21). The latter course module gives a more in-depth view into the specific areas of Posiva's safety case. The training is carried out in Finnish and Posiva's consultants are able to participate the course, too, when there are vacant seats.

Over the years Posiva's own personnel's role in addition to other experts from other research institutions and consultants has increased in the implementation of the course. The course is continuously improved based on a detailed participant feedback and this feedback is a vital source of further training needs, too. In 2008, Posiva's consultants formed the majority of one course module for the first time.

During 2006-2008 further tailored training courses were designed either internally, with our cooperation partners, or subcontracted. Such training courses included fundamentals in both geosciences (2 days) and groundwater chemistry and hydrology (2 days) for personnel without prior basic training these topics; an advanced six day workshop in Safety Case methodology in cooperation with NAGRA from Switzerland and ONDRAF/NIRAS from Belgium, and a 4-day course in microbiology in deep disposal with Micans from Sweden.

Since the training needs are currently not defined using a formal competence management system, several other means are used. These include open e-mail questions to the personnel on their perceived training needs and internal course feedback including questions about the next stage of development needs of participants. In 2006, an internal training group was established and the members now provide input from different units and departments about their training needs. The individual training plan was structured according to the chosen competence categories to ensure that a wider scope of training areas would be included as a part of the annual development talks. In 2007, the average number of training days for a Posiva employee was 10.5 days.

Further actions to strengthen the personnel's learning opportunities include Posiva joining the ITC-School Association in 2003; working together with the ITC-School to implement a course on *Cement and Cementitious Materials in Geological Disposal* in 2008; participating in 6th framework programme's E&T projects like CETRAD and ENEN II; and in the preparation of a new training scheme proposal for the FP7 framework call to continue the work of the CETRAD project and PETRUS group in geological disposal.

4. Developing a competence management system

4.1 Defining competencies

Competence as a term has many meanings (Viitala 2005, 31-36), which can be confusing, if the term is not defined. In this context, the competence of an individual is understood as being a part of human capital (according to Seeman, De Long, Stucky & Guthrie in Viitala 2005, 36). The competence can be either explicit or tacit and it consists of the individual's specific experience, knowledge, skills, mastery of procedures, or of a combination of all of these.

Our case treats competence as encompassing of wider areas professional capabilities that in a combination define the professional mastery or expertise needed to carry out a certain job. In addition to the competence for a certain professional mastery, a person may possess several other areas of competence, which are not currently required for a job. Also these competencies are taken into consideration, since they can guide e.g. in stand-in arrangements and in horizontal or vertical career development in the organisation.

The term competence management means a systematic management work with the purpose of securing the competence required to meet the company objectives and goals now and in the future (Viitala 2005, 38).

We differentiate between competence and a qualification. We consider a qualification as a legal or other requirements that an individual needs to meet or demonstrate formally either by acquiring a national academic degree or vocational accreditation given by an institute or examiner authorized to give the accreditation. Also the submission of an application to a professional organisation for quality assurance to meet a set of predetermined criteria and/or undertake and pass an examination can produce a qualification. We use this distinction, since in some theoretical discussions the term qualification (e.g. Toikka 1984) is also used in a similar meaning as competence. In our case, the qualification requirements at a minimum level include a basic radiation protection examination prior working in the nuclear facilities or passing an examination for a worker safety pass.

4.2 Towards a formal competence management system and training needs defined by competence requirements

Posiva carries out development work to develop a formal competence management system. The system is used to define the training and development needs by analysing existing competencies and identifying competence gaps in the development talks with the assistance of the competence management system. Thus the training needs would be more strategically derived and could focus also on the needs of the future.

In 2005, the first internal group interviews of selected personnel were carried out to define what type of special competence the existing personnel possesses and what type of competence is deemed to be missing that is needed. The same year in a planning meeting, the management set an objective to define the job competence profiles of Posiva's employees and this work continued during 2007. It resulted in a step-wise project to develop a strategy-driven competence and training analysis aiming at a systematic competence development system by the end of 2009 (Figure 1).

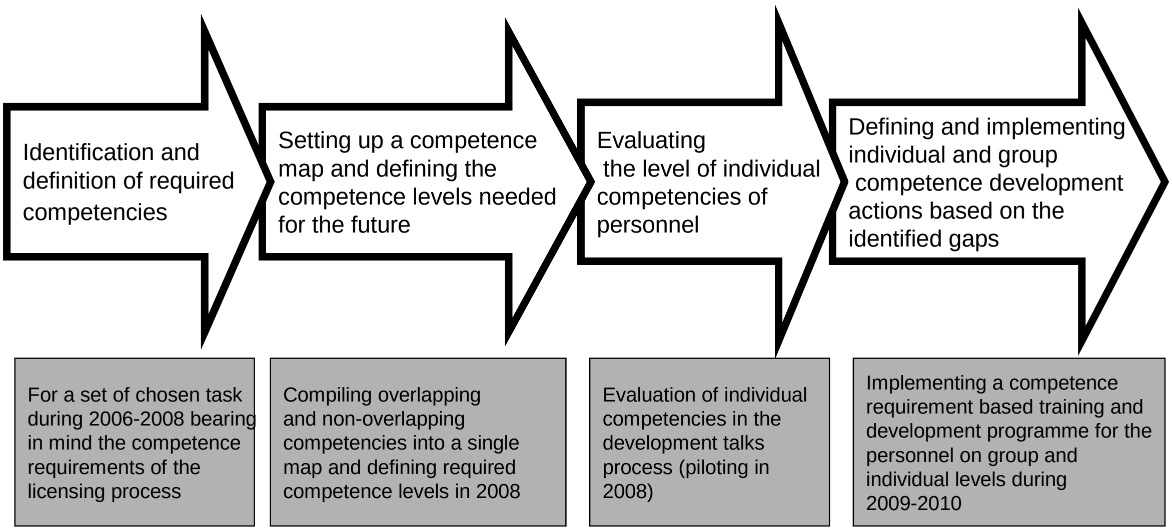

Fig 1. The development process of Posiva's systematic competence management

As a starting point of the project, we set up a categorization to facilitate the identification of competencies and training needs. The categories were adapted into Posiva's context from the work introduced by Hätönen (e.g. in Hätönen 1999).

The competence categories selected we selected are as follows:
1. General competencies needed to enter and function in working life like reading, writing, use of mother tongue, basic IT-skills, information acquisition skills, worker safety,
2. Communication and cooperation competencies like foreign language skills, presentation skills, negotiation skills, intercultural, team and project group working skills,
3. Organisational competencies like knowledge of the management and quality system, organisational procedures and information systems, and reporting systems,
4. Professional competencies like professional knowledge of a specific scientific or technical discipline (e.g. geosciences, chemistry) or administrative area like accounting, communications or quality management,
5. Competencies in geological disposal like knowledge of the disposal concept, safety case, nuclear requirements, interactions and interrelations between the different parts of the disposal system.

Competence profiles and a competence map of the existing jobs are compiled as a result of the work. In 2008, this map is stored into a database and the next steps of the competence management system development will be carried out with an aim to include this system as a part of Posiva's support process in competence development and resource planning during 2009. The level of competence can vary from a beginner (0-1) to a top expert (4-5) in each area. The required level of mastery should result in level 3 equalling a competent person in the specified competence (e.g. Viitala 2005, 157). Tools like Biggs' and Collis' Solo-taxonomy (in Tynjälä 1999, 182-183) assist in defining the competence levels.

The authorities continue to develop new requirements and modify the existing nuclear power plant personnel's qualifications for personnel operating in nuclear facilities. The Radiation and Nuclear Safety Authority (STUK) is reviewing and updating all of its safety guides by the end of 2011. Therefore flexibility to accommodate future changes is an important feature of the system.

4.3 Limitations of formal competence management systems

According to Virkkunen and Ahonen (2007, 16-19) a prerequisite for mapping competencies is that the jobs and the knowledge and skills are known in advance. However, this is not the case in industries where technology, products and business concepts are renewed fast.

We could also consider that the research and development nature towards deep geological disposal and toward the realization of the disposal concept includes similar uncertainties related to the needed competencies as a fast changing business environment. In an environment that is constantly changing or partly unknown, the personnel need to identify problems and develop solutions related to their work instead of following a given set of task definitions. If the training and development of personnel is based merely on the competence mappings, it is not sufficient to keep the personnel abreast of needed future developments. The learning processes in the organisation need to support continuous renewal according to the company strategy, too. There is a need to develop competence collectively and the challenge for the management is to lead the emergence of new competencies for the future, which do not exist yet (ibid).

In Posiva, we have chosen to develop the system collectively in internal group discussion with the current position holders and to use tools that could enable us to change the content of the system in a flexible and light way. This enables us to upgrade the established routines according to the changing future needs. Future will tell us how we have succeeded in taking into account the limitations of the formal competence management systems.

5. Conclusions

A formal competence management system is widely used in several industries. The nuclear utilities in Finland have applied a formal competence management system for about 20 years now. As demonstrated by the CETRAD project study in 2005 (CETRAD 2005), in the waste management organisations, only preliminary steps towards formally defining competencies required in developing and implementing waste management programmes were taken. Posiva started working towards this goal in 2006.

A lesson learned from the utilities' experience is that a formal system should look at the competencies as broader areas of professional mastery instead of individual detailed skills to be mastered. This enables setting up an efficient system also from the information maintenance point of view and allows for sufficient flexibility to update the content of the competence areas as the program advances and new competence needs emerge. A computerized system/database is also essential in the maintenance and update of the personnel's competencies.

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HOW KNOWLEDGE MANAGEMENT CAN HELP NUCLEAR COMPANIES TO FIGHT THE AGING WORKFORCE ISSUE?

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ABSTRACT

Aging of the workforce represent a major challenge for developed nations, especially for non-attractive industries – including nuclear companies. Organizations will lose a significant amount of institutional knowledge as their most experienced employees leave the workforce. The high costs associated with knowledge loss can be seen both on and off the balance sheet, affecting the entire enterprise. Formal knowledge transfer mechanisms supported by leading technology solutions can capture critical workforce knowledge and experience within retiring populations to pass on to future employees. Accenture's Enterprise Knowledge Retention and Transfer offering provides a holistic approach to help companies maintain critical knowledge.

1. The Aging Workforce Issue

Companies and governments in developed nations face a major workforce-related challenge that could evolve into a crisis situation:

- A large percentage of their workforces will be eligible for retirement in the next five to 10 years, resulting in a major exodus of talent and experience.
- This challenge is compounded by the fact that there's a much smaller talent pool coming up behind retiring "Baby Boomers."
- With workers aging and fewer people in succeeding generations, companies and governments will experience a significant exodus of talent in the next two decades and a dearth of new employees to step into those roles.
- Efforts to respond to this crisis to date have addressed some targeted knowledge and talent needs, but few if any organizations have addressed the problem in a way that will yield lasting benefits.

Accenture's Aging Workforce study[1] revealed four key findings:
1. <u>The workforce in many countries is aging</u>, and companies will begin to feel the impact of this aging in as little as 5 to 10 years.

- Globally, the elderly account for 15 percent of the population in the developed world, compared with 2 percent to 3 percent 150 years ago.
- By 2010, more than 25% of the US working age population will reach retirement age, resulting in a potential shortage of 10 million workers.

2. The impact of workforce aging is compounded by the fact that <u>people in many countries are leaving the workforce at a younger age</u>.

- In the US, the average retirement age has fallen from 67 in 1950 to 61 today.

- Europeans overall are exiting the workforce at a younger age than ever, and much younger than those in the United States. The average retirement age of European workers fell from 66.2 in 1950 to 59.8 in 2000. Reflecting that drop are the figures of employment rates for people in Europe aged 50 to 64 (as of 2000): 40 percent in Italy; 42 percent in Belgium; 52.7 percent in France; 54.6 percent in Germany; and 63.4 percent in the UK and Finland. These compare with 67.9 percent in the US.

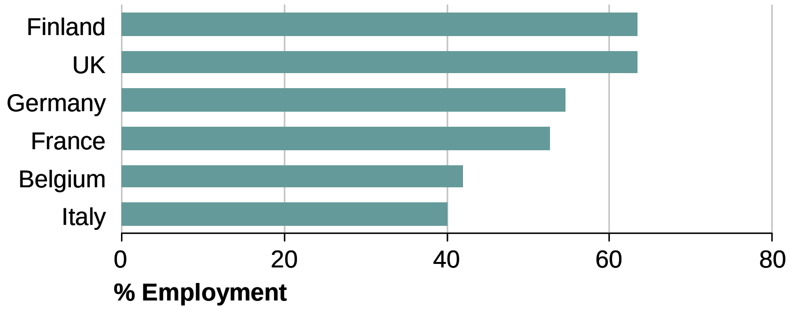

Fig 1. 2000 employment rate in people aged 50 to 64 in selected European nations

3. The aging workforce is a long-term issue. <u>This trend will last for several decades</u> because people are living longer and producing fewer offspring.

- At the turn of the 21st century, there were approximately 600 million older people globally—a figure that's anticipated to rise to 2 billion by 2050. At that time, when the median age globally is projected to be 36 (compared with 26 today), the number of older people is expected to exceed the number of young for the first time in history.
- From a country perspective, Italy, Japan and Spain will have as many people aged 60 or more as people between the ages of 15 and 59 by 2040. By 2030, 28 percent of Germany's population, and 20 percent of the United States', will be older than 65—and 19 million people in the UK will be over 60. In Canada, one in five people will be 65 or older by 2026—a major jump from one in eight in 2001. In Europe as a whole, the over-65 population is anticipated to rise from 15.4 percent of the EU population in 1995 to 22.4 percent by 2025.
- The aging trend will last for several decades because, quite simply, people are living longer and producing fewer offspring. For instance, life expectancy has reached 80 in Japan and 83 in the US. By 2075, at today's rates, US life expectancy is projected to reach 87. Globally, life expectancy has increased from 45 to 65 since World War II and shows no signs of slowing. Continuing advances in medicine and science likely will push life expectancy to 100 and possibly higher in the next few decades.
- Decreasing fertility rates also is a major factor. In the past 30 years, the worldwide fertility rate has been nearly halved—from 5.0 children per woman to 2.7. In the developed world, it's even lower—1.6—which is lower than the 2.1 replacement rate needed to maintain stationary population. In Canada, where the rate was three or more children per woman until the mid-1960s, the fertility rate has dropped to 1.5. The situation is particularly dire in Japan (1.5), Germany (1.3) and Italy (1.2).

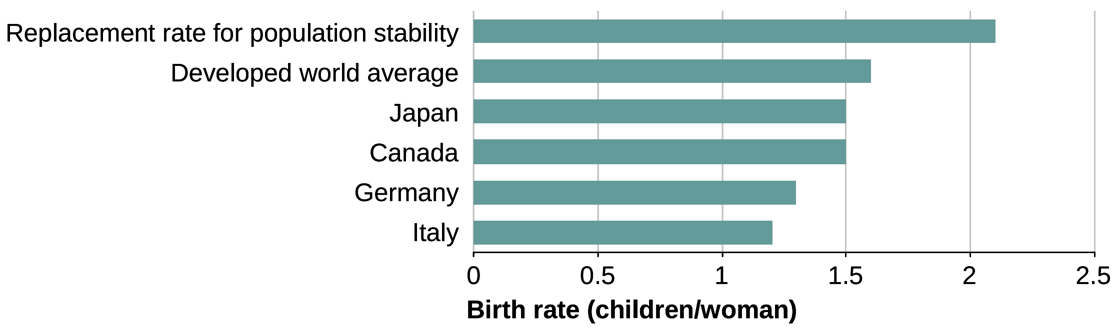

Fig 2. Birth rate in selected nations

4. Some sectors will be harder hit than others. Utilities, energy, mining and manufacturing, and government are viewed as 'unglamorous industries' by many people in their 20s and 30s. This mindset, if not altered, will further shrink the talent pool from which organizations can draw in the future. Newer employees tend to reject the notion of a "cradle to grave" career with the same employer.

2. Implications to Business

As current workers retire and a new - but smaller - generation of employees enter, organizations will need to understand the implications to their business:

Increased Costs

- Recruiting costs of 70-200% of annual salary
- Training up to 40% of employees is a multi-million dollar expense, typically $3,000 - $5,000 per employee
- Additional 5-10% contractor cost to have retirees come back and coach/train new employees

Decreased Productivity

- Supervisors incur at least 10-20% additional overhead overseeing new hires vs. experienced personnel
- Training effectiveness: 40% of new hires do not meet expectations or gain the right amount of experience in the first 18 months
- Bottom line impact of 3-5% due to lost productivity

Increased Safety Risk

- Less experienced workers could increase the number of workplace fires and explosions that kill 200 and injure more than 5,000 workers each year and cause billions of dollars in losses

Human Capital / Workforce Impacts

- If they don't act now, organizations will lose a significant amount of institutional knowledge as their most experienced employees leave the workforce. Important, sometimes critical, information and expertise may literally walk out the door.
- Organizations will find themselves locked in a battle for a shrinking pool of talent and confronting the escalating salaries that will accompany a limited supply of workers.
- Organizations will face the prospect of having to do the same amount of work with much fewer employees.

3. Knowledge Management solutions for fighting the battle against knowledge loss

Many organisations do not have a formal knowledge transfer mechanisms in place to capture critical workforce knowledge and experience within retiring populations to pass on to future employees. Both explicit and tacit knowledge needs saving and knowledge retention is a critical, yet challenging issue, especially in industries involving tacit knowledge. The high costs associated with knowledge loss can be seen both on and off the balance sheet, affecting the entire enterprise. The most forward-thinking organizations minimize the effects of knowledge loss by leveraging strategies such as phased retirements, re-hiring retirees to dissipate knowledge, job shadowing and succession planning.

For many organizations, the first order of business will be to implement a formal way to ensure that the experience and expertise of retiring workers are captured and transferred to their successors. Employees can be enabled to capture and communicate critical knowledge by providing them with technology solutions such as:

- Web-based collaboration tools that collect and distribute knowledge
- Mobile devices to capture knowledge in new ways
- Experts distributing knowledge across the company, not only within their team
- Ability to add context to knowledge
- Business simulation techniques that propagate important information
- An intelligent repository to facilitate and manage knowledge sharing

Accenture has worked with organizations in both the public and private sectors on such projects, using an approach called Enterprise Knowledge Retention and Transfer. This approach encompasses the tools and methods necessary to capture critical knowledge—both explicit and tacit—from experienced employees, and make this knowledge available to less-experience employees on an ongoing basis at the point of need.

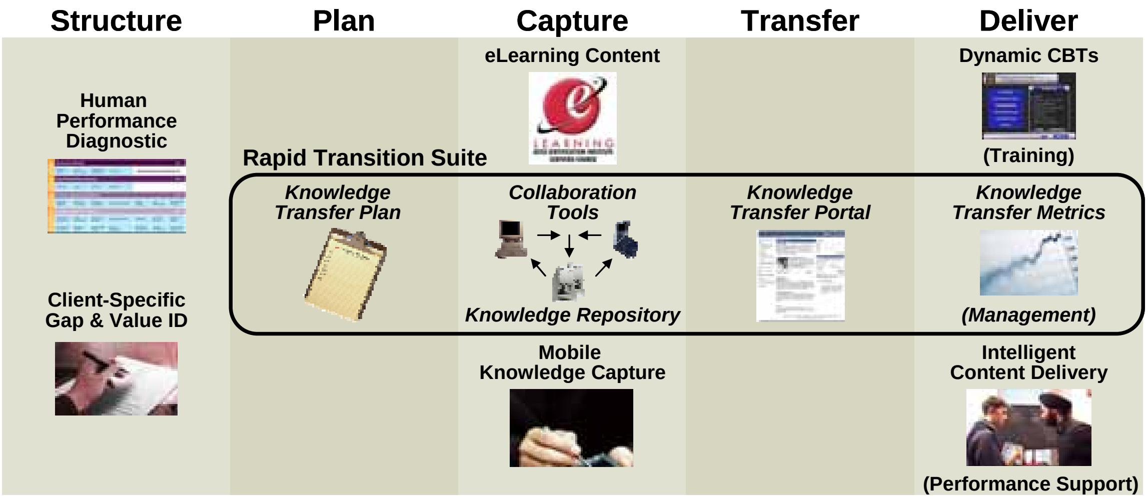

Fig 3. Accenture's Enterprise Knowledge Retention and Transfer offering

Enterprise Knowledge Retention is both a tool and a methodology. The methodology specifies how to determine the roles, responsibilities and skills that are to be transferred as well as how to manage the transfer process. This approach begins with the development of a knowledge transfer plan, assists with documenting processes through interviews, capturing contextual information about a project or system, and helping employees learn specific tasks through synchronous and asynchronous collaborative tools.

Accenture Technology Labs' Enterprise Knowledge Retention (EKR) tool is an integrated suite of applications designed to ease the transfer of knowledge from worker to worker. It was originally designed for outsourcing engagements (where it's had great success under the name Rapid Transition Suite), but has recently been helpful in facilitating knowledge transfer for mergers & acquisitions as well as situations in which a workforce is heading rapidly for retirement.

- At the heart of the offering is a Web-based suite of tools—based on proprietary, patent-pending software developed by Accenture—that intuitively guides teams through a successful knowledge capture and transfer program. The suite captures knowledge from experienced employees (the "instructors") by digitally capturing video of instructors and recording their narration as they perform key tasks (for example, closing an organization's financial books). These recorded sessions then are turned into digital "knowledge objects" that are stored in a knowledge repository that is accessible by "learners" whenever necessary through a Web portal customized to each employee. The benefits of the suite include reducing the time, cost and risk factors that organizations may face during knowledge transfer—especially the capture of valuable knowledge to be transferred between employees across a variety of different scenarios.

- Another tool that plays an important role in Accenture's knowledge management approach—specifically, in knowledge capture—is the Personal Awareness Assistant that can be used by mobile workforces to passively capture and store key information with context. Using a scrolling audio/video buffer, PAA recognizes and records relevant phrases, names, requests, or faces. Field force employees can perform their daily interactions without interference.
- On the knowledge delivery side, Accenture has developed technology that enables knowledge to be intelligently delivered to employees at the point of need. This technology could apply to any setting in which workers' interactions with people involve asking questions in an attempt to resolve an issue—such as a safety or environmental "auditor" who visits nuclear sites to ensure that they are meeting regulatory guidelines. Professionals could be prompted during conversations to ensure that they are using the correct terminology and approach.
- Also playing a key role in knowledge delivery is what Accenture calls a dynamic CBT. Because of how knowledge objects are captured and stored in the knowledge repository, we're able to present insights from a variety of different experts—and update these insights continuously to keep the content fresh and relevant.

Overall, Enterprise Knowledge Retention helps companies to overcome the most common knowledge retention barriers such as:

- Time & distance: retiring employees leave before new hires arrive, or employees in multiple, disparate locations
- Capturing and planning challenges: upfront planning to address impacts of employee loss, identifying network of relevant contacts/experts
- Ineffective knowledge transfer and deployment: employees don't know how to train and don't have time for the extra burden, not enough motivation or incentives provided; knowledge not leveraged due to lack of organization and formalized progress monitoring.

4. References

[1] Accenture's Aging Workforce Study: based on a survey of full-time employed adults, aged 40-50, with 1,407 respondents in U.S. & overseas. Conducted by ICR / International Communications Research for Accenture.

A NATIONAL APPROACH TO UNDERSTANDING SKILLS REQUIREMENTS IN THE NUCLEAR DECOMMISSIONING INDUSTRY

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ABSTRACT

This paper details the NDA Skills and Capability Strategy and highlights how it is working with others[1] to define skills demands across the UK and make investments where necessary to ensure that the infrastructure is in place to meet its Mission. It will detail how, working with Site License Companies, a national picture of resource demand has been identified and illustrate how the substantial progress to date in major projects such as the National Skills Academy for Nuclear, a Nuclear Institute, the Energy Foresight teacher training programme and others are making a difference to meeting current and anticipated demand for skills in the nuclear industry.

1. Introduction

1.1 The Nuclear Decommissioning Authority (NDA) is a non-departmental public body, set up in April 2005 by the UK Government under the Energy Act 2004 to take strategic responsibility for the UK's nuclear legacy.

1.2 The NDA mission is clear: 'To deliver a world class programme of safe, cost-effective, accelerated and environmentally responsible decommissioning of the UK's civil nuclear legacy in an open and transparent manner and with due regard to the socio-economic impacts on our communities'. In line with the mission, the NDA's main objective is to decommission and clean-up the civil public sector nuclear legacy safely, securely, cost effectively and in ways that protect the environment for this and future generations. The NDA does not carry out clean-up work itself but has in place contracts with site licensee companies[2] (SLCs), who are responsible for the day-to-day decommissioning and clean-up activity on each UK site. Individual sites develop Lifetime Plans that set out the short, medium and long-term skills and resource requirements for the decommissioning and clean-up of each site.

1.3 The Energy Act 2004 sets out the responsibility for the NDA to ensure there is *"an appropriately skilled workforce available to carry out decommissioning and clean up"* (Ref.1).

1.4 The key drivers for NDA investment in skills include the clear link to improved business performance and the availability of key skills in a diminishing and competitive environment.

[1] Others include such bodies as The National Skills Academy for Nuclear, Cogent Sector Skills Council, Higher and Further Education institutions, Training Providers and Trade Unions

[2] NDA Site Licence Companies are: Sellafield Ltd, Magnox North Ltd, Magnox South Ltd, Springfields Fuels Ltd, Dounreay Site Restoration Ltd, Reactor Sites Restoration Ltd and the Low Level Waste Repository Ltd.

2. The NDA Skills and Capability Strategy

2.1 The NDA Skills and Capability Strategy:

- sets out progress against the NDA Strategy 2005 with respect to Skills;
- consolidates progress to date;
- shares success stories and good practices; and
- outlines a Strategic Skills Action Plan to cover the next three to five years.

2.2 The Strategy demonstrates how the NDA is meeting its obligations within the Energy Act 2004 by *"developing world class skills"* through *"excellent people, skills and facilities."* It summarises current progress and future challenges.

2.3 Strategic Objectives are defined which capture activities, processes and investments made by the NDA, partners and stakeholders highlighting the mode of operation used to achieve success to date. Delivery of the Skills and Capability Strategy is defined through a robust Skills Programme (Fig 1), linked to the NDA Mission, reflected in Key Strategic Themes with "SMART" Objectives (Tab 1) leading to multiple Skills Projects managed in-house and through strong partnerships – all of which is underpinned by the "Skills Action Plan".

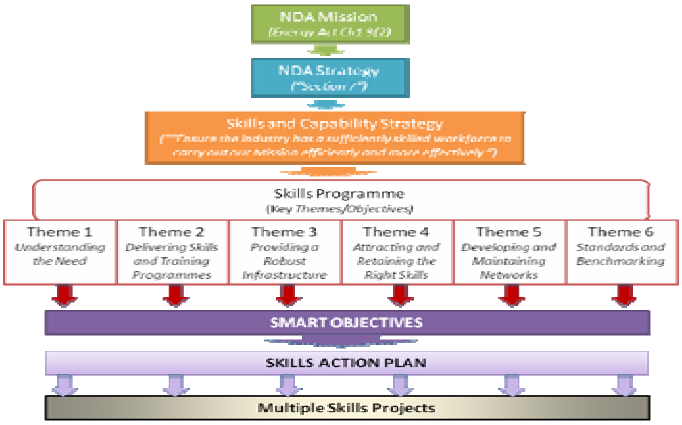

Fig 1. The NDA Skills Programme

1. Understanding the Need Identification of a series of cross-sector initiatives which promote an employer led approach to the demand for skills and training and development of world class skills which supports demand in the short, medium and long term	Establish and manage a National NDA skills resource
	Through appropriate Supply Chain organisations identify skills demand and shortages
	Produce a national statement of skills issues, demands, risks and opportunities for the NDA
	Work with national, regional and local bodies to plan provision to meet demand
	Liaise with sectors outside the NDA to understand the wider demand for transferable skills
	Support the NDA IT Strategy
2. Delivering Skills and Training Programmes Working with the sector employers, skills and training providers at all levels to develop skills and training initiatives and pro-actively engaging with universities and research providers to support the development of world class skills and technical capability for the nuclear sector.	Address identified skill shortage areas with appropriate frameworks
	Support the approval and take up of higher level qualifications to meet NDA needs
	Support the approval and take up of vocational qualifications to meet NDA needs
	Support the approval and take up of other training programmes to meet NDA needs
3. Providing a Robust Infrastructure Working with key stakeholders to identify, develop and promote excellent facilities to support delivery of world class nuclear skills programmes	Play a leading role in the development of new organisations and facilities to respond to national and local skills needs for the nuclear industry
	Review and develop where necessary training and education facilities near to NDA sites
4. Attracting and Retaining the Right Skills Encouraging collaboration across the sector, working with employers, schools, colleges and universities to raise awareness and develop the supporting framework which ensures the attraction and retention of key skills for the future	Invest in and support the STEM agenda in schools
	Support and participate in educational activities near to NDA sites
	Engage Graduates and Under-graduates to participate in developing career opportunities in the nuclear industry
	Work with Professional Institutes
5. Developing and Maintaining Networks Encouraging collaboration and partnership across the sector to develop solutions and raise awareness and share understanding of the skills agenda	Participate in and lead where appropriate skills networks related to the nuclear industry
6. Standards and Benchmarking Using recognised national and international standards, business improvement methodologies and tools related to skills performance to measure, compare and work towards become recognised as one of the leading world class industries	Implement the use of nationally and internationally recognised Standards related to skills
	Determine a methodology for measuring and improving business performance linked to skills

Tab 1. Themes and Objectives

3. Major Achievements to Date

3.1 SLC Skills Strategies – all of the NDA Site Licence Companies produce comprehensive documents which set out skills and resource requirements in the short, medium and long term.

Fig 2. Example Site Skills Strategies

3.2 National Standard Resource Codes – all of the NDA Site Licence Companies have agreed a common set of Resource Codes and are working to define associated “Dictionaries”. This will allow the collation of data and resource planning on local, regional and national basis to support better management of available resources, skills and opportunities for employees within the industry. These will also be aligned to the Sector Skills Council (Ref.2) definitions and roles profiles to aid opportunities for cross-sector resourcing and analysis as well feeding into their “Career Pathways” programme.

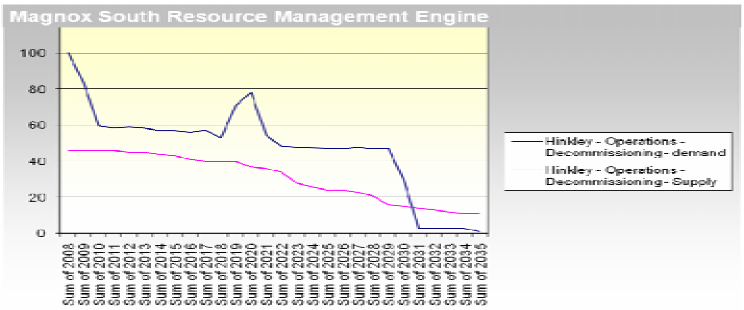

Fig 3. Example Skills Profile

3.3 A PhD sponsorship[3] and bursary programme[4] is in place to support individuals in targeted areas of research which supports the NDA mission.

3.4 Foundation Degrees – available in England, these are new qualifications which are designed with employers, and combine academic study with work place learning to equip people with relevant knowledge and skills to improve performance and productivity. Foundation degrees are awarded by universities and require equivalent standards of academic attainment as the second year of an honours degree. To date, working with Sellafield Ltd, Lakes College West Cumbria and GenII, Foundation degrees in Nuclear Decommissioning[5] and Nuclear Related Technologies[6] have been developed and are now being delivered to employees to provide new skills for the changing work environment.

3.5 A Community Apprenticeship Programme has been established by the NDA to fund 100 Apprentices in the nuclear decommissioning supply chain.

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[3] http://www.nexiasolutions.com/content.php?pageID=229
[4] http://www.nuclear.nsacademy.co.uk/Bursary%20award%20scheme.html
[5] http://www.uclan.ac.uk/courses/ug/fdsc_nd.htm
[6] Awaiting validation

3.6 National Skills Academy for Nuclear[7] – a founder member and principle funder, the NDA has supported and assisted the development and successful establishment of the National Skills Academy for Nuclear and its operating arms particularly in West Cumbria, Scotland and North Wales.

Fig 4. Initial design for the Nuclear Academy in West Cumbria

3.7 Dalton Cumbria Facility – a partnership with the University of Manchester to establish a nuclear research and skills facility aimed at post graduate level with world class research areas in Radiation Sciences and Decommissioning Engineering linked with the British Technology Centre (and emerging National Nuclear Laboratory) at Sellafield. Chairs and students have been appointed in the research areas and plans for additional infrastructure facilities are well advanced.

3.8 The Energy Foresight Programme[8] aimed at 14-16 year olds to encourage the take up of Science, Technology, Engineering and Mathematics (STEM) has been updated to include a module on “Managing Nuclear Waste” and delivered to 400 schools across the UK. Plans and funding are now in place to roll out to some 50% of all secondary schools over the next 2 years.

3.9 The NDA National Graduate Scheme[9] has been a huge success to date with over 1500 applicants for the first 10 places. 13 offers have been made to graduates who will start a 2 year programme in April 2008 and carry out projects in the NDA, Site Licence Companies, the nuclear supply chain or Regulators, abroad in nuclear related organisations and a period of work with “corporate social responsibility”.

4. Mode of Operation

4.1 The NDA recognises that it cannot work alone in developing and implementing its approach to skills but has a key role to play in acting as the catalyst to lead the development of sustainable world class nuclear skills by developing excellent people, skills and facilities operating to the highest quality standards in order to fulfil its mission.

4.2 The NDA mode of operation in delivering its obligations with respect to skills is through a strong and well established network of partners and stakeholders (Fig 5.).

[7] http://www.nuclear.nsacademy.co.uk
[8] http://www.energyforesight.org
[9] http://www.nda.gov.uk/recruitment/nucleargraduates

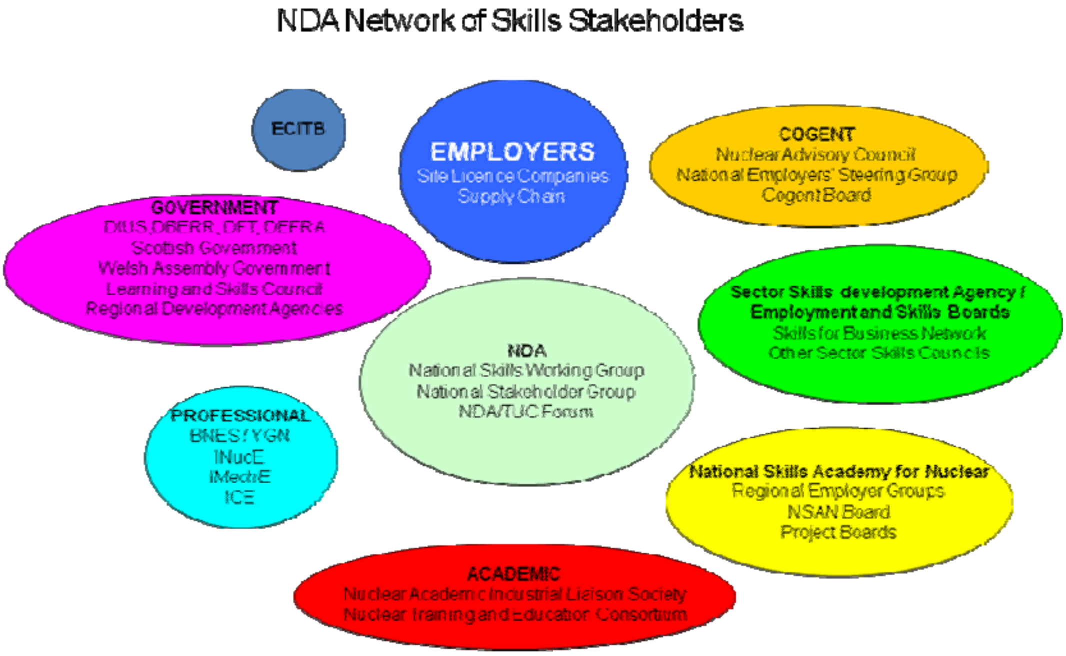

Fig 5. "Examples of NDA Partners and Stakeholders"

4.3 With the support of partners and stakeholders, the NDA is committed to taking a strong leadership role where appropriate in developing and delivering skills solutions using the following principles:

- strong partnerships with SLCs;
- delivering skills solutions collaboratively;
- networking to the best advantage;
- leading and influencing where appropriate;
- leverage and sustainability of investments;
- sharing good practice; and
- defining "World Class" and benchmarking the industry.

5. Conclusion

5.1 The challenges facing the nuclear decommissioning sector are substantial:

- a diminishing skills base and low uptake of key subjects such as Science, Technology, Engineering and Maths. This is in part due to demographics but also competition from other industries;
- the ability to meet regional and national requirements;
- a diversified contractor base;
- a lack of clarity on the long term needs;
- perceptions of the industry; and
- mobility and transferability of resources

5.2 The work by the NDA so far is the start to understanding and addressing the skills requirement for the nuclear decommissioning sector. There is still much more to do but with support from stakeholders and partners it can act as an enabler to make real and substantial changes to "*develop world class skills*" through *"excellent people, skills and facilities."*

References

1. Energy Act 2004 Chapter 1 section 9 (2) "General duties when carrying out functions."
2. Cogent – the Sector Skills Council for Chemical, Nuclear, Oil and Gas, Petroleum and Polymers

ENSURING KNOWLEDGE AND SKILLS IN DEEP GEOLOGICAL DISPOSAL: PROGRESS OF THE ITC-SCHOOL INITIATIVE

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ABSTRACT

The ITC School of Underground Waste Storage and Disposal is an independent, non-profit Association, based in Switzerland. It has more than 50 member organisations worldwide and was established in 2003 with the specific objective of responding to the clear need for continued training in radioactive waste management over the coming decade. Many national repository programmes were in difficulties and expertise was dwindling internationally. The ITC School has filled this gap by providing an average of four or five training courses a year in Europe, Japan and the USA, often with large practical elements. This short paper outlines the work that has been undertaken by the Association over its first five years of operations.

1 Introduction

At the beginning of the 21st century, national organisations and programmes developing safe approaches to deal with the back-end of the nuclear fuel cycle were faced with concerns that were common across the nuclear industry in general: how to ensure the availability of professional skills and knowledge in the field. These concerns were acknowledged by international organisations such as the IAEA, the OECD Nuclear Energy Agency and the European Commission.

In 2003, several initiatives started in Europe and worldwide to ensure the propagation of knowledge and skills in deep geological disposal over the generation gap. One of the key initiatives was the founding of the non-profit association, ITC School of Underground Waste Storage and Disposal, initially by five organisations from Switzerland, Spain, and Japan. Today, the ITC School, with its currently 57 members from 16 countries, has matured into an organisation that can be considered as the leading professional training provider in deep geological disposal in Europe. By the end of 2007, ITC-School had provided high quality professional training, benefiting from its position as a focal point in relation to the experts in its member organisations, for around 350 participants from 38 countries in 20 specialised courses and other activities.

2 The looming skills gap

The growing need for permanent solutions for the management of long-lived radioactive wastes is both a societal and technical challenge for the different actors and stakeholders in the industry. One of the main factors adding to the complexity of the management of long-lived radioactive wastes is its multidisciplinary nature.

At the beginning of 2004, the European Commission funded a 15-month programme called CETRAD, to identify the training needs, capabilities and resources available in the EU in the field. The findings of the project confirmed the existence of the generation gap in deep geological disposal, the lack of formal post-graduate level education, and the scarcity of professional training providers in the field. In addition, specific legal qualification or competence requirements on the training of personnel working with deep geological disposal do not exist yet.

Gaining high-level expertise in geological disposal takes tens of years. Last year was a significant turning point in the industry, because the industry experienced the retirement of many internationally acknowledged top experts and this will continue for at least the next 10 years.

The findings of the CETRAD project supported the need for both the ITC School and the IAEA supported project that established the Network of Centres of Excellence in Training and Demonstration of Waste Disposal Technologies in Underground Research Facilities and led to new European initiatives such as the EC sixth framework programme's PETRUS initiative, within the ENEN II project, initiation of the European Nuclear Training Network and the ESF supported underground training facility (USF) Josef Gallery in the Czech Republic.

3 Some ITC history

The concept of providing continued training with a high practical content and access to laboratory facilities arose in late 2001, at the time when Nagra, Switzerland, was designing the 6th Phase of activities at the Grimsel Test Site (GTS). The initial idea was to have a 'school' component within the future GTS activities. Over the next few months Nagra explored the idea with other organisations and the concept of the ITC ('International Training Centre') was born. Nagra provided resources to establish the School and set it on its feet for the first critical years of its existence.

The ITC School was established as an Association (*Verein*, under Swiss law) in April 2003 after a one-year period of exploratory discussions. For the first 12 months or so, Nagra provided the secretariat and offices for the new Association. However, the ITC Executive and Members agreed with Nagra that ITC should become independent as soon as possible, not least because this was considered to be in the better interests of Members and of overall transparency – too close a link to one Member or one sector being undesirable once ITC was able to stand on its own feet.

By the middle of 2004 the financial situation, although difficult, looked stable enough to make this move and ITC formally moved out of Nagra's offices to Dättwil, near Baden, although the domicile of the Association remains in Innertkirchen, in the Kanton of Bern, close to the GTS. Indeed, may of the courses provided by ITC are given in this region, using the excellent facilities of the nearby tourist village of Meiringen as a base.

ITC is run with a small secretariat of part-time staff and makes considerable use of support from its Member organisations in setting up and running training courses. For example, the majority of course tutors are provided by the Members. Nevertheless, many course users are actually from outside the Association, largely as a result of the close link between ITC and the IAEA Network of Centres of Excellence entitled 'Training in and Demonstration of Waste Disposal Technologies in Underground Research Facilities' (see next Section). Apart from fully open courses, ITC has also organized a number of tailored training activities for specific Members and is also involved in a number of European Commission RD&D projects as the partner responsible for running project training activities (e.g. OBRA, TIMODAZ and the initial training in FUNMIG).

ITC membership is open to any organisation supporting the broad concept of providing training and education in waste disposal. As and association, new Members have to be elected by the existing Members. Membership growth was rapid over the first few years, reaching 50 by early 2005, and has been relatively stable since that time. As a non-profit Association, the ITC School exists solely to serve the needs of its Members. As noted above, the original intention in establishing ITC was that it should be representative of all sectors with a working interest in radioactive waste disposal and this has certainly been the case, as can be seen in Figure 1. There is strong representation from organisations in every sector associated with underground disposal of radioactive wastes.

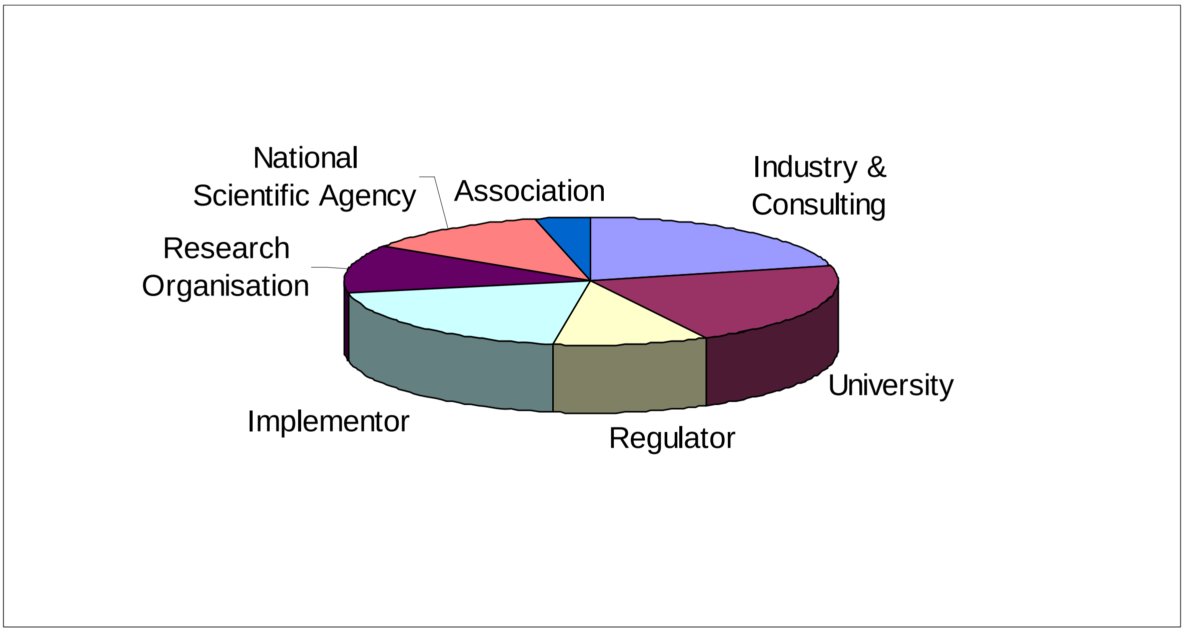

Figure 1: Current (early 2008) ITC membership, by sector.

4 The IAEA Network of Centres of Excellence

The birth of ITC School coincided with, and developed in close association with, a major training initiative organised by the IAEA. At around the same time that the concept of the ITC was being discussed, the IAEA also recognised the need for propagation of experience and dissemination of knowledge to newer waste management programmes worldwide. In particular, it saw the value of using existing underground laboratories to help provide practical, hands on training to those scientists and technologists just entering the field. In 2001 it established a Network of Centres of Excellence on 'Training in and Demonstration of Waste Disposal Technologies in Underground Research Facilities'. The objective of the Network is to assist in the transfer of knowledge and technology from IAEA member States with advanced research and development programmes in underground research facilities to Member States with less well-developed repository implementation programmes and/or having no direct access to underground research laboratories.

The project is led from the IAEA's Department of Energy, Division of Waste Technology (NEFW). Primarily, the project is funded and managed through Agency Project L.402/11 (Building Confidence in Geological Disposal of Radioactive Waste). Significant support to the project is provided by the Department of Technical Co-operation and indirectly through extra-budgetary contributions from some Member States that own Underground Research Facilities.

Through various pathways such as classroom and underground instruction, scientific visits, fellowships, coordinated research programs and on-site group training, the Network provides opportunities to increase levels of competence in nuclear waste management among countries having spent nuclear fuel and highly radioactive waste to be disposed of.

The core Members of the Network are radioactive waste management organisations and universities from Belgium, Canada, Sweden, Switzerland the UK and the USA. Member countries participating in the programme are:

IAEA Network Recipient Countries		
Argentina	Czech Republic	Philippines
Armenia	India	Romania
Brazil	Lithuania	Russian Federation
Bulgaria	Kazakhstan	Slovakia
Chile	Republic of Korea	Slovenia
China	Mexico	South Africa
Croatia	Pakistan	Ukraine

Classroom and underground instruction began in 2003, with courses offered in Europe through the ITC and in North America through a cooperative effort between the USA's Department of Energy and Lawrence Berkeley National Laboratory, and Canada's Atomic Energy Canada Limited (AECL).

Since the inaugural ITC course (the first IAEA Network course in Europe), ITC has facilitated 9 out of the 16 courses in the Network programme and is expected to continue in its 'facilitator' role during the next three years of the programme (2009-2011). Facilitation means that ITC works closely with the host organisation, which provides facilities such as a access to URLs, with ITC structuring the course and developing the course materials and exercises.

5 Course programme

Training in radioactive waste management needs to tackle a range of requirements, and focus both on new professionals in waste management who have just started a career and experienced professionals who may have changed or broadened their responsibilities. There are also other users, including decision-makers who are not professionals but who need to be aware of the issues surrounding waste management. Consequently, ITC organises courses and training ranging from the generalist – covering all key aspects across the broad spectrum from waste arisings to societal and decision-making issues – to intensive, specialist courses. Since the foundation of ITC, the following courses have been organised or are scheduled for 2008 (the location and main collaborating partners are identified):

1. 2003: The Fundamentals of Geological Disposal & The Theory and Practice of Underground Rock Facilities (IAEA, Nagra and SCK.CEN; Switzerland and Belgium).
2. 2004: Geochemical Modelling of Natural and Contaminated Groundwaters (University of Bern, Switzerland).
3. 2004: Workshop on Case Studies of Subsurface Radionuclide Migration (EAWAG, Switzerland).
4. 2004: Siting of Deep Geological Repositories (IAEA and RAWRA; Czech Republic).
5. 2004: Fundamentals of Geological Disposal (IAEA and Nagra; Switzerland).
6. 2004: The Role of the Safety Case in Planning and the Implementation of a Repository Programme (RWMC; Tokyo, Japan).
7. 2005: Decision-Making and Stakeholder Involvement (IAEA and PURAM; Hungary).
8. 2005: Deep Repository Design (IAEA and Nagra; Switzerland).
9. 2005: Multicomponent Reactive Flow and Transport (University of Bern; Switzerland).
10. 2005: Fundamentals of Radionuclide Migration (FUNMIG), Barcelona, Spain.
11. 2006: Geologic Disposal of High-Level Waste (USDOE, USA).
12. 2006: Interface between Geology & Safety Assessment (HSK; Switzerland).
13. 2006: Planning Preliminary Site Investigations (NUMO and SKB; Switzerland & Sweden).
14. 2006: Fundamentals of Geological Disposal (IAEA and Nagra; Switzerland).

15. 2007: Natural and Archaeological Analogues in Waste Disposal (Switzerland).
16. 2007 Practical Environmental Radiochemistry (PSI; Switzerland).
17. 2007: Geologic Disposal of High-Level Waste (USDOE; USA)
18. 2007: Deep Geological Repositories in Sedimentary Environments (IAEA and DBE Technology; Germany).
19. 2007: Transport and Retardation Processes in Fractured Rocks (IAEA and Nagra; Switzerland).
20. 2008: OBRA Project Workshop: Providing information for local communities (European Commission; Switzerland).
21. 2008: Geological Disposal: The Methodology of Safety Assessment (HSK; Switzerland).
22. 2008: Cement & Cementitious Materials in the Geological Disposal of Radioactive Waste (Posiva; Finland).
23. 2008: TIMODAZ training course: THMC properties of clays and claystones (EPF Lausanne, Switzerland).
24. 2008: Geologic Disposal of High-Level Waste (USDOE; USA).
25. 2008: Fundamentals of Geological Disposal (IAEA and JAEA; Japan).

An area that ITC intends to engage in over the next few years is provision of training for university students, especially at postgraduate (Masters) level. ITC has many universities as members and is becoming more closely involved with them and with separate programmes that they are organising (e.g. PETRUS – which aims to develop a European Masters degree in geological disposal) to fill the training gap at the academic level. For example, and avenue being explored is that ITC courses might be accredited and incorporated into academic modules to provide both a valuable network link between students and professionals and practical access to underground training facilities.

6 Conclusions

A few years ago, ITC observed that the future outlook for training in radioactive waste management was mixed. Despite the need, the funding of training was apparently widely regarded as of low priority and seemed often to be regarded as a marginal organisational expenditure, with training activities sometimes being opportunistic, rather than well planned and structured. It was not well appreciated that the provision of high quality training requires much preparation, access to large facilities and the input of the best expertise – and is consequently expensive.

The extent to which this situation has improved is currently hard to gauge, but there is certainly a renewed will to improve matters. This is most likely driven more by the perceived requirements of a nuclear power renaissance than the specific needs for managing the 'back end' of the nuclear fuel cycle. Without the present political drivers of reducing carbon emissions and improving the security of electricity supply that are pushing nuclear energy forward again after decades in the doldrums, it is arguable whether the impetus would exist to fill the skills gap in waste management. But the outlook today is really encouraging – and certainly much brighter than it was when ITC was being established five years ago.

For further information on the activities of the ITC School, visit: www.itc-school.org.

NUCLEAR KNOWLEDGE PRESERVATION, CONSOLIDATION, VALIDATION, DISSEMINATION AND TRANSFER ACTIVITIES AT THE JOINT RESEARCH CENTRE

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ABSTRACT

Nuclear knowledge had been build up continuously since the beginning of the last century. After Chernobyl in 1986 the acceptance of nuclear energy decreased in many Member States. The interest of younger generations for nuclear studies dramatically decreased and nuclear education was abandoned by many engineering faculties. In the meantime the generation of senior nuclear experts is retiring. On the other hand a renaissance of nuclear power is ongoing. In order to avoid a possible loss of capability and knowledge in the EU action should be taken now preserving and disseminating it to the new generation.

Following several recommendations the JRC has formulated 3 actions in its Work programme dealing with Nuclear Knowledge Preservation, Training and Education, each of them covering a different area of competence. This paper describes the JRC activities foreseen for 2008 but concentrates on nuclear knowledge preservation activities.

1. Introduction

After the Chernobyl accident in 1986 a trend at universities and in industry was observed of a decrease in students choosing nuclear related studies. Now the generation of senior nuclear experts is retiring. On the other hand, due to security supply and climate change issues (green house mitigation measures) receiving more importance lately, a renaissance of nuclear power is ongoing. In order to avoid a possible loss of capability and knowledge in the EU action should be taken now preserving and disseminating it to the new generation.

There is a huge amount of information and knowledge available, either published or easily available, but also publications difficult to trace. Especially those are at risk of being dispersed or lost due to a series of factors.

Considering that

- the European Commission in its Green Paper, in the 7th Framework Programme (FP7) and in a Communication recognises the need to efficiently disseminate research results [1,2,3],

- the International Atomic Energy Agency (IAEA) has adopted in 2002 a resolution on "Nuclear Knowledge" emphasizing the importance of nuclear knowledge management, which was reiterated in subsequent years [4],
- the Working Party on Nuclear Safety (WPNS) recommends the improvement of exchange of nuclear safety information [5],
- the Council of the European Union recommends in its conclusion regarding nuclear safety the compilation and exchange of any information regarding nuclear safety research [6],
- the European Atomic Energy Community recommends that the expected fading out of nuclear knowledge qualifies for a potential European solution [7],
- the OECD Nuclear Energy Agency adopts a statement about qualified human resources in the nuclear field due to the tremendous decline in students for nuclear studies in the last decades [8],
- the European Nuclear Energy Forum (ENEF) raised the idea of a European Nuclear Academy directly co-ordinated with the European Nuclear Education Network (ENEN) at its inaugural meeting [9],

nuclear knowledge preservation and consolidation activities will be carried out with a strong political support. Also from the IT industry signals are pointing into the same direction. IBM's Nuclear Power Advisory Council recommends strongly knowledge management in nuclear technology [10].

2. Initiative

Following the above political recommendations and due to its experience in Education and Training the JRC has formulated 3 actions in its 2008 Work programme dealing with Nuclear Knowledge Preservation, Consolidation, Validation, Dissemination and Transfer, namely "Capture", "KTE" and "TENS". Each of them covers a different area of competence in the nuclear domain. Additionally, some horizontal activities are taking place throughout the JRC.
"Capture" stands for "Consolidation and Preservation of Nuclear Technology Knowledge and Reference Data for Education and Training of Experts for Plant Life Management and Future Plant Designers". "KTE" covers the knowledge management, education and training field regarding the nuclear fuel cycle. The objective is to create a management system which will allow collection, dissemination, use and organization of the scientific information. Such system is founded on different pillars, e.g. documentation archiving, knowledge transfer, education and training, project management and scientific and public communication. "TENS" deals in priority with nuclear training and education aspects in the area of nuclear safeguards, non-proliferation and nuclear security but owns also a specific Safeguards knowledge management.

3 Knowledge Collection, Preservation and Consolidation

Lately, many stakeholders, such as Institutes, R&D Organisations, Regulators, Utilities, Governmental Organisations, have recognised the need for collecting, preserving, consolidating (validating), and disseminating nuclear knowledge (documents, competences and data), in order to make it easily accessible to future generations through modern informatics tools and training and education measures.
In the nuclear safety area it needs to cover an as wide as possible range of reactor designs, systems, components, materials and technologies, including PWR, WWER, BWR, CANDU, MAGNOX, MTR, etc.. A broad spectrum of components and technologies will be considered, i.e. reactor pressure vessel (RPV), piping, internals, steam generator, etc. regarding knowledge, material data and practices. In the long run, this will also support future decommissioning exercises of nuclear installations as a valuable knowledge source.
The urgency of such activity is valid in particular for Russian designed Nuclear Power Plants in the new Member States, facing a serious issue in terms of losing fundamental knowledge which is furthermore scattered in many countries and in different languages.
In addition to the knowledge available in each Member State, JRC produced a long standing record of results from its own institutional activities and even more through the participation

to a large number of European Network partnership projects. In particular, substantial knowledge is available at JRC-IE on plant-life-management (PLIM) topics as well as structural design, nuclear science, structural safety analysis, thermo-fluid dynamic, reactor dosimetry, safety management systems, decision making and human factors, design criteria, super critical water, etc. in most cases relevant for supporting the development of advanced reactor systems as GEN IV applications.
It is important, besides preservation, to consolidate the enormous amount of scientific results produced since. This can be effectively done utilising a dedicated method developed at the IE for consolidation of knowledge. The method is based on the active involvement of those senior experts who participated since the beginning of the nuclear era and are still active and available. It makes extensive use of well focused consolidation workshops and has been tested in recent years achieving encouraging results.
Training and education material can be developed in this way very effectively for the use in academic organisations such as the European Nuclear Education Network (ENEN), National Universities, etc..
GEN IV cannot afford to fall into the same shortcoming in the future. A systematic approach needs to be developed to start knowledge preservation and slowly entering into consolidation exercises. It has to be noted that the development of GEN IV is also based on knowledge created along several decades already and in many cases spin offs of previous generation R&D. The same could be said for Fusion, Accelerator Driven Systems and other applications.
Based on the experience of the JRC with its “Online Data & Information Network for Energy” (ODIN) web portal (http://odin.jrc.ec.europa.eu) and the pilot project on WWER RPV knowledge collection, multi-lingual reports (e.g. Russian, Ukrainian, Slovakian documents in original language, articles in local magazines, proceedings from national events, etc.) will be collected and organized into prior defined subjects. Experts will be proposing summaries of related publications and after “Consolidation Workshops” State-of-the-Art will be produced and published as open EUR Reports (with references to the original papers). In this way the EUR Reports will have no restriction for further distribution (while Intellectual Property Rights [IPRs] might still be part of the original documents).
The below figure illustrates the proposed way forward for consolidation.

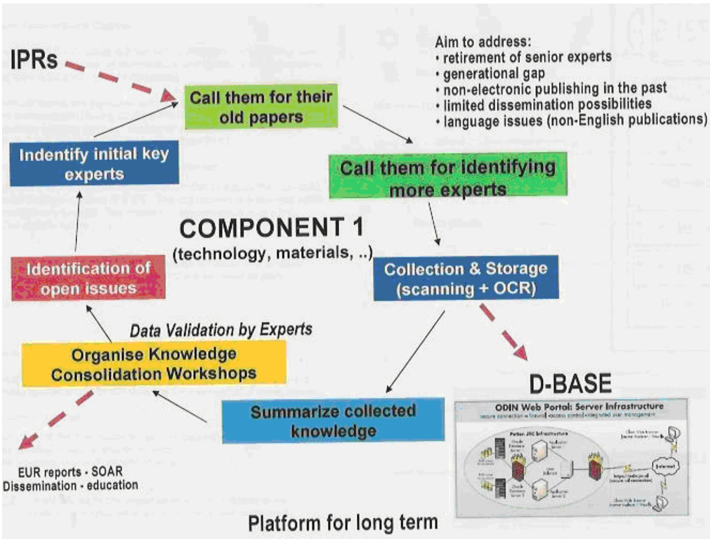

Figure 1: Nuclear Knowledge Consolidation Circle

Besides hard knowledge it is crucial to construct a Network of EU experts, who are available for consultation in case of crisis situations (EC-FP7 priority). The leading experts (including those already retired) need to be traced and their coordinates should be kept in a central database. The EUR Reports and the results from the Workshops are the bases for dissemination and developing training material mainly for younger staff entering the field. Collaboration with ENEN is also envisaged.

4. Data Validation

In the past several International projects have produced large amounts of relevant data which are dispersed in a number of d-bases or only available on paper; mainly the IAEA, EC Round–Robin exercises, etc. Such data need to be re-examined and validated for further use. For example, in 2005 the IAEA has transferred its International Reactor Pressure Vessel Database, which is one of the largest of irradiated materials databases in the world, to the JRC for further management. The change was necessary due to outdated users interface software; whereas JRC had implemented already Java based data retrieval software, which can be developed further according to the future requirements.

A modern and useful database should have the three following functions:

1. Data collection, processing, storage
2. Data validation, and
3. Data evaluation

The first function is fulfilled by a JRC databank in ODIN. The second requires the continuous work of specialists to fit trend curves and check outliners. The third is also the task of specialists, as new trend curves have to be established after validation of the data.

This data validation could become a follow-up activity, in case the knowledge consolidation methodology proves to be successful on a wider scale. It would support designers, safety authorities, modellers and also upgrade C&S.

5. Web Portals

One of today's activities of the IE concerns data management and dissemination in nuclear safety. An Online Data & Information Network (ODIN) is set-up, which maintains one document database and four engineering databases. These databases aim to deploy networks for energy related research & development, specifically for nuclear energy and to provide the public experimental data of European projects on mechanical and thermo-physical material properties in comparison with international standards and recommendations. Moreover ODIN manages six nuclear databases, which have restricted access. They cover: (i) data on High Temperature Reactor (HTR) Fuel Elements, (ii) HTR graphite element data, (iii) data on safety of Eastern European Type Nuclear facilities, (iv) information on current research reactor safety assessment approaches, (v) data on hydrogen incidents and accidents, (vi) information on long term radioactive waste management, to enable co-operation and technology transfer for member states with small nuclear programmes.

Nucleonica is a new science web portal from the ITU. It provides a customisable, integrated environment and collaboration platform in fields as diverse as the life and earth science, and more traditional disciplines such as nuclear power, health physics and radiation protection, nuclear and radiochemistry. It is also used as a knowledge management tool to preserve the nuclear knowledge built up over many decades by creating a modern web-based version of so-called "legacy" computer codes.

6. Knowledge management in Safeguards

The JRC is part of the European Safeguards Research and Development Association (ESARDA) created in 1969 to assist the European safeguards community with the advancement of safeguards, enhancing the efficiency of systems and measures, as well as investigating how new techniques can be developed and implemented.

As such, the JRC provides the secretariat of the association and has developed a specific website (http://www.jrc.cec.eu.int/esarda/) to provide the latest issues of the Bulletin, as well as scientific and practical information about the working groups and symposia. It also contains a comprehensive database with associated search tools gathering all the reference materials relating to safeguards since its origin (treaties, a safeguards glossary, technical sheets, modules of courses and key publications).

7 Education

Education is commonly defined as a basic, knowledge-driven, learning process, involving academic institutions as suppliers and students as customers, which encompasses the need to maintain completeness and continuity of competences across generations.
The implementation of the second part of Article 9 of the EURATOM Treaty, "to establish an institution of university status", became only possible almost 40 years later when European universities started a mutual recognition process. A transparent exchange mechanism between the different national higher education systems had to be agreed between leading universities in Europe. This was obtained within the Sorbonne-Bologna process in 1998, which formalized a European Credit Transfer System (ECTS) for studying at those European universities [11]. With the decreasing number of nuclear engineering and nuclear physics students, the number of nuclear courses offered today is more limited than 30 years ago, but they are therefore, with the ECTS internationally recognized, more accessible for foreign students.
The temporary European Nuclear Engineering Network, established through the RTD FP5, was given a permanent character by the foundation of the European Nuclear Education Network (ENEN) Association in 2003, pursuing a pedagogic and scientific aim. [12]
The ENEN is approached by JRC to extend its programme into nuclear safeguards and security. A Memorandum of Understanding between the JRC and the ENEN, associating JRC to the ENEN which is under establishment, is a first step in this direction.
The JRC is contributing mainly to education by offering R&D projects for graduate students towards a PhD degree. In very limited scientific domains in which universities are not involved the JRC is providing academic courses of short duration for a limited audience. On the other hand, it is clear that the JRC is a research centre and has no vocation to play the role assigned to universities.

7.1 Academic Courses

With the support of the European Safeguards Research and Development Association (ESARDA), in particular the ESARDA Working Group on Training and Knowledge Management, the IPSC is organizing yearly a Nuclear Safeguards and Non Proliferation course. This course will be organized this year for the fourth time from April 14 to April 18. The BNEN/ENEN has recognized the course as a standard academic one semester course of 3 ECTS. To formalize and maintain this recognition, the course syllabus is being finalized with all presentation materials for the so-called "mandatory" section. Both the lecturers and ESARDA WG's have been called upon for contribution/collaboration to this.
At the GELINA facility in the IRMM yearly two courses are given on neutron measurements (incl. time-of-flight experiments and accelerator experiments). One is recognised as an elective course in the ENEN programme. The other has been organized twice for the academic network for co-operation in Higher Education on Radiological and Nuclear Engineering (CHERNE).
Some JRC courses are covered under a Collaboration Agreement (CA) between JRC and Universities. As most recent example, such a CA has been drafted upon request of the University of Florence for contributing with teaching in the master "Nuclear Materials and the control of the Non-Proliferation Regime". This master, which was opened with the explicit support of Dr. El Baradei, will be started in 2008 and JRC is offering a one week course of 3 ECTS points.
In addition, some experts of JRC are teaching academic courses in the nuclear field at universities (e.g. Universities of Ghent, of Leuven, of Brussels, of Delft, of Heidelberg).

7.2 Traineeships

The JRC traineeship scheme provides trainees with experience of working in a research environment and a better awareness of the operation of JRC and the Commission. It benefits the JRC by providing extra resources, an influx of fresh ideas and closer links to the academic community.

There are three categories of trainee – (1.) industrial placement (or pre-graduate work experience), (2.) preparing a thesis and (3.) post-graduate work experience.
JRC is also reinforcing its collaboration with universities by providing university students access to its research facilities. In this way ITU was one of the founding members of the "Association for research and lecturing in nuclear engineering in Southwest Germany" together with the Forschungszentrum Karlsruhe, Energie Baden-Württemberg, the Ruprecht-Karls University of Heidelberg, the University of Karlsruhe (TH), the University of Stuttgart and the Universities of Furtwangen and Ulm.

7.3 PhD and Post-doctoral Fellowships

The JRC offers PhDs and post-doctoral fellowships to encourage young scientists to enhance their experience in an international, multicultural and multidisciplinary environment. JRC hosts PhD students with internal grants (in close collaboration with the university surveying that at the end of the research a PhD title can be awarded) and with external grants, such as e.g. the Marie-Curie Fellowships for pre- and post-doctoral researchers, or national fellowships (e.g. from the German Alexander von Humboldt Stiftung).

8 Conclusion

The JRC has a longstanding experience in nuclear training and education, mainly in the field of nuclear safeguards and the nuclear fuel cycle. Recently, also knowledge management issues are tackled more systematically by the different Institutes, mainly by creating a management system, which allows the collection, dissemination, use and organization of the scientific in-house information and by applying a new methodology to collect, preserve, consolidate and disseminate external nuclear safety knowledge. The need for this, expressed from different international institutions and committees, may lead to an increase of efforts in the nuclear knowledge management area.

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ACTIVE LEARNING - A NEW METHODOLOGY? APPLICATION TO EDUCATION ON NUCLEAR ENGINEERING

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ABSTRACT

One of the objectives of European Higher Education Institutions in order to improve the formation of their graduates is to promote the use of active learning methodologies. A new methodology as old as the teaching activity. Remember Socrates, Plato and the Ancient Greek Academy. Students should be the active subject of their own learning. Teachers should supervise and direct this learning process in order to optimise teaching results. It is thus necessary to involve students in the development of lessons being indispensable their personal motivation. The issue is to invite students to actively participate in the class by discussing each lesson whose objectives are proposed by means of questions in order to stimulate the participation of students in the discussion. Some experiences developed at the Polytechnic University of Valencia are presented. Results obtained over the last years have demonstrated that the application of this methodology enhances the student learning performance.

1. Introduction

One of the objectives of European Higher Education Institutions in order to improve the formation of their graduates is to promote the use of active learning methodologies. Many people refer to this as a new methodology. However, it is as old as the teaching activity. Just remember Socrates, Plato and the Ancient Greek Academy.

The student should be the active subject of his own learning. Teachers should supervise and direct this learning process in order to optimise teaching results. It is thus necessary to involve students in the development of lessons being indispensable their personal motivation.

The issue is to invite students to actively participate in the class by discussing each lesson, although they have no background in the field. The objectives of every lesson are proposed by means of questions in order to stimulate the participation of students in the discussion.

Obviously, students must be previously provided with the information necessary to prepare the discussion. Sometimes this information is put in a web page from where it can be downloaded by the students. It can include notes about the matter, bibliography, practical exercises and questions. Students can also use different books, journals or websites to complete the study of the lesson.

In particular, a textbook [1], has been published for a course on Radioactive Contamination, which includes Fundamentals and Applications, that is, basic concepts on radiations and radiation protection as well as contamination features and decontamination techniques. The active learning methodology developed for this course was presented at a previous conference, ETRAP 2005 [2].

Active learning methodology usually implies that students are evaluated by means of a continuous evaluation [3]. It takes into account the comprehension of basic concepts and their application to practical cases, verifying the accomplishment of objectives. It is stressed the development of personal works with an oral presentation. Results obtained over the last years have demonstrated that the application of active learning methodology enhances the student learning performance.

Some experiences developed at the Polytechnic University of Valencia are presented. They refer to courses given by the author related to Radioprotection and Nuclear Engineering.

2. Methodology

The teaching methodology must be focused on an active participation of students in their own learning. They will learn –if they want!– and the role of their teachers is leading their learning and preparing and providing the material necessary to help them to achieve learning objectives [3].

The student should be then the active subject of his own learning. Teachers should supervise and direct this learning process in order to optimise results. It is thus necessary to involve students in the development of lessons being indispensable their personal motivation.

One of the strategies used with this goal is to present a short list of questions the first day of the course, so that students can express their expectations for the course and the professor could know about gaps in their knowledge. Another way to motivate the students is to carry out without announcement an exercise at the middle of the term, so that they could realise about the concepts well learnt so far.

The main component of this active methodology is the development of each lesson at the classroom. Lessons are not exposed in a traditional way but they are discussed in the classroom following some guidelines with several objectives in mind. It is necessary that students prepare the lesson previously and obviously they need some guidelines as well as a reference text. A web page linked to each course is very helpful to provide information to the students.

During the development of the class, different questions are proposed to the students in order to perform an analysis of the lesson achieving the objectives previously established. These objectives shall include, if possible, the following points:

- what must be learnt by the student;
- trying to find out why must he learn it; and
- maintaining a connection between the different matters.

During the discussion the students shall present their own points of view as well as their doubts and problems of understanding. The professor shall lead the discussion directing it to fix and understand the objectives proposed for each theme. After clearly understanding the concepts of the lesson, it will finish with a summary of the most important points to underline them and stress its comprehension. This development should be complemented with practical exercises.

The participation of students in the development of the lesson is first timid, but increasing with time. They carry out many exercises and works proposed at the classroom and this contributes clearly to their formation. Besides exercises proposed during the class, a list of questions for self-evaluation is provided at the end of each lesson.

In the next paragraphs a review is done to specific aspects of two courses given by the author at the Polytechnic University of Valencia.

2.1 Radioactive Contamination

Students in the 5th year of Industrial Engineering (branch Environment) have a course on Radioactive Contamination. They arrive to this course with scarce or no background about radiation or radioactivity. Therefore, some basic concepts on radiations and radiation protection should be learnt before starting the study of radiation applications, contamination features and decontamination techniques. One can say that they start from scratch. Nevertheless, they are invited to actively participate in the class by discussing each lesson. To stimulate their participation the objectives of the lesson are proposed by means of questions. Of course, students have been previously provided with the information necessary to prepare the discussion. During several years this information was included in a web page, but finally a textbook was published [1].

The development of the class is centred on basic concepts and practical applications, being complemented with works in group and practical exercises in the laboratory. A booklet for laboratory practical exercises was also published [4].

Practical exercises include laboratory and computer calculations (shielding and doses) but one of the most innovative tasks –very appreciated by students– was the analysis of a real situation, usually a radiological accident. Students should prepare their work reading the available information and preparing in small group a presentation of their analysis in a public session at the seminar. They are provided with a summary of the accident and some guidelines to develop their work [5].

2.2 Nuclear Materials and Fuel Cycle

It is a course also given in the 5th year of Industrial Engineering (branch Energy in this case). It belongs to the master course on Nuclear Engineering so students have already a background on radiations and nuclear applications. Nevertheless, they are likewise invited to actively participate in the class by discussing each lesson. Their participation in the class is also stimulated by proposing the objectives of the lesson by means of questions. Once more, students should be previously provided with the information necessary to prepare the discussion. A web page linked to the course is very useful to give them information. Planning of the course and proposed questions and exercises are also uploaded on this web page. An extensive bibliography is also provided and the works developed by students of previous courses are complementary information quite useful for preparing the discussion. Some textbooks are also used [6,7].

It is very important for this course to perform visits to the installations of the fuel cycle. It is done when possible. Otherwise, some virtual visit should replace it, for instance with videos. Another important issue for this course is a practical exercise whose goal is the partial assembling at the laboratory of PWR and BWR fuel elements. This exercise permits to the students the handling of pieces of fuel elements and helps them to understand the function of each piece.

3. Evaluation

The learning process of all students is actively conditioned by the evaluation method applied. For an active learning methodology the best evaluation method should be the continuous evaluation of the student participation in classes. Of course, it may be complemented with other traditional evaluation methods such as written or oral exams. Also, for each exercise (numerical, computer, laboratory reports, other works…) performed and presented during the course a mark should be given.

The participation in the class and the presentation of exercises are a free decision taken by students. Therefore, in those cases when students do not actively participate in the activities of the course, they must pass an exam, written or oral.

Nevertheless, whenever it is possible the final evaluation is carried out by means of an oral presentation of a work developed by a group of 2 students. The mark obtained with this work will complement the continuous evaluation taking also into account all notes obtained from voluntary individual exercises and works.

The final written exam, when it is done, has a non-traditional structure. For the course on Radioactive Contamination it is usually divided into three parts. In the first one, students should demonstrate their good knowledge of basic concepts and solve some single numerical exercises. In the second part, a practical analysis of some situation (usually an accident, real or imaginary) is proposed and the student should summarise some guidelines for a possible solution. The third part contains free questions. For instance, the student has to choose a theme and underline its main objectives with a clear justification of them. Whenever these free questions are proposed, students show an initial surprise, but usually results obtained can be considered good.

In the case of the course on Nuclear Materials and Fuel Cycle, the continuous evaluation obtained from the student participation in classes is complemented with a personal contribution to one of the themes of the course. When this activity is proposed, each student must present a short resume of the theme previously to its discussion in class.

4. Results

The number of students in the group never exceeded 30 students over the last eight years and this is an advantage to apply an active learning methodology.

Results (final marks) obtained by students in the last eight years are listed in Table 1. Marks in Spain range from 0 to 10. It is necessary a mark greater than 5 to pass the course and the students passing the course are classified into 4 groups: Approved (5-6), Notable (7-8), Excellent (9) and Honour (10) the highest mark. Presently there are legal restrictions so that only a maximum of 1-2 honours (depending on the number of registered students) per course may be given.

Table 1. Marks obtained by students when an active methodology was applied.

Year	Students	Presented	Refused	Approved	Notable	Excellent	Honour
2000/01	29	23	0	12	8	2	1
2001/02	29	28	3	7	14	3	1
2002/03	23	18	2	4	7	3	2
2003/04	15	14	0	3	6	3	2
2004/05	21	17	0	5	6	4	2
2005/06	20	19	1	3	12	1	2
2006/07	13	12	3	5	2	2	0
2007/08	8	8	0	0	5	2	1

Marks obtained by students in previous years, when master classes were given with greater groups, are listed in Table 2, where it can be seen that final marks were not so good.

Table 2. Marks obtained when master classes were given without an active methodology.

Year	Students	Presented	Refused	Approved	Notable	Excellent	Honour
1996/97	29	21	7	10	1	2	1
1997/98	73 (#)	53	6	23	18	4	2
1998/99	33	30	8	11	10	0	1
1999/2000	32	24	4	8	7	2	3

(#) There were a greater number of students because students from Chemical Engineering joined the group.

Differences observed between tables 1 and 2 can be attributed to the methodology. The main differences in favour of the active methodology are the lower number of students refused, the increase in the number of students participating in all activities, so that they are fully evaluated, and finally the increasing number of students with higher marks. Nevertheless, the main difference is the satisfaction shown by students although they have more work and the knowledge by the professor that the learning level is increased.

5. Conclusions

The active participation of students in the class permits them to improve their learning. To achieve this goal, the class should not be a master class but it is necessary to maintain a discussion with questions addressed to the comprehension of concepts as well as to fix objectives for each lesson, checking out that they have been completely achieved.

It is indispensable to obtain an adequate motivation of students. A possible strategy for this is to permit them to express their expectations in the course and to adjust the development of the classes in terms of the feedback obtained from their attitude and work.

It is necessary to provide students with documents so that they can prepare lessons before attending the class. It is useful to upload the information in a web page but the best solution is to provide them with an appropriate textbook.

All activities proposed in the class should stimulate the participation of the students. They must be not compulsory but with positive repercussion, if any, in the final mark.

The elaboration of the lesson objectives by the students themselves is an exercise very useful to enhance their learning process.

The continuous evaluation seems to be the best method when this active learning methodology is applied. On the other hand, an evaluation taking into account the understanding of basic concepts, its application to practical cases and the free exposition of the objectives of the course by the student has been shown, in general, very positive.
The marks obtained by the students as well as their satisfaction seem to confirm this point.

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EDUCATIONAL KNOWLEDGE RETENTION IN NUCLEAR RESEARCH INSTITUTES IN JAPAN, THE U. S. AND EUROPE

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ABSTRACT

Bibliometric analysis was carried out for champion data comparisons among prestigious nuclear research institutes (PNRI) existed in Japan, the U. S., France and Germany. The analysis was relied on database INIS (IAEA), ECD (DOE) and WOS (Thomson). INIS is advanced, key ex-post evaluating tool for champion data comparisons. The world champion among 11 PNRI is ORNL, confirmed by INIS, ECD and WOS. Over the 25-year time span of research paper publication, JAERI is the 3rd ranked institutes following ORNL and ANL. INIS database results revealed that CEA/Saclay is the French domestic champion regarding research paper publication. The research knowledge within the present scope is retained successfully and is available elsewhere. The retained knowledge (some over 50 years old) could and should be utilized for educational and training purposes for younger generation.

1. INTRODUCTION

Valuable and retention-worthy knowledge is born as a result of research activities in nuclear institutes. Such knowledge should be provided explicitly in the form of research papers to facilitate more usage for educational purposes and nuclear knowledge management. Using research papers provided by JAERI-Japan and 10 prestigious international nuclear research institutes (PNRI), an institutional comparison by bibliometric method was performed for this study from the view point of educational knowledge retention. This comparison is aimed at learning the volume of intellectual assets produced by each institute and also looking from the view point of knowledge management for the benefit of taxpayers in order to explain an accountability or a transparency of national institutes funded mainly by the government [1]. It is the principal author's hope that the results will be encouraging to younger generations who wish to become nuclear researchers in the near future.

2. ANALYTICAL METHOD

2.1 Prestigious institutes chosen

The following PNRIs (JAERI plus 10 other international institutes) were chosen for the present study. They are all well-renowned national institutes (laboratories) with historical nuclear research programs.

JAPAN:	Japan Atomic Energy Research Institute (JAERI)[1]
The U.S.:	Oak Ridge National Laboratory (ORNL), Sandia National Laboratory (SNL), Argonne National Laboratory (ANL), Brookhaven National Laboratory (BNL) and Idaho National Laboratory (INL)

[1] JAERI was reorganized in 2005 and renamed as the Japan Atomic Energy Agency (JAEA). The present study addresses intellectual assets created by JAERI. Hence, JAERI is used in the text.

EUROPE: Karlsruhe (FZK) and Jeulich (FZJ) in Germany. CEA/Saclay, CEA/Grenoble, and CEA/Cadarache in France

2.2 Research tools

As the principal research tool, the International Nuclear Information System (INIS), owned and operated by International Atomic Energy Agency (IAEA) was used [2]. INIS has been in existence since the year 1970 and today 118 countries and 23 international organizations co-operate for managing nuclear information resources. Research outputs from JAERI and the other international research institutes chosen for the study are provided into the system regularly.

Additionally, the U.S. Department of Energy (DOE) Office of Scientific and Technical Information (OSTI) builds the Energy Citation Database (ECD), operating since 1948 [3]. Research outputs of JAERI and other renowned international research institutes are also included in this database. The subject scope includes all energy-related topics. ECD includes international information published through the mid-1970's. Since that period, ECD is populated primarily with U.S.-published research results due to dissemination limitations placed on internationally-exchanged information. ECD in the present study was used as a reference. Further, the Web of Science (WOS) from ISI-Thomson [4] was also used as a reference because managers interviewed indicated it to be a more familiar tool to many of the major nuclear research institutes located in Europe.

2.3 Time span

From CD-ROM or the Website, INIS provides published papers with a time span of 25 years (1978-2002) and for 5-year periods, that is, present (1998-2002), past 5 (1993-1997), past 10 (1988-1992), past 15 (1983-1987) and past 20 (1978-1982). In comparison, ECD can provide submitted papers with a time span of 50 years (1953-2002), 25 years (1978-2002) and 5-year periods. WOS has a similar functionality as that of ECD.

3. RESULTS

3.1 Trials to determine the representative institutes for France

France is a very advanced country in applications for the peaceful use of nuclear energy. At the moment, a total of 58 nuclear power plants (PWR) are in operation. The share of nuclear was about 78% of the gross electricity totals. As far as the principal author's knowledge is concerned, there existed 9 CEA (Commissariat à l'Energie Atomique) research institutes covering the country. They are Fontenay-aux-Roses (since about 2000 main interest in life sciences), Saclay (main interest in physical sciences and fundamental research), DAM Ile de France (defence sector), Valduc (defence sector), Grenoble (technological research, electronics, instrumentation, etc), Cadarache and Valrho (nuclear sector), Cestra and Le Ripault (defense sector). In accordance with the purpose of this study, a domestic comparison to gain a few French representative institutes was carried out. Using the INIS database, the papers published by the prestigious French nuclear research institutes during past 25 years are studied. Results shown in **Figure 1** revealed that the papers are ranked in the following order:

Saclay > Grenoble> Cadarache > Fontenay-aux-Roses > other institutes・・・・・・・/1/

In the Saclay and Grenoble institutes alone, more than 15,000 papers were published during the 25-year period and they are still available for reference. The retained knowledge in the form of these papers will be of much benefit to many younger French and international students or researchers. For the wider bibliometric comparison used in this study, the top three institutes, CEA/Saclay, CEA/Grenoble, and CEA/Cadarache, were selected.

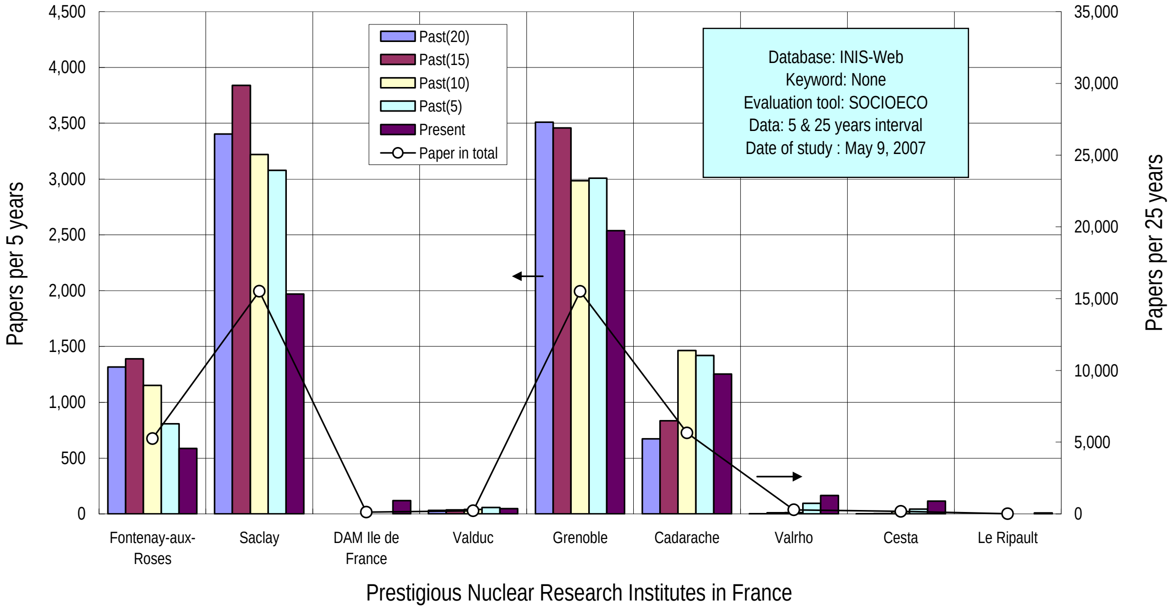

Fig. 1 All papers published at 9 French PNRIs during the period 1978-2002. Open circles show the total published papers during 25 years at each institute (scale is shown on the right-hand side) and the columns show the papers published during 5-year increments at each institute (scale is shown on the left-hand side). Database used was INIS.

3.2 Institutional comparison by INIS

The next step was to look at comparing these top French institutes to a selection of international institutes noted in section 2.1. **Figure 2** shows the total number of papers provided by JAERI and 9 other PNRIs over the 25 year period of the study (the third French institute, Cadarache, fell below the threshold used for the analysis).

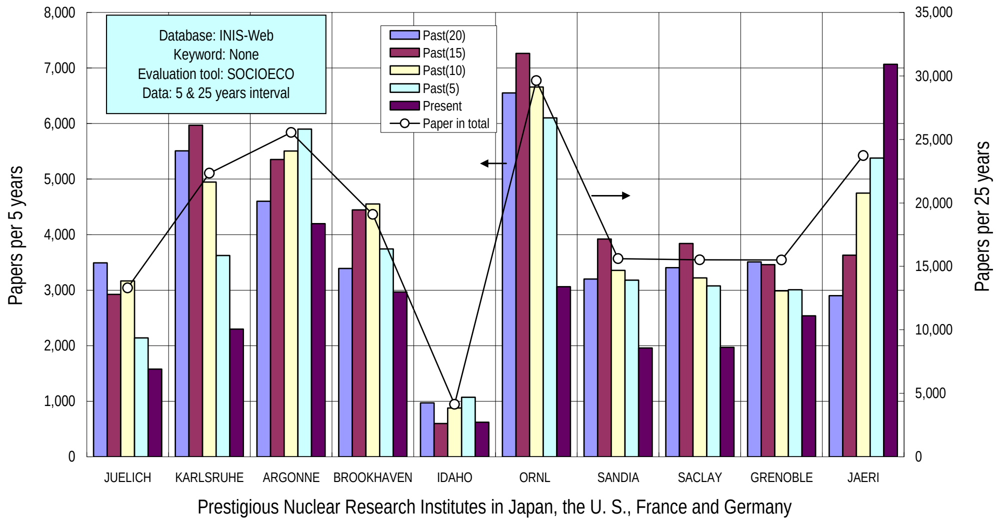

Fig. 2 All papers published in JAERI and 9 PNRIs during the period 1978-2002. Open circles show the total published papers during 25 years at each institute (scale is shown on the right-hand side) and the columns show the papers published during 5-year increments at each institute (scale is shown on the left-hand side). Database used was INIS.

After review of the data, the following conclusions can be reached:

(1) Over the 25 years of research activities, the papers are of the order

ORNL>ANL>JAERI>FZK>BNL>SNL>Saclay>Grenoble>FZJ>Idaho・・・・・・・・・/2/

JAERI is in the 3rd position, following ORNL and ANL. Through interviews with corresponding managers, it was understood that the change of nuclear policies (e.g., de-emphasis of reprocessing policies in the U. S.), the nuclear accidents (e.g., TMI (1979) and Chernobyl (1986)), and economical dynamics (e.g., the 2nd oil shock in Japan) and so on, are significant factors having much influence on research activities, including the number of research publications produced. Therefore, the capability of knowledge retention is affected by those external events.

(2) For each 5-year period of research activities, the number of papers in JAERI increased period to period. However, research papers in the other 9 PNRIs decreased from the past (20) to the present. A comparison between ORNL and JAERI at present (1998-2002) shows that ORNL is about 3,000 and JAERI is about 7,000. Just reviewing the numbers, it appears that readers would think that JAERI is alone in increasing its research activity in the world and the other 10 PNRIs are decreasing their research activities. This viewpoint is, on the surface, rather unlikely. To gain further insight as to its validity, the principal author carried out a similar bibliometric analysis using WOS.

3.3 Institutional comparison by WOS

WOS focuses mainly on the research papers submitted to journals in the field of natural sciences; WOS has the advantage of being able to show a citation index or an impact factor. Research papers presented at international conferences and published in the form of proceedings are usually omitted, however. Because WOS has a large volume of citations, though, WOS data may be a good representation of publishing patterns in advanced research fields.

A bibliometric study was done similar to that of the INIS database. Results obtained are shown in **Figure 3**. Note that in this case, the time span was extended an additional 5 years from 1978-2002 (present) to 1978-2007 (present-m) as denoted in the legend of the figure.

Conclusions reached from this analysis were interesting.

(1) It is evident that there is a significant difference between the totals for U.S. papers and those from the other international sources. It is surmised that WOS may draw its data primarily from U.S. data sources, especially for historical periods.

Among the U.S. papers, the ranking according to WOS is of the order

ORNL>ANL>BNL>SNL>Idaho ・・・・・・・・・・・・・・・・・・・・・・・・・・/3/

(2) As was clear from equation /2/, ORNL here is the champion, too. One regrets to say that Japan, France and Germany totals are negligible, based on the data available within WOS.

(3) It is worth to mention that in the 5-year data increment comparisons within WOS, all research institutes had a tendency to increase from the past (20) to date. This observation is apparently the reverse to that shown using the INIS database. The authors attribute this reversal to the likelihood that journal publishing is less dependent on the factors influencing research report and conference paper generation noted as contributing factors to the INIS database results. A shortcoming of WOS, though, is that there is insufficient bibliometric data for Japan, Germany and France (only Cadarache even appears at all). Thus at the moment, it is not realistic to carry out meaningful international comparisons using WOS, although it was valuable for U.S. sources and to verify research trends.

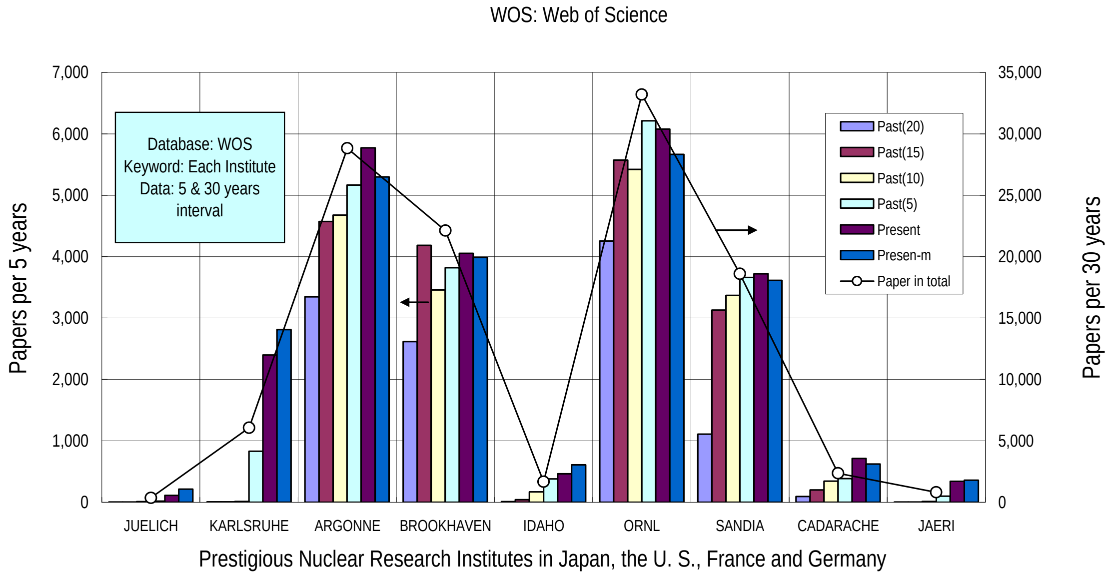

Fig. 3 All papers published in JAERI and 8 PNRIs during the period 1978-2007. Open circles show the published papers during 30 years at each institute (scale is shown on the right-hand side) and the column shows the papers published during every 5-year intervals at each institute (scale is shown on the left-hand side). Database used was WOS.

3.4 Institutional comparison by ECD

To gain a third perspective of the results available from these prestigious institutes, **Figure 4** illustrates the total number of papers using ECD as the basis.

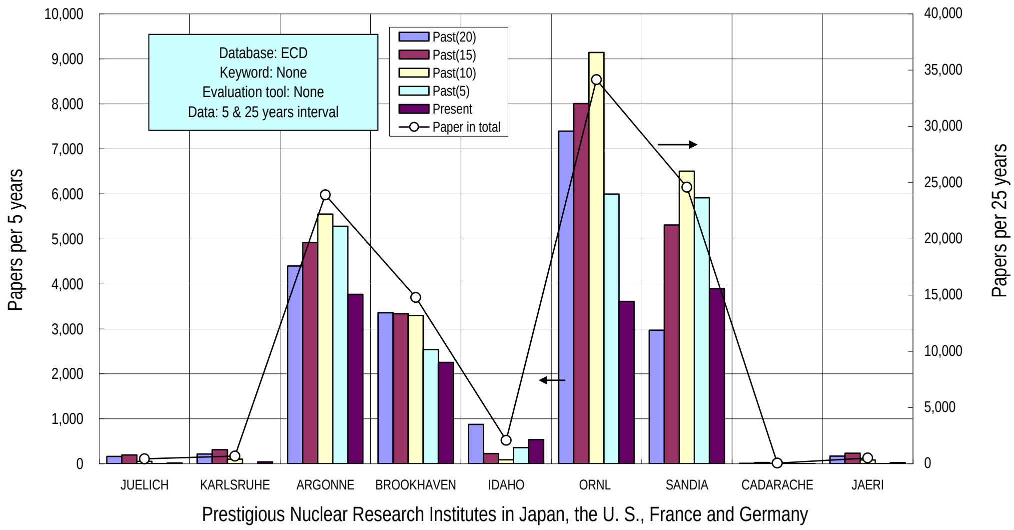

Fig. 4 All papers published in JAERI and 8 PNRIs during the period 1978-2002. Open circles show total published papers during 25 years at each institute (scale is shown on the right-hand side) and the columns show papers published during 5-year increments at each institute (scale is shown on the left-hand side). Database used was ECD.

The following observations can be made from these results.

(1) For the time span of 25 years (1978-2002), non-U.S institutes have a very poor number of papers reported (only 4 of the PNRIs selected for the study appear). This is a quite different point of view from the INIS analysis but quite similar to that of WOS. Likely, ECD and WOS are the distinguished databases targeted at reflecting U.S. research. For ECD, this has been verified to be

the situation for the period evaluated. Out of the U.S. papers evaluated in ECD, they are ranked in the order of

ORNL (34,149 papers)>SNL>ANL>BNL>Idaho ・・・・・・・・・・・・・・・・・・・・/4/

ORNL is here the champion, too. One regrets to say that JAERI is in the 7th position, almost negligible. However, this appears due to the strong U.S.-focus of the database, not necessarily reflective of JAERI's research efforts.

(2) For the time span of 50 years (1953-2002), the total number of papers are of the order of

ORNL (55,857 papers) >ANL (37,129 papers) >
SNL (24,628 papers) >BNL(24,289 papers)>Idaho (2,398 papers)・・・・・・・・・・・・/5/

It should be noted that SNL may have additional papers that have a different subject scope, while SNL and Idaho did not publish papers before 1979 and 1975, respectively as the named institute.

(3) For the 5-year increments of research activities, papers vary from one to another time span. Around the past (10) timeframe (1988-1992), a significant reduction of papers occurred at most U.S. institutes. Possible factors contributing to this reduction learned during interviews could be changes to the nuclear mission by the U.S. government, reduction of human resources to create and process papers, and reduced reporting requirement policies being put into place.

3.5 Comparison of databases for Japan, the U.S. and European sites

The results from the three databases used in the present study were compared with each other, using ORNL, FZK, Cadarache and JAERI as representative international institutes for each figure. **Figures 5** through **8** illustrate these comparisons.

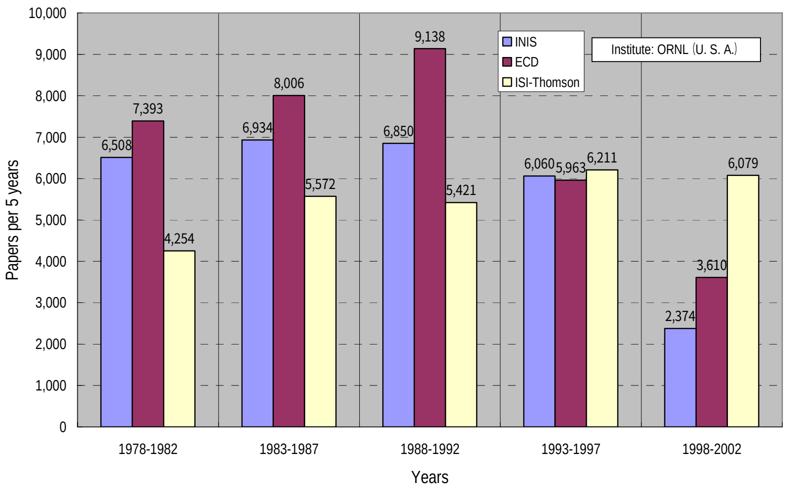

Fig. 5 Research papers registered in INIS, WOS and ECD as a function of 5-year time spans at the PNRI ORNL, U.S.

Trends from **Fig. 5** (ORNL) show that research papers registered by INIS gradually decrease from the past to the present. Those registered by ECD also show a decrease after the 1988-1992 timeframe, while those registered by WOS increased overall. With respect to ORNL, INIS, ECD and WOS worked well, as all databases show good coverage.

Trends from **Fig. 6** (FZK) show that research papers registered by INIS gradually decrease from the past to the present, but those registered by ECD have considerably less magnitude although also show a decrease. For those registered in WOS, there is an increase. This appears to imply that WOS is likely the preferred source to use to find papers from FZK, especially at the present stage.

Trends from **Fig. 7** (Cadarache) show that research papers registered by INIS as well as by WOS are gradually increasing from the past to the present, while those registered by ECD are much less and negligible. This appears to imply that both INIS and WOS are preferred sources when trying to find papers from Cadarache, France.

Trends from **Fig. 8** (JAERI) show that the number of research papers registered by INIS is significantly large in magnitude, while those registered by WOS and ECD are much less so and negligible. This implies that the INIS database is the predominant source for research in Japan.

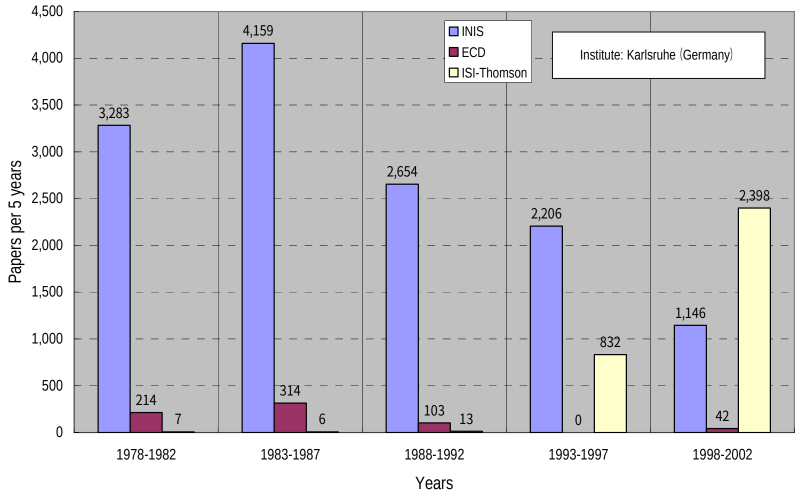

Fig. 6 Research papers registered in INIS, WOS and ECD as a function of 5-year time span at the PNRI FZK (Karlsruhe), Germany.

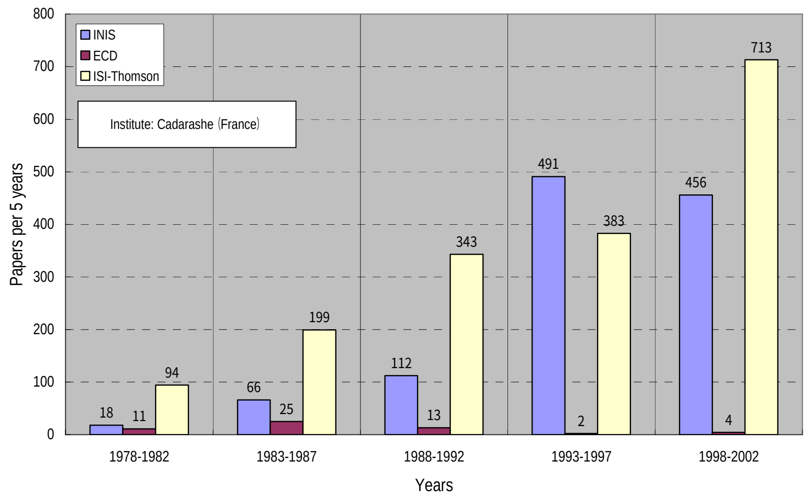

Fig. 7 Research papers registered in INIS, WOS and ECD as a function of 5-year time span at the PNRI Cadarache, France.

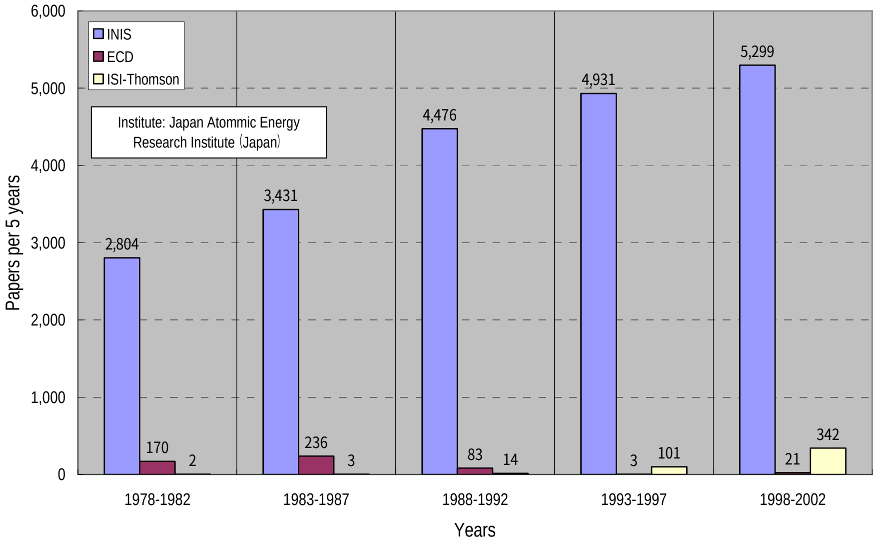

Fig. 8 Research papers registered in INIS, WOS and ECD as a function of 5-year time span at the PNRI JAERI, Japan.

4. CONCLUSIONS

(1) The present bibliometric study shows that research knowledge from JAERI and 10 PNRIs is retained successfully and is available in the INIS database, as well as the more U.S.-focused WOS and ECD systems. The retained knowledge (some over 50 years old) could and should be utilized for educational and training purposes.

(2) Well-retained and indexed knowledge can provide a sound basis for institutional comparison which is valid from the viewpoint of nuclear knowledge management. Within the present study's scope and period evaluated, the world champion among JAERI and the 10 other institutes is ORNL. This is supported by the volume of papers included in INIS, WOS and ECD, although international information in the latter two is limited.

(3) INIS is an advanced, key tool for performing international comparisons among PNRIs. Over the 25-year time span of research paper publication, JAERI is the 3rd ranked institute following ORNL and ANL.

(4) INIS database results revealed that Saclay is the French domestic champion regarding research paper publication.

(5) Different characteristics exhibited by individual databases can sometimes generate conflicting bibliometric results. This was true among INIS, WOS and ECD when looking at trends between 5-year periods. It implies that results from analytical tools used in bibliometric studies should be viewed with careful consideration to learn of any influencing factors.

(6) Based on interviews, use of WOS has tended to grow for U.S. and Europeans, while use of INIS has predominance in Japan, and ECD in the U.S. However, users looking for research results from JAERI and other non-U.S. institutes would be better served using INIS. ECD and WOS are both valuable for U.S. research results, with the latter system potentially growing in international content.

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