IAEA-TECDOC-1399

The nuclear power industry's ageing workforce: Transfer of knowledge to the next generation

IAEA

International Atomic Energy Agency

June 2004

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The originating Section of this publication in the IAEA was:

Nuclear Power Engineering Section
International Atomic Energy Agency
Wagramer Strasse 5
P.O. Box 100
A-1400 Vienna, Austria

THE NUCLEAR POWER INDUSTRY'S AGEING WORKFORCE:
TRANSFER OF KNOWLEDGE TO THE NEXT GENERATION
IAEA, VIENNA, 2004
IAEA-TECDOC-1399
ISBN 92–0–107704–1
ISSN 1011–4289

Printed by the IAEA in Austria
June 2004

FOREWORD

This report is intended primarily for senior and middle level managers in nuclear power plant operating organizations. It is intended to provide them practical information they can use to improve the transfer of knowledge from the current generation of NPP operating organization personnel to the next generation in an effective manner. The information provided in this report is based upon the experience of Member State operating organizations as well as other related industries.

In September 2000, the IAEA held a technical meeting on the topic of an ageing workforce and declining educational infrastructures. The proceedings of this meeting were distributed on CD-ROM as Working Material. Several recent IAEA meetings including a senior level meeting held in June 2002 in Vienna and a technical session of the IAEA General Conference in September 2002 addressed methods of knowledge transfer. This is the first IAEA report published on this specific topic.

In 2000, the IAEA Technical Working Group on the Training and Qualification of NPP Personnel (TWG-T&Q) suggested that the IAEA should develop a publication on the definition of core competencies to be maintained by an NPP operating organization. The TWG-T&Q suggested that this TECDOC should provide additional detail beyond that specified in the recently revised Safety Guide NS-G-2.8, Recruitment, Qualification and Training of Personnel for Nuclear Power Plants. This task was included in the approved programme for 2002–2003. In March 2001, IAEA-TECDOC-1204, A Systematic Approach to Human Performance Improvement: Training Solutions was published. This TECDOC provides a comprehensive list of core competencies. These competencies provide the additional detail beyond that specified in Safety Guide NS-G-2.8 that the TWG-T&Q had suggested. The aspect of core competencies that is not addressed in IAEA-TECDOC-1204 is how to effectively transfer these competencies to the generation that replaces the workforce that gained its competency through the commissioning and initial operation of the plant. Methods for such knowledge/competencies transfer are provided in this report.

This report was produced through distribution of a survey to NPP operating organizations in Member States and through a series of meetings, where meeting participants shared information regarding effective practices in their organizations with respect to transferring knowledge to the next generation of NPP operating organization personnel.

The IAEA staff member responsible for this publication was T. Mazour of the Division of Nuclear Power.

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1. INTRODUCTION

1.1. BACKGROUND

In many Member States, demographic and economic factors pose potentially difficult challenges to the continued safe and reliable operation and maintenance of nuclear power plants (NPPs). Many of the personnel currently operating and maintaining NPPs in Member States are reaching retirement eligibility. In most cases, these are the people who were responsible for the commissioning and initial operation of the plant, through which they learned a great deal about the plant design and operating characteristics. The younger age cohorts of many Member States are neither as large nor as interested in working in NPPs as were their predecessors. And, the economic conditions in a number of Member States have resulted in workforce reductions in the nuclear industry and disruptions of traditional new worker hiring patterns. That, in turn, has negatively impacted the interest of potential new employees and the availability of relevant institution-based educational programs. In a related phenomenon, many NPP operating organizations have merged or, re-organized. In still other Member States, plants are relatively new, and additional plants are being constructed; these organizations have younger workforces, and generally less difficulty in recruiting personnel.

The safe, reliable, and cost-effective operation of NPPs requires that personnel possess and maintain the requisite knowledge, skills, and attitudes to do their jobs properly. Such knowledge includes not only the technical competencies required by the nature of the technology and particular engineering designs, but also the “softer” competencies associated with effective management, communication and teamwork. Traditional worker training programs have addressed ***explicit knowledge*** that is contained in written documents, policies, and procedures. However, ***tacit knowledge*** that is held in a person’s mind has not typically been either captured or transferred in any formal manner. Rather, new workers have acquired such knowledge over time (if at all) through their working with those who already possess it. As those workers who are in possession of **this *tacit knowledge*** leave the workplace for retirement, the effective capture and transfer of that information becomes even more critical. Although this need has always existed as individuals transferred to other jobs or left the organization, there have usually been others in the organization who also had the tacit knowledge to provide continuity of operation. It is the increased rate of knowledgeable worker departures, along with the decreasing numbers of qualified replacements that has made this a more significant problem. The long term operation of NPPs requires that this entire body of ***explicit*** and ***tacit*** knowledge be transferred to new personnel as they enter the workforce. Accordingly, new and different techniques may be required to ensure timely and effective knowledge retention and transfer.

1.2. OBJECTIVES

The objectives of this report are to:

(1) Make middle and senior level NPP operating organization managers more aware of the most significant issues in the industry regarding an ageing workforce and transfer of knowledge to the next generation.

(2) Assist in the industry’s response to these issues through the identification of practices that NPP operating organizations have found effective in attracting appropriate people to the nuclear industry and in transferring knowledge to the next generation of nuclear industry personnel.

1.3. SCOPE AND DEVELOPMENT OF THIS REPORT

The issues found to be most prevalent and important to NPP operating organizations in Member States regarding transfer of knowledge to the next generation of NPP personnel are identified in this report. This report also identifies effective practices to address such issues. These are practices that have been used successfully by NPP operating organizations. These effective practices do not include theoretical considerations or justification. There are ample textbooks and other materials addressing such theories, some of which are identified in the bibliography.

This report provides information on experiences in Member States regarding retention and transfer of knowledge needed to design, build, operate, and maintain NPPs in the context of the ageing nuclear workforce. The information to be provided on the transfer of knowledge includes lessons being learned in NPP operating organizations and selected examples of management strategies and initiatives that may protect NPPs against significant loss of both explicit and tacit knowledge. Accordingly, the information provided in this document can provide NPP operating organization managers and specialists a more informed and, therefore, more effective ability to address challenges associated with the ageing, retention, and retirement of the current workforce and the education, recruitment, and NNP training of an adequate number of replacements.

This report is primarily directed to NPP operating organization middle and senior level managers. However, the report is also expected to be of value to managers and technical specialists of other nuclear facility organizations, regulatory bodies, training and educational organizations, industry technical support organizations, as well as government decision makers

A survey on this topic was distributed to NPP operating organizations in Member States to collect information regarding both the magnitude of the problems in this area and also the methods being used to transfer tacit and explicit knowledge to the next generation of NPP personnel. The results of this survey provide the basis for much of the information provided in this report regarding practices in Member States.

Section 2 provides information on workforce status and trends in the nuclear power industry, while Section 3 provides brief descriptions of effective practices that have been developed to deal with the ageing nuclear industry workforce and transfer of knowledge to the next generation.. The practices are described further in the annexes. These practices are based upon real examples that have been successfully applied in NPP operating organizations, or other related industries. Details have been intentionally omitted in order to focus attention on the essentials, and also in recognition that detailed implementation of such practices needs to consider the culture of the organization as well as national and regional characteristics.

1.4. HOW TO USE THIS REPORT

Managers should assess the situation in their organization with regard to the issues presented. If sufficient concerns are raised regarding a particular issue, a review of the effective practices identified in the report might suggest ways to deal with the issue.

2. WORKFORCE STATUS AND TRENDS IN THE NUCLEAR POWER INDUSTRY

2.1 SUMMARY OF THE CURRENT SITUATION

In many Member States, working in the nuclear power industry has less prestige today than it did in the past, particularly as compared to the time when many NPPs were first commissioned, in the 1970's. There are also greater uncertainties about the long term future of nuclear power today than in earlier times. In some Member States, measures have been taken to terminate operations prior to the scheduled end of plant life, or agreements have been made to phase out nuclear power. Privatization and more open energy markets have created greater financial uncertainty. Downsizing and right sizing efforts in NPP operating organizations can result in the departure, almost simultaneously, of much of the organizational knowledge. Collectively, these factors mean that, in many Member States, it is more difficult today to attract people into the nuclear power industry. Additionally, the growth in information technology opportunities for young professionals has resulted in fewer students pursuing traditional engineering degrees, not just in nuclear engineering. In still other Member States, significant numbers of experienced personnel have emigrated to other countries due to better opportunities. It is also important to recognize that the situation described above does not apply in all Member States. In some, particularly those with continuing construction and commissioning of new plants, there are few concerns or issues with respect to an ageing workforce and transfer of knowledge.

Recent positive trends in the nuclear power industry include continuing new construction in Asia, a return to new construction in Europe, new plants being seriously discussed in North America, plant life extensions being implemented for many existing plants, improved operational and safety performance of plants overall, and innovative designs being developed through the Gen IV initiative. The success of all of these efforts depends upon having sufficient well qualified personnel for their implementation.

2.2. NUCLEAR INDUSTRY TRENDS

The IAEA's PRIS data indicates that of the 437 NPP units in operation in 2003, over 80% (355) have been in operation for 15 years or more. If one considers that most of the initial professional and technical staff for an NPP are hired approximately 5 years in advance of the commercial operation date, then for this group of plants, the personnel who grew up with the plant have a *minimum* of 20 years experience, which suggests that the youngest of this group is in their mid-40's, and most are older. One common characteristic of NPP personnel in IAEA Member States has been workforce stability; most people came to the organization shortly after completion of their formal education and internships, and stay until they retire. This combined with a general trend toward smaller plant staffs, particularly over the past decade, means that for most NPP operating organizations that have not built new plants within the past 15 years, there has been a very small influx of new personnel. That is until recently, when current staff began to retire in significant numbers.

For those NPPs that began operation in 1960s and 1970's, the first wave of retirements has already occurred. Therefore, these plants already have experience in dealing with ageing workforce issues and transfer of knowledge that can be valuable for organizations that have not yet reached this point in large numbers. In Section 3, information from the experience of such plants is provided.

Recently, restructuring and downsizing have been a reality for NPP operating organizations in a number of Member States. Downsizing has, in some cases, aggravated ageing workforce issues through compressing the time period over which the transition occurs and, if not well thought out, can provide insufficient lead time to plan a well organized transition of know how (and know why) to replacement personnel. Early decommissioning of NPPs creates special needs.

2.3. TRENDS IN EDUCATION

In a number of Member States, due to uncertainties and fewer career opportunities, interest in nuclear industry courses of study has continued to decrease. This decrease has happened in many cases in all engineering areas, not just nuclear engineering. In some MS with economies in transition, the overall quality of education has decreased, and education budgets are very limited. In these situations, nuclear training centers need more effort to prepare specialists to be able to fulfill all needs of NPPs.

In 2000, OECD/NEA published a report entitled, *Nuclear Education and Training; Cause for Concern?.* This *report* was based largely on the results of a questionnaire distributed to OECD/NEA member countries. This report indicated that:

"In most countries there are now fewer comprehensive, high-quality nuclear technology programmes at universities than before. The ability of universities to attract top-quality students to those programmes, meet future staffing requirements of the nuclear industry, and conduct leading-edge research in nuclear topics is becoming seriously compromised. A number of concerns exist:

- The decreasing number and the dilution of nuclear programmes.
- The decreasing number of students taking nuclear subjects.
- The lack of young faculty members to replace ageing and retiring faculty members.
- Ageing research facilities which are being closed and not replaced.
- The significant fraction of nuclear graduates not entering the nuclear industry."

In 2002, OECD/NEA launched a follow-up study to assess the evolution since the previous study. The preliminary results from this soon to be released study show that a large number of actions have been initiated and positive development has been reported in several countries. However, the situation in many countries demands further actions. International level collaboration may offer a complementary route to improve the amount and the quality of nuclear education.

Since 2000 there have been other national studies completed which provide specifics for particular situations. For example, a survey completed in late 2001 for the Nuclear Energy Institute (NEI) indicated that the U.S. nuclear industry, as a whole, will need to attract roughly 90,000 new employees over the next 10 years in order to sustain the current level of industry activities. Of this 90,000, the nuclear power plant component is expected to be 26,000. For the most part, the supply of prospective degreed and non-degreed graduates is expected to meet the industry's needs, but there are some exceptions and challenges. Similarly, a 2002 Nuclear and Radiological Skills Study conducted in the UK indicated that "conservative estimates suggest that the sector will require around 50,000 recruits over the next 15 years [in the UK], excluding potential demand from new build, equivalent to just under 60% of the current skilled population, and this demand must be satisfied from the wider engineering and physical science sector at a time when the 'disconnect' between the strengthening demand for graduates (particularly in highly numerate subjects) on the one hand, and the declining numbers of mathematics, engineering and physical science graduates on the other, is starting to result in skills shortages."

A number of international efforts have been initiated to address the need for greater numbers of well qualified and educated nuclear industry recruits. The most recent of these is the World Nuclear University (WNU) [http://www.world-nuclear-university.org]. The World Nuclear Association (WNA) launched it in September 2003. The WNU founding supporters are the IAEA, NEA/OECD, WANO and WNA, and membership includes 26 organizations worldwide. The mission of the World Nuclear University is to strengthen the international community of people and institutions so as to guide and further develop:

- The safe and increasing use of nuclear power as the one proven technology able to produce clean energy on a large global scale.

- The many valuable applications of nuclear science and technology that contribute to sustainable agriculture, medicine, nutrition, industrial development, management of fresh water resources and environmental protection.

Through a worldwide network that coordinates, supports and draws on the strengths of established institutions of nuclear learning, the WNU will promote academic rigor and high professional ethics in all phases of nuclear activity, from fuel and isotope supply to decommissioning and waste management.

Other recent international initiatives regarding nuclear education and training include the European Union's European Nuclear Engineering Network (ENEN) and it successor the Nuclear European Platform for Training and University Education (NEPTUNO) (these initiatives are for both current EU Members and those countries planning to soon join the EU [www3.sckcen.be/enen]), and the Asian Nuclear Safety Network. Additional information regarding these initiatives is provided in Section 3.3.

2.4. TRENDS IN INFORMATION TECHNOLOGY SUPPORT FOR KNOWLEDGE MANAGEMENT

Most MS NPP operating organizations use information technology (IT) to improve their systems for designing, developing and implementing training programmes and other human resource management functions. Some organizations have implemented or are now implementing integrated human resource management systems for all activities concerning planning, employment, organizing, assessment, training, development, payment, protection of health, and use of human resources in the organization. Use of IT tools for knowledge management (KM) are not yet common in most Member State NPP operating organizations. E-learning is used by some but not most operating organizations, and generally in limited ways (e.g. general employee refresher training). Some operating organizations have integrated computerized operation management systems, including work planning and control, and document management functions. The outputs from these systems are readily available to all plant personnel through intranets.

Some operating organizations are looking into concept mapping technology developed at the University of Western Florida by the Institute for Human and Machine Cognition (These include the Diablo Canyon NPP, and TVA in the USA, and Eletronuclear in Brazil)

3. STRATEGIES FOR MANAGING AN AGEING WORKFORCE

3.1. DEFINING THE NATURE AND MAGNITUDE OF THE AGEING WORKFORCE CONCERN

In recognition of the magnitude of the concern regarding an ageing workforce and transfer of knowledge, many NPP operating organizations have become more formal and quantitative in identifying the retirement plans of their employees, as well as in determining whether there factors exist that may cause employees to leave the organization prior to their retirement Among the tools being used for this purpose in the industry are:

- Staffing plans/work force plans.
- Succession plans.

Staffing plans/work force plans provide a standardized and consistent methodology for overall human resources planning driven by strategic and business goals. These plans identify planned retirements and vacant positions as well as the required staffing levels needed to support business strategies. They include attrition data, development plans, succession plans and current work force requirements. They are long term plans typically looking forward 5 or more years. Many NPP operating organizations are now planning expected retirements 10 years or more in advance and making sure that the successors are recruited early enough to allow an overlapping of employment sufficient to transfer needed knowledge.

The following provides an example of the results from such a staffing/work force plan from the Gösgen NPP in Switzerland, which went into commercial operation in 1979. The age distribution of the personnel shows a broad distribution with roughly two main groups. There is one group with ages between 45 and 65 that consists mostly of people from the commissioning generation. And there is a second group with ages mainly between 29 and 43 who represents the age cohort who have already replaced part of the commissioning generation. An essential part of this replacement planning is a period of overlapping of the employment time of the present holders of a function and their successors. As shown below, the planned overlapping time ranges between 1 and 8 years depending on the function.

Shift Safety Advisors	8 years
Shift Supervisors	6 years
Reactor Operators	5 years
Plant Operators	2 years
Heads of Department	3 years
Heads of Workshop	3 years
Craftsmen	1 year

The board of directors annually approves the staffing levels needed to implement this overlapping for the next five-year period. Key positions in the NPP are regularly identified, proxies are defined, and successors are prepared for their assignments. As shown below, there is a significant overall staffing increase associated with these overlapping times.

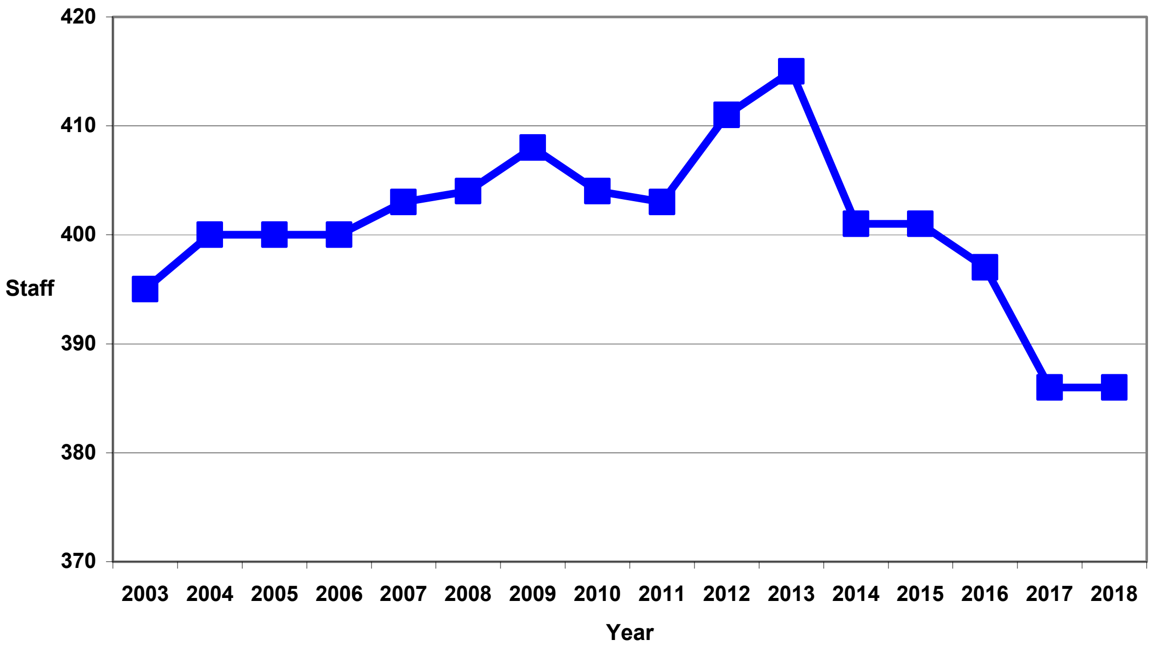


FIG. 1. Gösgen NPP: Planned temporary increase in the number of staff for transferring knowledge to the next generation.

Through using a combination of an SAT-based training and information technology, it may be possible for NPP operating organizations to use the overlap times more efficiently and effectively, and thus reduce the total time. Even a modest improvement of 20-30% would have considerable financial benefit. Also, young professionals have grown up using computers, cable/satellite television, the internet, and video games. They have different learning styles and methods than the previous generation, which may result in faster transfer of knowledge during overlap periods.

Annex A describes quite a different situation regarding NPP staffing than is provided above. It is a summary of NPP staffing for USA NPPs for the past five years, and a forecast of staffing and attrition for the coming five years. It shows that average staffing levels at USA NPPs have decreased by almost 15 percent during the past five years, that the average attrition expected for 2-unit sites during the coming five years is 166 people, and that NPP operating organizations expect to replace less than 60 percent of this attrition through hiring new employees or contractors. Technology improvements, improved processes and reduction of work scopes are expected to compensate for more than 40 percent of these losses. In the USA, the Nuclear Human Resource Group (NHRG), a community of practice under the Nuclear Energy Institute (NEI), has initiated a team to evaluate best practices in the area of knowledge management. This community of practice may provide some best practices to assist NPP operating organizations in process and work scope improvements to fill this attrition gap. A draft report is expected in 2004.

Succession plans provide a methodology for identifying and developing employees to ensure that key positions can be filled with qualified internal candidates (or when necessary, that candidates can be recruited externally) in advance of actual needs. Often succession plans include individual development plans for the candidates as well as identification of mentors who provide coaching, feedback and input to the development plans. Annexes B and C provide a description of the succession planning process used by the TVA Nuclear operating organization in the USA, and British Energy, respectively, for key leadership positions in their organizations.

Another example of work force planning and succession planning comes from the Tricastin NPP, one of the oldest of the EDF NPPs in France. In 2000, the Tricastin NPP initiated a project on anticipated management of job positions and skills. This project provided a precise picture of the nature and magnitude of the ageing workforce concern for this plant; 55% of current employees will leave the NPP between 2003 and 2015 (30 to 70 per year). Based on this information a strategy has been developed that includes a mix of complementary actions:

- recruitment of 150 new employees, the majority of whom are technicians/engineers;
- systematic annual performance review for each employee with a specific part on career development;
- succession planning for field workers and technicians followed by department manager;
- three year succession planning for managers, project managers and engineers (followed by plant manager) with identification of potential candidates for each job position;
- identification of employees with the potential to progress;
- creation of specific “career committee” with department managers for discussion on NPP succession planning.

For new plants, the most effective approach for planning of replacement personnel would be to consider this issue beginning with the commissioning phase. The design and commissioning phases are also the best times to make a strategic decision as to what information is to be included in the plant documentation system (explicit knowledge) and what knowledge is to be retained in the minds of plant workers (tacit knowledge).

3.2. DEVELOPING PROGRAMS TO RETAIN CURRENT WORKERS

In the past, one of the important positive characteristics of working in nuclear operating organizations had been stability of employment. Most employees came to the plant shortly after completing their education and stayed with the company until they reached retirement age. While for many operating organizations this continues to be the case, for others, a new, less stable employment situation has developed. Some of these changes have been the result of economic forces; e.g. more competitive energy markets causing reductions in the workforce, or economic transitions where in the past almost all social services were provided by the operating organization, and now such services are being separated from the operating organization. Other changes have resulted from termination of operations of some NPP units prior to the planned end of life, resulting in a loss of jobs, or reassignment of personnel to different types of jobs. Another important characteristic of the nuclear workforce is the long lead time (and large investment) required for replacement personnel. This is particularly the case in operations, maintenance and engineering positions. Less stable employment situations lead to employees being more likely to consider alternative employment or career paths. If key, experienced personnel leave the organization unexpectedly, the effectiveness, efficiency and safety of plant operations can be jeopardized. These factors combine to make retention of nuclear operating organization personnel even more important than in most other industries/organizations.

Some NPP operating organizations have learned these lessons painfully. For example, aggressive efforts to quickly reduce the numbers of personnel have sometimes resulted in situations where operational and safety performance has suffered (e.g. Ontario Hydro/Ontario Power Generation in Canada). Similarly, following decisions for early termination of NPP operations, personnel reductions resulted in loss of key knowledge needed to facilitate decommissioning, resulting in costly errors (e.g. Connecticut Yankee/Haddam Neck NPP in the USA) It is not intended here to suggest that such changes should not happen, but rather that they should be implemented in a way that ensures the continued safe and effective conduct of plant activities.

Based upon responses received to an IAEA survey on this topic, and information provided by participants in Agency meetings on this topic, the following are examples of methods being used by NPP operating organizations to retain current staff or reduce the impact of staff departures:

- Promote long term perspectives.
- Solicit inputs from employees regarding their job satisfaction and motivation.
- Monitor external markets to ensure that employee benefits and compensation are competitive.
- Provide opportunities for career/professional development.
- Use knowledge management (KM) tools before outsourcing/downsizing to ensure critical skills are not lost.

Many NPP operating organizations have found considerable advantages in giving employees, managers included, **a long term perspective** as to their contributions within the organization. These organizations attach great importance to a good working atmosphere, interesting jobs and job security. As a consequence of this situation, the knowledge of the staff remains within the organization for a very long time and there is enough time to continuously transfer this knowledge to new employees. There are also financial incentives like loyalty bonuses or attractive mortgages. Collectively, the objective of these programs is to ensure that people have a long term perspective within the organization.

At the Leibstadt NPP in Switzerland, an overall goal of manpower policy is that the employees shall feel comfortable. In order to achieve this, a broad variety of measures are taken. Very important for a large proportion of management decisions is that those concerned are asked about their opinion, in general personally in an informal manner. In addition, regular employee surveys are performed in order to identify de-motivating factors within the organization.

One of the potential difficulties with a stable workforce is that some people, particularly those with the most enthusiasm and capability, may become less motivated. Some operating organizations have dealt with this situation through encouraging **personnel development**. In Bulgaria at the Kozloduy NPP, the internal selection procedure for vacant positions in the company provides opportunities for personnel progress, searching, finding and performance of jobs that satisfies the inner needs of the person and is in accordance with his/her education and qualifications. It provides possibilities to develop the knowledge and skills for improved performance of the current job, as well as for professional and career development.

Monitoring the external job market to ensure retention strategies are competitive was found to be important by a number of NPP operating organizations. In Romania, for example, there are two trends which affect the Cernavoda NPP workforce. One related to young and qualified personnel leaving for better paid jobs (usually abroad) and second of less qualified personnel from the Romanian workforce market, attracted by the NPP jobs. To prevent the migration of personnel the Cernavoda NPP management tried to stabilize and increase the salaries and to provide social benefits (e.g. houses, transportation).

Situations involving the **early termination of operations** of NPPs and subsequent decommissioning have special challenges regarding retaining needed personnel and maintaining staff motivation. Most NPP operating organizations in these circumstances have found it important to provide social protection for personnel that are subject to dismissal due to the decommissioning to include compensation as well as employment counseling along with incentives for retaining personnel needed for the transition from operations to decommissioning.

NPP operating organizations have sometimes found it necessary to develop new **employment arrangements and contracts** in order to retain key personnel. In some organizations, key employees are offered annually renewed multi-year contracts in order to improve the stability of the work force. In order to make these contracts attractive, bonus-payments are provided. At the Philipsburg NPP in Germany, the company offers the possibility of part-time employment; for the period just before retirement there is a period of 5 years at the most, during half of which people work 100% and the second half of which they work 0%. In some cases applicants are asked to give up their retirement applications and stay longer in order to keep the knowledge in the company.

In a number of Member States, **outsourcing** of "non-essential" services has been implemented extensively. There has been a broad range of services outsourced including: maintenance, cleaning and janitorial, plant security, information technology, secretarial and administrative, and financial. Clearly, such outsourcing has the potential for reducing the retention and transfer of mission critical knowledge in the operating organization. The planning for such outsourcing should include identification and implementation of methods to maintain mission critical knowledge for the life of the plant.

In some Member States, such as the USA, many younger workers do not expect long term employment with one company for their careers. This is a general situation, not unique to the nuclear industry. For such workers, job security, which has been an important positive characteristic of work in NPP operating organizations is not so important. Different incentive and motivation systems are needed for them, including more focus on current salary than job security or pension plans, and the opportunity for rotational assignments to develop a broad range of job skills.

3.3. ENHANCING EDUCATIONAL PROGRAMS TO PREPARE STUDENTS FOR NUCLEAR POWER PLANT CAREERS

In 2002, a UK Nuclear and Radiological Skills Study was completed. Annex D is the executive summary from this study, which identified the following key issues:

Engineering and physical sciences are unpopular fields of study and unpopular career choices for young people; and nuclear and radiological technologies are unpopular choices in this unpopular field. Action to encourage more young people into these sectors is urgently needed.

The learning pathways required to develop the skills needed by the sector must be defined and a means devised of underpinning those pathways.

- The education and training institutions, colleges and establishments needed to service the above learning pathways must be identified and a means of ensuring their viability established, otherwise the infrastructure to deliver essential training will be lost.

The above issues are not limited to the UK, but rather exist, to a greater or lesser extent, in most Member States where nuclear power programmes have not added any new units in the past decade or two. Educational institutions are generally driven by the interests and focus of their students and by the sources of funding for their programmes. In many Member States, the nuclear industry hasn't been an interesting and growing area for young people for some time. Also, often the nuclear industry hasn't provided much funding or other support for educational institutions, as they weren't often in the market for new staff. As a result, now when there is an emerging need for large numbers of new, well qualified staff, it will take some considerable efforts and funding to respond to these needs.

This Section provides information regarding the current status and various initiatives being taken in some Members States to attract and prepare potential candidates for careers in the nuclear industry. Examples of such initiatives are provided, organized functionally:

Short term work opportunities for students. In a number of cases these short term assignments are an integrated part of the university curriculum, where students complete practical assignments at an NPP that complement or reinforce their theoretical training. In others internships are provided during summer holiday periods or following completion of university studies. In many Member States there has been a downward trend in the number of students interested in these opportunities.

Scholarships and funding. In a number of Member States there have been recent efforts to implement new, industry wide scholarships and other funding for students interested in the nuclear industry. In some cases these scholarships are provided through government funding and in others through industry or a combination of industry and government sources. Other funds have been made available to encourage students to participate in industry meetings and conferences. The Swiss Association for Electrical Power Generation sponsors a chair for nuclear technology at the Swiss Federal Institute of Technology in order to enable the building up of a new course of studies of nuclear technology. The Swiss Nuclear Society provides grants for practical training in the nuclear industry abroad. In addition, some NPPs offers apprenticeships for mechanical, electrical, electronic and chemical technicians

Industry feedback to university/vocational programmes. This feedback has included recommendations on curriculum content based upon industry needs. Recently this feedback has been complemented by additional scholarships and funding to provide needed university and vocational programme resources.

Training provided by local universities/vocational schools for the nuclear industry. Examples of such training include summer, compressed courses (e.g. continuing education/professional development), workshops, and distance learning. Additionally, there are a number of university and vocational school programmes in Member States that have been specifically tailored to NPP operating organization needs. Annex E provides information concerning some of these tailored programmes in North America, as well as some thoughts on how partnerships between NPP operating organizations and universities/vocational schools might evolve.

Maintain visibility on university campuses. This includes participation in career fairs, and information sessions, as well as selected technical specialists providing lectures for courses.

Several NPP operating organizations indicated that they participate each year in educational trade job fairs and encourage young people into programs that will prepare them to join their workforce.

Mentor students. This includes establishing mentor relationships between NPP employees and students, as well as providing opportunities for employees to interact with student more informally. Some NPPs offer supervision of diploma theses of vocational school students, as well as supervision of practical training of vocational and technical school students.

Promote cooperative work between industry and universities/vocational schools. Examples of such cooperation include student projects proposed/supported by operating organizations. The Kozloduy NPP in Bulgaria has well-established relationships with educational institutions of all levels – technical school, college, and university. The inter relations are regulated by long term bilateral contracts and are realized in many areas; preparation of syllabuses and materials, participation of NPP experts as lecturers or in the research teams and respective participation of tutors and students in projects of the NPP, ensuring preferential conditions for the pupils and students for using NPP facilities, and material and financial support of the educational institutions. The Pt. Lepreau NPP in Canada works closely with community colleges & local universities (including providing funding) to address the needs of its technical work force. It offers summer employment programs and participates in active student programs (such as the co-op student program).). CEZ of the Czech Republic has long-time cooperation with Czech universities which provides interconnection of theoretical and practical education for students through field-trips or short term attachments of students to its NPPs. Cernavoda NPP provides to the Univeristy of Bucharst training documents, technical support, training programs, summer projects support for the students and also sponsors student internships. TVA has partnered with four-year universities within the TVA region to provide assistance to the universities in obtaining speakers, tours and other support. For example, TVA has established relationships with the University of Tennessee, Nuclear Engineering Department, to provide opportunities for faculty and students and to assist TVA. TVA recruits regionally from these local universities. This approach has resulted in low turnover of new engineers. In addition, TVA has partnered with several local technical colleges (two year) to identify potential students for maintenance and operational training programmes. TVA provides scholarships for qualified students.

Industry training and education initiatives beyond those provided by universities/vocational schools. Modifications of the Swiss education system, mainly the introduction of the Professional Certificate and Higher Vocational Schools, have led to a growing number of academics and a decreasing number of skilled workers. This has required modifications of the NPPs' training programmes. So far, most operational staff have entered the Gösgen NPP as skilled workers and then attended nuclear industry related vocational school education financed by the NPP. In the future, probably a higher proportion of entering personnel will be academics whose training needs and career expectations are different. Due to the development of the PBMR in South Africa, additional qualified personnel from both the regulator and the operator had to be provided. This was done in conjunction with the University of the Witwaterstrand, in Pretoria. The course is a post graduate course and has been recognised as such by the National Qualification Forum. South Africa is re-organising its current education processes with the introduction of a South African Qualification Authority, SAQA. All training performed by companies has to meet the standards and Eskom, the NPP operating organization, has invested resources to ensure compliance. The training will become accredited with SAQA and dependent on the training it is awarded a qualification level. This is still in the development stage and the standards are still being developed for each level of training. TC VUJE helps to upgrade the university study in the nuclear area. This institute has cooperation with Slovak Technical University in Bratislava and with University of the Saint Cyril and Method in Trnava. (to prepare special training courses for people from the plant, and post graduate study).After finishing their university studies, young people start at TC VUJE to prepare for their assigned job position. The AXPO-group, which is the holding company of the Beznau NPP, introduced a trainee programme for university degree holders and engineers. The trainee programme is a three-year effort with either nuclear power or hydro power as the main focus and less experience within the second field. People who decide for nuclear power as the main focus are offered a three-month NPP training at the PowerTech Training Center in Essen (Germany).

International efforts to improve nuclear industry education programmes. As indicated in Section 2.5, the Agency expects to co-operation with the WNU in a variety of ways, including:

- Participation in WNU studies to assess the nuclear training and education needs of participating countries.
- Assisting in the development and review of standardized WNU course content and curricula.
- Developing 'distance learning classrooms' and Internet-based learning to maximize the accessibility of WNU courses to IAEA Member States.
- Enabling free access for all WNU participants to the Agency's International Nuclear Information System (INIS).

The underlining objective of the ENEN (European Nuclear Engineering Education Network) project in the 5th framework program of the European Commission was to safeguard the nuclear knowledge and expertise through the preservation of higher nuclear engineering education. Some of the objectives that have already been taken forward are:

- Through co-operation between universities and research centers, better use can be made of dwindling teaching capacity, scientific equipment and research infrastructure.
- The ENEN project set the foundation of the European Master of Science degree in nuclear Engineering and elements of future nuclear engineering education in the European Union. ENEN is now established as a legal entity at INSTN Saclay, France.
- The first pilot sessions were co-ordinated (SUT Bratislava, CTU Prague, BUTE Budapest, AOU Vienna) into the Eugene Wigner course on Reactor Physics experiments. The second pilot session between SCK.CEN Mol and BNEN (Belgium Nuclear Education Network) delivered Nuclear Thermal Hydraulics in October 2003 and Nuclear Reactor Theory in November 2003.

Work initiated under the ENEN project will be taken forward under the 6th framework program of the European commission (2002-2006) in the form of the extended NEPTUNO (Nuclear European Platform for Training and University Organizations). The expected result from the NEPTUNO project is an operational network for training and lifelong learning schemes as well as academic education at the masters, doctoral and post-doctoral level underpinning:

- Sustainability of Europe's excellence in nuclear technology.
- Harmonized approach to nuclear safety and best practices, both operational and regulatory, at the European level (for example Finland Nuclear Safety Course).

- Preservation of competence and expertise for the continued safe use of nuclear energy and other users of energy.
- Harmonized approach for training and education in nuclear engineering.

Additional details regarding ENEN and NEPTUNO are provided in Annex F.

The ANSN (Asian Nuclear Safety Network) [http://www-ansn.iaea.org] is intended to share technical knowledge and practical experience relevant to safety amongst the countries participating in the IAEA extrabudgetary programme (EBP) on the Safety of Nuclear Installations in the South East Asia, Pacific and Far East countries. In its pilot phase the ANSN is concentrating on education and training. The IAEA, China, Germany, Japan, Korea, and the USA are the main providers of training material.

3.4. ENHANCING PROGRAMS TO ATTRACT STUDENTS INTO NPP CAREERS

This section provides a small sample of various initiatives being taken by the nuclear industry to raise the interest of the students in careers in the nuclear industry.

NPP visitor centres. These centres are generally located adjacent to the controlled area around an NPP. The target audience for these visitor centers is students, teachers and the general public. As such, videos, games and other material provide information about NPPs, their environmental impacts as well as information about other energy sources. A number of NPP operating organizations support periodic visits in their Information Centres by students from schools in the region. There are high quality video programmes prepared for them; the video programmes inform about nuclear energy and all its aspects. Also, examples, quizzes and competitions are used; as these are very popular among young visitors. A number of NPP visitors centre offers courses for teachers. Typically there are about 20,000 visitors per year to NPP visitor centres, over half of which are students and teacher groups.

"Open gates" days to present how the plant functions. These visits help to de-mystify plant operations and illustrate the high standards maintained at such facilities. Recently, for many NPPs, heightened security provisions have reduced public access to the plants for such purposes.

Communicating typical job profiles in NPPs to high school students. Some organizations support publication of special magazines for high school and other educational establishments students; these provide basic information about the company, and for some, an encyclopedia of energy production. Also information about social conditions for current workers of NPPs is provided.

Public relations. Many NPP operating organizations are active in local media presenting the plant, its achievements, and its needs. Many NPPs provide information to the public via the internet.

The Young Generation in Nuclear Power represents the interests of young nuclear professionals and looks for avenues to enhance recruiting and retention of young professionals in the nuclear field. participates in public education programs and organizes meetings and events to facilitate networking among young nuclear industry professionals. In 1995, the European Nuclear Society (ENS) launched an initiative to spread the Young Generation Network (YGN) to all ENS member countries. Today, the YGN exists in many European countries. The objectives of the YGN are to attract more young people to the nuclear industry by working with students, to train new leaders, by facilitating the exchange of knowledge between the older and younger generation, to support the participation of young people in the national and international nuclear societies, particularly in leadership positions, and to support the participation of young people in conferences as speakers and organizers.

Recently a **Nuclear Cadet Programme** was developed by ESKOM of South Africa to prepare potential candidates to fill a shortcoming in personnel with the experience and education needed to work at the plant. During 1999, a nine-month pilot Nuclear Cadet Programme for a group of multi-cultural students was developed. The Plant Manager approved the Nuclear Cadet Programme. A selection process was undertaken that used a validated technical and cognitive thinking test, a competency based assessment interview, and psychometric testing to select 24 candidates. The Nuclear Cadet Programme commenced in June 1999. The first course was successfully completed by end of February 2000. These students were provided with meals as well as housing accommodations adjacent to the training venue. A major benefit derived from providing board and lodging was to improve Eskom's ability to attract suitable candidates to join the programme. This environment also assisted with building the Nuclear Cadets into a highly motivated, integrated and cohesive team exhibiting the desired organizational culture. Due to weaknesses in the South African education system, the course of study was intensive and aimed at strengthening the academic skills, improving team dynamics, and developing logical thinking skills. The SAT process was used to pinpoint the problem areas that would be trained on for the Nuclear Cadet Programme. This process clearly highlighted the need for a high level of understanding of first principle technical concepts by operating students. It was also identified that these concepts had to be taught during the initial phase of the training of operators to have the desired effect later in the progression of operators. The design of the programme is thus geared toward improving the knowledge and understanding of mathematics, physical science, chemistry, and electrical fundamentals by focusing on the application of key principles to the power plant setting. The Nuclear Cadet Programme has been conducted three times to date, with 24 commencing the course in 1999, 24 in 2000 and 20 in 2001. Of the candidates that commenced the course 19 were successful from the first group, 20 from the second group and 17 from the last group. The successful individuals were then transferred to the operations department and began the initial non-licensed operator training programme. The Nuclear Cadets are provided with 13-weeks of power plant fundamentals training and are required to pass the generic fundamentals examination prior to moving into the plant's Operating Department as non-licensed operator trainees. The Nuclear Cadet graduates who are now progressing through the non-licensed operator qualification process are performing exceptionally well. Comments from shift personnel and station managers as well as from the on-the-job trainers indicate that the nuclear cadets are highly motivated and are able to quickly grasp the knowledge and skills needed to complete the various non-licensed operator qualification requirements. This type of programme is now being utilized by other power stations within Eskom and the oil and gas industry in South Africa have also expressed an interest in using the course.

3.5. MANAGING EXPLICIT KNOWLEDGE IMPORTANT TO NPP OPERATIONS

Personal computers, computer networks, databases, text, graphics, and image processing and presentation graphics software, as well as digital photography have revolutionized NPP documentation systems. Advances in information technology make it possible to create highly sophisticated NPP documentation that can be updated efficiently, including consideration of all linked documents. In general, the internet makes it easier to exchange and access information worldwide, quickly and efficiently. While intranets using the same technology are becoming quite common among NPP operating organizations.

With the introduction of SAT to the training arena, many operating organizations have utilized databases and a management tools for the control of training material. This has allowed the capture of information and revision of material to be performed (e.g. analysis of plant modifications, procedure changes, operating experience feedback, regulatory changes, and other change actions.)

The use of integrated plant management systems has beneficial effects upon knowledge transfer. Such systems can automate the collection, storage and presentation of plant operations data as well as other plant documents. In order to implement such a system, comprehensive knowledge about nearly all plant systems needs to be collected, including design bases information. Such a system is especially important for new employees who might otherwise spend years learning where to find and access needed knowledge.

All the simulation and calculation tools within an NPP provide an extensive knowledge base. For example, a new core surveillance system offers formerly unknown possibilities of three-dimensional visualizations, which leads to new knowledge and offers new possibilities of preserving and transferring knowledge.

One example of an integrated plant management system is that of the Mühleberg NPP in Switzerland which has an advanced computer network, a full-replica simulator, a process visualization system and an Integrated Operations Management System. The IBFS (Integrated Operation Management System) is an excellent tool for planning and processing all deficiency reports, work-orders and related work sheets and managing the work-order-System. IBFS annually processes 16,000 periodic work orders. The system has 1,600 validated Standard Tagging lists available. IBFS provides the basis for plant daily meetings and is accessible throughout the plant on its intranet. This includes also access to the information through computer terminals in the controlled area. The IBFS was regarded as good practice in the OSART missions of 2000 and 2002. When designing and implementing these systems, a large amount of knowledge had been collected and documented systematically. This is an ongoing process.

Another useful example comes from the Swiss Federal Nuclear Safety Inspectorate. In 1997 it started a project to introduce a new generation electronic document management system. The system had to fulfil the following requirements: The entire correspondence – at that time an estimated 5,000 to 10,000 documents per year – and all relevant internal documents were to be scanned, classified and stored in a format suitable for long term archiving. Complex full text search functions allow fast and easy retrieval of the contents of all documents. Access to data is controlled. After extensive tests, in 2000 the system was put into operation. The experience is very positive. Because the document management system not only reproduces the paper documents graphically, but also does text recognition of all scanned texts, it has become easy for everyone within the Swiss Federal Nuclear Safety Inspectorate to have, from every workstation, immediate access to any document. Additionally, a large proportion of the old documents that had originally been archived only on paper have now been scanned. The archive is searchable by text, title, reference, date or time period, processing status, sender and a number of additional characteristics. After new documents have been scanned, links to these documents are automatically distributed within the organisation by e-mail according to fixed rules. This requires that before scanning every document is given a machine-readable bar code. The purpose is to inform everybody to whom new information stored in the system is likely to be of interest. The system has modified internal communication in additional ways. When looking for information about a specific power plant, project or task, it is often easier and faster to search it electronically than to ask colleagues within the authority. It is also a powerful means for transferring knowledge to new colleagues. The electronic document management system of the Swiss Federal Nuclear Safety Inspectorate has proven to be a vast knowledge base that makes explicit knowledge accessible, even if there is no one left within the organisation that still has it in mind.

With respect to knowledge capture and retention, what is often missing from these systems is some structured decision making as to which knowledge is important to be documented (explicit knowledge) and which is to remain tacit knowledge. Also, of importance is the structure of knowledge retention efforts. For example, it may be useful to capture the information associated with "why" things are done as well as the "how" things are done. However, if the why information is embedded in the procedures, they may be more difficult to use. One proven approach is for the "whys" to be provided in a separate document that supports the procedures (perhaps a training manual) Then knowledge retention efforts can be achieved without negatively affecting the usability of plant procedures.

4. IDENTIFICATION, CAPTURE, AND USE OF TACIT KNOWLEDGE IN NPP OPERATING ORGANIZATIONS

The term **"*tacit knowledge*"** is used to describe knowledge that resides within individuals as contrasted to **"ex*plicit knowledge*"** that has been captured in various forms such as documents, engineering designs, databases, or training materials. Tacit knowledge includes what is sometimes referred to as "*tribal knowledge*". If one considers the typical task of a field operator to conduct routine rounds (inspections) in his/her assigned areas, the explicit knowledge related to the task may be provided in checklists or procedures specifying the frequency of these rounds, and the information to be recorded during these rounds. The associated tacit knowledge may include the recognition of abnormal conditions or potential problems based upon any of the five senses (smells associated with damaged equipment, sounds indicating rotating equipment degradation, visual indications of a steam leak, taste of a contaminant in the air, etc.). Usually it is difficult to express tacit knowledge directly (or completely) in words. Often the only ways of presenting it are through metaphors, drawings, and various methods of expression not requiring a formal language. On a practical level many experts are often unable to clearly express all they know and can do, and how they make decisions and come to conclusions (i.e., they know more that they can tell (or write)). There is not a clear division between explicit and tacit knowledge but rather a spectrum. For NPPs explicit knowledge is primarily about what to do or how things are done (e.g. start the pump when the expansion tank is half full) and tacit knowledge is about why it is done. Most teaching and learning in schools relates to explicit knowledge.

Several existing IAEA TECDOCs have focused on the systematic approach to training (SAT) and other means of selecting and qualifying NPP personnel to perform their jobs. Those documents have primarily focused on explicit knowledge. Certainly those methodologies will continue to be necessary as a new generation of personnel is employed; and, the Agency will continue to be interested in identifying ways by which NPPs might be applying those more established, conventional processes and programs to address the challenges being presented by the ageing of the nuclear industry's workforce.

Yet, while explicit knowledge is necessary, it is not sufficient for successful performance of all tasks for NPP personnel. Therefore, it is important to also to focus on tacit knowledge that resides with the ageing workforce by virtue of specialized expertise developed through both experience and individual learning that has not typically been captured through normal documentation and training practices.

Of the total information and knowledge available, much is not directly relevant to the accomplishment of an NPPs mission. Therefore, the identification of **mission-critical tacit knowledge**; that necessary to properly operate and maintain NPPs must be determined, and then be made available to those who need it. This mission-critical tacit knowledge should encompass the total life cycle of plant design, construction, operation, life cycle optimization, and eventual site closure. It also spans the spectrum of work activities including operations, maintenance, engineering, projects, and support functions.

Results from the IAEA's survey on this topic indicated that in the nuclear industry the main approach for transfer of tacit knowledge is through assigning experienced personnel to coach or mentor new employees. Experience has shown that one of the principal limitations of such individual transfer of tacit knowledge is the potential for variability in the quality of transfer. Thus, personal transfer should be supplemented, whenever feasible by support systems including guidelines, job aids, individual development plans, structured on-the-job training (OJT) and communities of practice (CoPs) that both help to provide consistent and high quality transfer of tacit knowledge as well as providing a way to transfer tacit knowledge, where appropriate, to explicit knowledge. The remainder of Section 4 provides information regarding methods that NPP operating organizations are using to maintain the quality of their efforts to effectively identify, capture, preserve and transfer mission-critical knowledge.

4.1. METHODS USED TO IDENTIFY AND CAPTURE MISSION-CRITICAL TACIT KNOWLEDGE

Two of the organizations that responded to the IAEA's survey provided detailed information regarding their structured methods to identify and capture mission-critical tacit knowledge (as well as mission-critical explicit knowledge).

Eletronuclear, owner and operator of the nuclear power plants in Brazil, is applying systematic measures to preserve its essential technological knowledge. A special project was established in January 2001 for this purpose. The extent and location of the existing know-how was identified and the gaps in mission-critical knowledge (both tacit and explicit) were evaluated. Annex G provides further information regarding the approach being used by Eletronuclear. This Annex provides information not only about identification and capture of mission-critical knowledge but also provides Eletronuclear's planned approach to knowledge transfer and retention.

The Tennessee Valley Authority (TVA), the largest Government-owned electricity generation and distribution company in the USA, owns and operates several NPPs as part of its generation fleet. TVA has developed, piloted, and deployed a process to identify and capture the undocumented knowledge of employees nearing retirement. This process, and associated tools and support, enable line managers to:

(1) Identify critical "at risk" knowledge and skills, particularly those associated with impending attrition.

(2) Evaluate the risk associated with losing this critical knowledge and skills and focus on areas of greatest risk.
(3) Develop, implement and evaluate actions (documentation, mentoring, training, reengineering, sharing expertise, etc.) for managing this risk.

The results to date from this process include:

- An effective approach to addressing a critical organization need.
- Process and tools for line managers to manage their workforce.
- Integration of staffing, training, job and organization redesign, process improvements and other responses.

Annex H provides an overview of the processes and tools at TVA for knowledge identification and retention. A complete description of the TVA process, including associated procedures and data collection forms, is available on the TVA website [http://www.tva.gov/knowledgeretention/]. This website is particularly recommended for those who are new to this topic, as it provides an uncommonly open and complete description of what has been found to be an efficient and effective approach.

The British Energy subsidiary BEPET conducted a knowledge management benchmarking effort recently. The content of the survey and conclusions regarding the process are provided in Annex I. This Annex provides some thought provoking questions that most NPP operating organizations might benefit from asking themselves.

A number of NPP operating organizations indicated that their job and task analyses, conducted during **the analysis phase of the Systematic Approach to Training (SAT)** served to identify mission-critical knowledge (both explicit and tacit). Then, through the subsequent design and development phases of SAT some of the tacit knowledge was converted to explicit knowledge through including this knowledge in training materials. Also, particularly through the development of OJT guides, the structure for the transfer of explicit knowledge related to particular tasks was identified in such a way that it should be transferred in a consistent manner, regardless of the individuals involved.

Experience in a variety of fields suggests that no matter what methods are used to identify and capture mission-critical tacit knowledge, their success will depend upon an **organizational climate that rewards people for sharing their tacit knowledge**. Among the methods that NPP operating organizations indicated they use to establish and maintain such an organizational climate include:

— Open, honest and trustful collaboration, open communication and teamwork make it easier to mutually exchange tacit knowledge at all levels. Mission-critical tacit knowledge is identified and captured through daily teamwork and also in the annual objectives-setting and performance evaluation interviews. (Beznau, Switzerland)

— The Gösgen NPP in Switzerland suggested that identification, capture and transfer of knowledge not only be considered as a process of bringing knowledge to others, but that equally important is the **questioning attitude** of the learning staff. Within the organizational culture of the Gösgen NPP it is essential that people are curious, critical and ask their superiors and experienced colleagues questions on their own initiative. In this process of asking and answering questions on the job an enormous amount of tacit knowledge is made explicit, or at least shared in an open way.

— The Mühleberg NPP in Switzerland indicated that a key element for the identification of mission critical knowledge is a good **communication culture** which can lead to good team-work. The OSART of the Mühleberg NPP in 2000 identified as a good practice that the plant staff has an excellent sense of teamwork, which contributes to effective sharing of knowledge.

Another area that a number of NPP operating organizations identified as being important for their identification and capture of tacit knowledge is the **effective use of operating experience**; in documenting analyzing and discussing events and near misses, both internal and external to the organization; in learning from problem identification and corrective actions. Reviews of operating experience have reinforced the importance of tacit knowledge because in many situations correct action depends on tacit behind written procedures. Quality management approaches often have underestimated the importance of tacit knowledge and only stressed explicit knowledge. The following are some examples of effective use of operating experience for identifying mission-critical tacit knowledge:

— The Gösgen NPP (in Switzerland) transfers tacit knowledge into explicit knowledge as far as possible. One of the methods used for this purpose is **documenting, analysing and discussing events and near-misses**, documenting operational experience in test instructions and the operations manual and by evaluating and documenting the experiences made in simulator training. However, this transformation of tacit knowledge to explicit knowledge is difficult because the carriers of tacit knowledge are not conscious about large proportions of this knowledge and often not very good at documenting their knowledge. In addition, tacit knowledge is often difficult to describe. Therefore, in addition to attempts of transforming tacit knowledge to explicit knowledge, the Gösgen NPP finds it important to transfer tacit knowledge directly by transferring it personally on the job. In order to promote this form of knowledge transfer, experienced staff and specialists do their jobs in general together with less experienced personnel who will later be responsible for this work.

— The Cernavoda NPP in Romania continually improves operating manuals and training manuals with mission critical knowledge. This knowledge usually comes from **event analysis**, which once identified is transferred into station documentation, training programs or just in time training.

— The Diablo Canyon NPP in the USA has successfully captured some mission critical tacit knowledge using “tribal knowledge” web sites or in desk guides, and these have been very successful. They also provide a question bank to used by supervisors “conversation starters” to identify tacit knowledge that employees have.

— The Institute of Nuclear Power Operations (INPO) has developed an extensive database of **“operating experience”** (OE). Worldwide, WANO and the IAEA have analogous databases on operating experience. These have proven to be very valuable tools to make NPP operating organizations more aware of the undocumented, tacit knowledge that provides the basis for many mission critical decisions.

— The Pt. Lepreau NPP in Canada indicated that it identifies mission critical tacit knowledge through its **problem identification and corrective action** system that identifies and tracks current problems and concerns within the workplace. It is an action information system available to all workers.

NPP operating organizations in general have a higher ratio of explicit to tacit knowledge than most industrial organizations. This is the case because of the rigor of documenting design information, procedures and training materials for NPPs. However, particularly for older NPPs, this ratio is sometimes lower than necessary for safe and reliable operations. A number of NPP operating organizations have found it necessary to improve their identification and capture of tacit knowledge (as well as, to the extent practical, to transfer this tacit knowledge to explicit knowledge), particularly for major projects/activities such as; license renewals or extensions, periodic safety reviews, instrumentation and control system modernizations, power up-rates, and installation of plant-specific control room simulators. For example, the knowledge as to the design basis for the minimum required flow for an NPP safety system may not have been fully documented during the design process, and may be needed for a plant license renewal. However, the individual who designed the system may remember the basis. This tacit knowledge can be transferred to explicit knowledge. As has been indicated earlier, however, not all tacit knowledge can be converted to explicit knowledge (experts know more than the can tell (or write)).

4.2. PRESERVATION AND TRANSFER OF MISSION-CRITICAL TACIT KNOWLEDGE IN AN NPP OPERATING ORGANIZATION

Once it has been identified and captured, mission-critical tacit knowledge, in order to be effectively used, needs to be preserved in the organization, and transferred to those who need it. The following provide some examples of methods being used by some NPP operating organizations for this purpose, organized in four categories:

(1) Organizational climate/culture.
(2) Work organization.
(3) Information management systems.
(4) Training systems and individual development.

4.2.1. Organizational climate/culture

- A systematic succession planning system is established for key personnel. Successors for key positions are identified at least a year in advance and the information is openly communicated in order to create good conditions for the transfer of knowledge. Successors from within the company are preferred.

- An environment of mutual trust and respect at all levels, but particularly between older workers who are transferring knowledge, and new employees, facilitates knowledge transfer, particularly regarding tacit knowledge. (Experienced workers are recognized and rewarded for transferring knowledge and newcomers respect the knowledge of older workers.)

- Don’t assume that knowledge transfer will occur just because the opportunity is provided; monitor results regularly, and obtain feedback from participants in the process in order to continually improve it. There is a recognition that generational issues may exist. Younger people don’t necessarily learn in the same way as the retiring workers.

- People share and spread their tacit knowledge by working in teams, not in isolation.

- Open communications are encouraged up, down and horizontally.

- Workers take pride in anticipating the needs of others and making preparations so that work can be efficiently performed.

- Employees are given a long term perspective of organization, including its goals and objectives.

- Top level management support for the process is evident in both words and actions.

4.2.2. Work organization

Communities of Practice are effectively used in areas such as human factors, risk analysis, and team leadership, with the goal to share experience and good practices.

Working teams include a mix of experienced and young employees, and also a mix of expertise in order permit sharing of knowledge, and with the goal to develop flexibility in work organization.

Pre-job briefings are required for all but the simplest and most routine tasks.

Young professionals are participate as full members in working groups, meetings, conferences, reviews, and safety committees. They bring energy, fresh ideas and a questioning attitude to the job.

Proxies (substitutes) are defined for all functions. These proxies are expected to fully replace the persons they represent during any absences.

Job rotation is used an important means for transferring knowledge. For example, maintenance personnel, who did a certain job during an outage will be assigned a different job for the next outage so that they are qualified in a number of areas.

Quite some time before people retire, e.g. a year in advance, they are released from much of their work so that they have time to systematically document their knowledge. In parallel, they work together with their successors. It is part of the company philosophy to organize succession in a way that the predecessors do not view their successors as competitors. People are motivated to share their knowledge and to work within teams

4.2.3. Information management systems

Data bases are used to track and record results and associated corrective actions from operating experience. Knowledge and information are documented within one official data base that is easily accessible by all staff. Knowledge/information should not be documented in personal files that are not accessible by others and that are not consistent with other documents.

Explicit knowledge (and to the extent feasible tacit knowledge) is captured systematically in desk references, documents, procedures and on websites. Where feasible, tacit knowledge is converted to explicit knowledge.

The process of updating procedures is made easy. Personnel are encouraged to suggest modification of procedures whenever they see that procedures could be improved.

For every repair a work order request form is completed. In doing so, the problems detected and the solutions suggested are available for future use.

A taxonomy to document and organize the needed know-how of the NPP operating organization, as well as a document that provides a “flow path” of the knowledge transfer process, or perhaps a Concept Map of the process can be very helpful In 2004 Eletronuclear in Brazil, intends to test the concept map method developed by EPRI and the Institute for Human and Machine Cognition, University of West Florida. (see Annex G)

A process to rank the relative priority of knowledge retention issues is essential. Having a “formula” is helpful because it is in the comfort zone of most individuals within the nuclear industry and because a formula that works will truly help an organization prioritize what issues related to knowledge retention to attack first. This is necessary because knowledge transfer activities take so much time.

A living quality management system has been implemented. Its process descriptions contain a lot of formerly tacit knowledge. When analysing events and near misses, tacit knowledge is transferred into documents, instructions and training using the SOL-method (Safety through Organized Learning)

It is important to recognize that even the best information management system can not totally replace face-to –face interactions, particularly as related to tacit knowledge. (experts know more than the can tell (or write)).

4.2.4. Training systems and individual development

- A permanent working group has been established with representatives from the technical departments. The group analyzes the mission critical knowledge needs and proposes specific actions including training.

- Many experienced employees are involved in training courses (as part time trainers) with the goal to transfer to trainees their experience.

For each job position change a special employee adaptation system is applied that elaborates in detail the use of mentoring and back-up methods. Experienced personnel coach new people in the most effective way to perform their duties. Mentoring guides are provided to ensure consistency in knowledge transfer.

- Individual development plans are updated annually for each employee with their supervisor as part of the performance appraisal system.

- The decision of whether or not a person is competent to perform duties is decided by demonstration of the individual performing the task as well as theoretical knowledge. This ensures that individuals are able to perform the function and that the material used to train has sufficient information, (both tacit and explicit knowledge requirements), to allow training on the task.

All shift personnel participate in “training days” each month. During this time, analyzes of special operational situations and events are conducted in detail. If some mission-critical tacit knowledge is identified, all relevant personnel are informed about this fact. This information is also used to update of plant documents.

The preservation of tacit knowledge is done by upgrading station documentation (mainly operating manuals and training packages). Also, as needed, training sessions are organized to be sure that everybody is aware of the new information.

Once identified information is captured through the SAT process, it is controlled by a database. This information is maintained through the review of modifications, operational experience, procedure changes, etc. to identify whether the database needs to be updated.

- Mission critical tacit knowledge is captured on websites and in desk references.

- The tacit knowledge necessary for solving problems is often distributed among a number of people. Therefore, communication and collaboration are essential for documenting and transferring tacit knowledge.

- Tacit knowledge is made explicit within the NPP documentation management system and made available for all personnel by means of the internal computer network. An electronic document management system allows people to quickly, easily and accurately find mission critical information.

- The results of analyses of internal and external events and near misses are communicated monthly to personnel through the information management system.

- Line organizations organize the transfer of knowledge to new staff by customized orientation programmes. The training organization supports their efforts and facilitates sharing of lessons learned to ensure efficiency and effectiveness of these efforts.

- New mission critical knowledge is immediately transmitted to all appropriate groups and is also used to revise all effected classroom and practical training, as well as associated procedures/documents.

5. SUMMARY AND CONCLUSIONS

As indicated in Section 1, the objectives of this report are to:

(1) Make middle and senior level NPP operating organization managers more aware of the most significant issues in the industry regarding an ageing workforce and transfer of knowledge to the next generation.

(2) Assist in the industry’s response to these issues through the identification of practices that NPP operating organizations have found effective in attracting appropriate people to the nuclear industry and in transferring knowledge to the next generation of nuclear industry personnel.

The main conclusions from this report regarding strategies for managing an ageing workforce are:

— **The nature and magnitude of the ageing workforce problem for the organization should be defined and regularly updated**. Staffing plans/work force plans should be prepared that provide a standardized methodology for overall human resources planning driven by strategic and business goals. These plans should identify planned retirements and vacant positions as well as the required staffing levels needed to support business strategies. They should include attrition data, development plans, succession plans and current work force requirements. They should be long term plans typically looking forward 5 or more years. Many NPP operating organizations are now planning expected retirements 10 years or more in advance and making sure that the successors are recruited early enough to allow an overlapping of employment sufficient to transfer needed knowledge.

— **Activities should be strengthened to retain current employees**, including regularly soliciting inputs from employees regarding their job satisfaction and motivation, monitoring external markets to ensure that employee benefits and compensation are competitive, and providing opportunities for career/professional development.

— **Partnerships** with educational institutions and universities that provide qualified professionals for the nuclear industry should be assessed based upon medium and long term needs, and strengthened where needed. Actions should be taken to make the organization an attractive employer and neighbor in the community.

The main conclusions from this report regarding the capture and preservation of mission critical knowledge, and the effective transfer of this knowledge to the next generation of NPP personnel are the following:

— Experience has shown that one of the principal limitations of such individual transfer of tacit knowledge is the potential for **variability in the quality of knowledge transfer**. Thus, personal transfer should be supplemented, whenever feasible by support systems including guidelines, job aids, individual development plans, structured on-the-job training (OJT) and communities of practice (CoPs) that both help to provide consistent and high quality transfer of tacit knowledge as well as providing a way to transfer tacit knowledge, where appropriate, to explicit knowledge.

— The nuclear industry due to its need for well documented procedures, specification, design basis, safety analyses, etc. has a greater fraction of its mission critical knowledge as explicit knowledge than do many other industries. This facilitates the task of knowledge transfer. For older plants in particular, there may be a need for additional efforts to transfer tacit knowledge to explicit knowledge to support major strategic initiatives such as plant license extensions/renewals, periodic safety reviews, major plant upgrades, and plant specific control room simulator development.

— The challenge in disseminating explicit knowledge is to make employees aware that it is available, provide easy access, in formats and forms that are useable.

— Tacit knowledge is more difficult to identify and disseminate. The challenge is to identify what can be converted to explicit knowledge and to create an environment where tacit knowledge is routinely shared and disseminated (knowledge-sharing culture). No information management system can replace the need for face-to-face interactions, particularly for transfer of tacit knowledge (experts know more than they can say, or write).

— Many NPP operating organizations have taken positive and decisive steps to address the ageing workforce situation. A number of these actions are described in this document, and should be considered for use by others, as appropriate. Particularly recommended are the knowledge retention and transfer methods developed by TVA and freely distributed on its website.

Annex A

PERSONNEL ATTRITION & KNOWLEDGE TRANSFER IN THE US NUCLEAR POWER INDUSTRY

1. Introduction

This annex was prepared by Goodnight Consulting Inc., a USA management consulting firm that focuses on personnel related issues, including staffing benchmarking, organizational development and redesign, and process improvement. This report consists of material developed from client engagements, industry surveys, and industry research.

2. US Industry Conditions

A wide range of performance indicators reflect significant improvement in the U.S. nuclear power industry over the last six years. Since 1997, the following improvements have been realized:

- Production costs ($/MWHr) have been reduced 21%.
- Capacity factors have improved 28%.
- Average refuel outage durations have been cut 33%.
- Safety performance indicators have improved.
- Total staffing has been reduced by almost 15%.

To support these improvements, organizational designs have been restructured to support fewer personnel and more efficient operations. Additionally, new approaches have been applied to increase plant performance, while safety performance has improved. These improvements have been achieved with fewer personnel each year. When average plant staffing in 1997 is index to a level of 100, staffing levels at the end of 2002 had declined by almost 15 percent. This data is shown below in Figure 1.

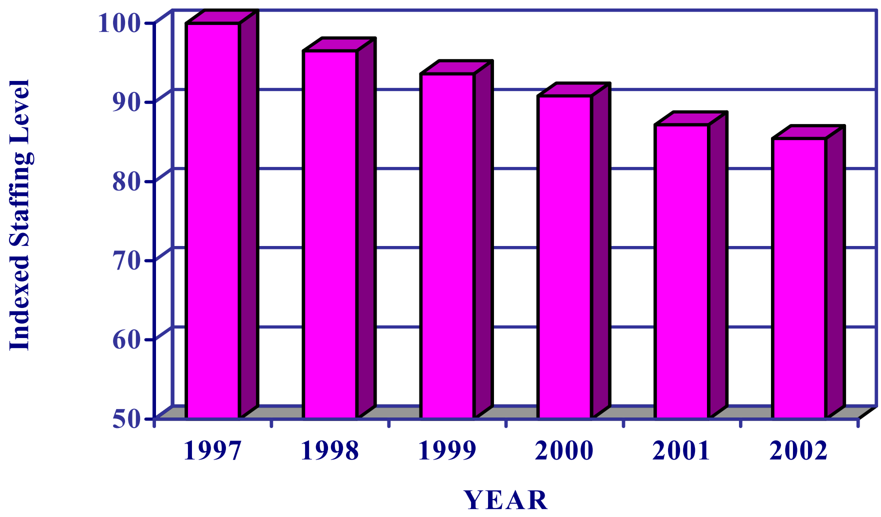


FIG. 1. Average indexed staffing.

These staffing levels include site employees, corporate staff dedicated to nuclear generation, and long term contractors. Long term contractors are defined as staff augmentation individuals that support a nuclear generation facility for six months or longer, or are services contractors that are used every year, such as facilities maintenance.

As nuclear plants have reduced staff to become more efficient and realize lower costs, another near-term issue has been slowly developing. That issue is retirement attrition, and the associated transfer of knowledge from these experienced personnel to those with less experience. Many U.S. nuclear plants are facing near-term "retirement cliffs," which are large numbers of personnel eligible to retire in a short period of time. Some plants expect to lose up to one-third of their engineering staff while others may have one-third of their maintenance crews retire within the next five years.

Many plant management teams say they are managing attrition. In reality, they are monitoring the effects of personnel losses on key technical areas and then responding by hiring new personnel as needed. However, there are several serious potential consequences of this approach:

- Where personnel are not replaced as they retire, there are often no process changes in place to accommodate process execution with fewer personnel.
- As staffing reduces, process inefficiencies become more evident and must be dealt with. In spite of management's best efforts, they are often unable to control when key personnel retire.
- As key personnel leave, replacements must be hired, trained, and retained; often, nuclear plant human resources organizations are not prepared to perform these critical tasks on a large scale to compensate for the large "retirement cliffs".

In dealing with the retirement issue, a key element is the future nuclear worker. In the U.S., younger nuclear workers typically do not expect long term employment with one company. Job security is no longer the incentive for utility employment that it was with current managers when they were new hires. Today's young people do not plan on retiring from the same company they start working for early in their career. Additionally, U.S. public training and education today often do not match the needs of workers in our plants. Finally, because competition for nuclear workers is high, companies must increase salaries or offer other incentives to attract good workers. These options are difficult in a cost sensitive environment where power companies are trying to reduce costs.

3. Nuclear Plant Personnel Attrition

In March of 2003, Goodnight Consulting, Inc. published the results of a nuclear plant personnel attrition survey. The survey was sent to all U.S. commercial nuclear plant operating companies, of which approximately 40% responded. Figure 2-9 were developed from those survey results.

Figure 2 below shows the survey results for expected personnel attrition levels at 2-unit nuclear power plants in the next 5 years. The maximum level was reported by a nuclear power plant (NPP) that has the highest staffing levels in the U.S. Consequently, the value of 349 that is more than double the average level of 166 is not surprising. However, the minimum level of 46 appears less consistent. We believe that the NPP reporting this low level may not have completed a thorough evaluation of their potential retirements, and that this data point should be treated as a statistical outlier.

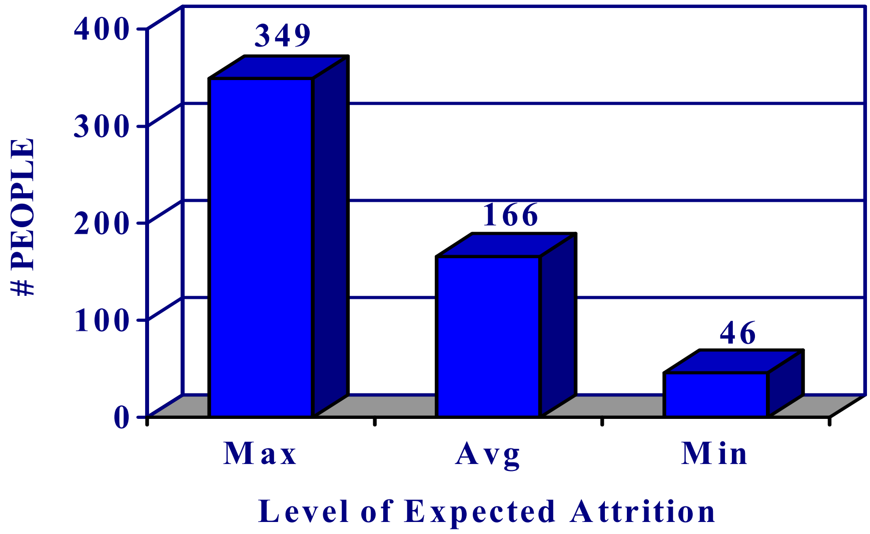


FIG. 2. US 2-Unit expected 5 year attrition.

Figure 3 below shows the survey results for expected personnel attrition levels at 2-unit NPPs over the next five years. The groupings reflect common organizational alignments at U.S. NPPs. For additional detail, the groupings are defined in Appendix A of this report. As shown, the greatest expected attrition will occur in the Maintenance, Support Services, and Engineering areas. Few personnel are expected to retire from the areas of Radiation Protection or Senior Management.

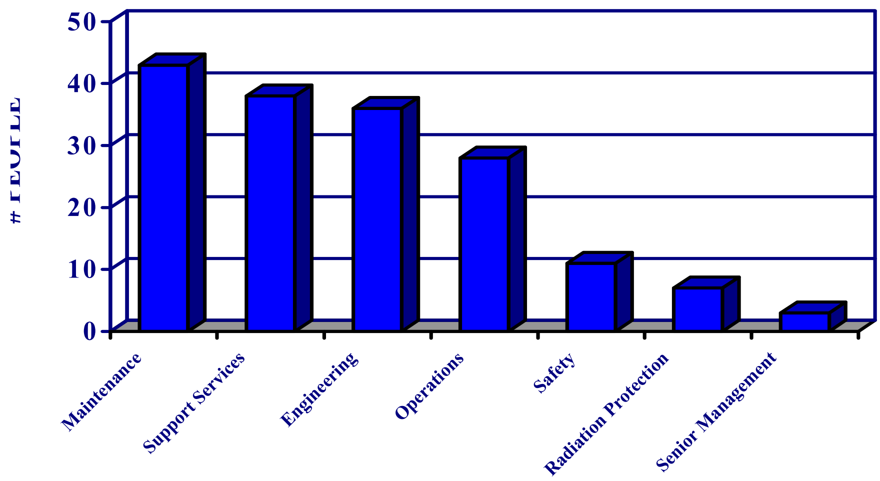


FIG. 3. US 2-Unit average expected attrition over the next 5 years.

Figure 4 below shows the distribution of expected retirements, by group. Almost half, 47.6 percent, of the expected retirees will come from the technically critical areas of Maintenance and Engineering.

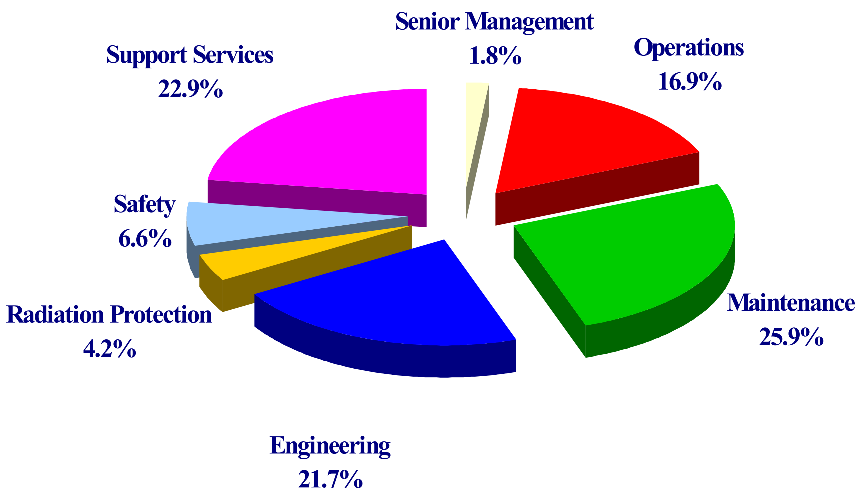


FIG. 4. 2-Unit plants' distribution of expected 5 year attrition.

Figure 5 reflects the survey results for expected attrition replacement approaches at 2-unit NPPs over the next five years. On average, these U.S. NPPs plan to hire new employees to replace about half of those personnel who will retire. Only a small number, about one-twelfth, are expected to be replaced by contractors. More than 40 percent of personnel who retire are not expected to be replaced. Rather technology improvements, improved processes, and the reduction of work scopes are to compensate for these losses.

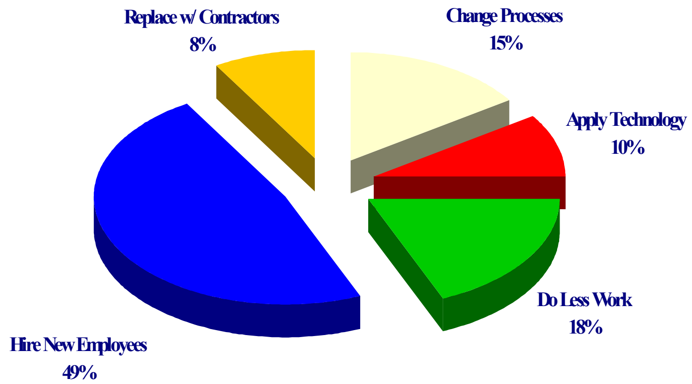


FIG. 5. Planned attrition replacements at 2-unit plants.

Figure 6 reflects the survey results for expected attrition at U.S. 1-unit NPPs. Here, the minimum level again appears unrealistic, reflecting an average of only 4 personnel retiring each year for the next 5 years. Where average staffing at a 1-unit U.S. NPP is 838, 20 retirements over 5 years would represent less than one-half of one percent per year. The average number of 100 personnel expected to retire over five years represents an annual retirement rate of 2.4 percent, which is more consistent with industry experience.

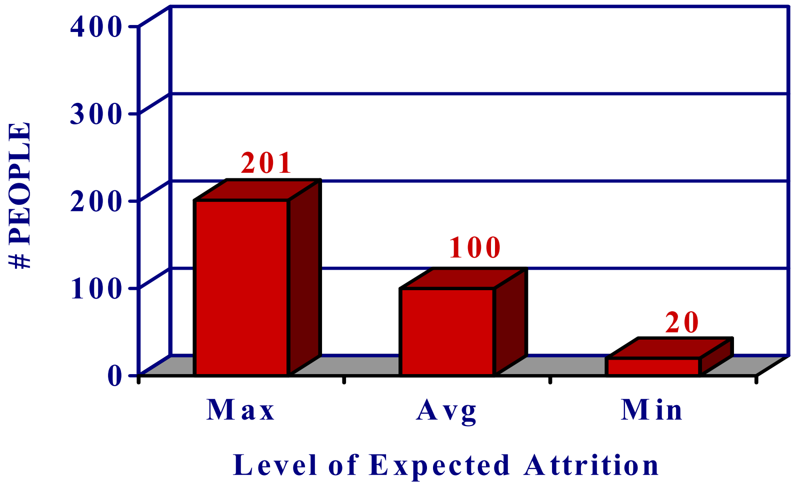


FIG. 6. US 1-Unit expected 5 year attrition.

Figure 7 below shows the survey results for expected personnel attrition levels at 1-unit NPPs over the next five years. Again, the groupings are defined in Appendix A of this report. As shown, the greatest expected attrition will occur in the Maintenance, Support Services, and Engineering areas. The data in Figure 7 is very similar to that in Figure 3 for 2-unit NPPs, with the principle difference being the number of expected retirees is lower at the 1-unit NPPs.

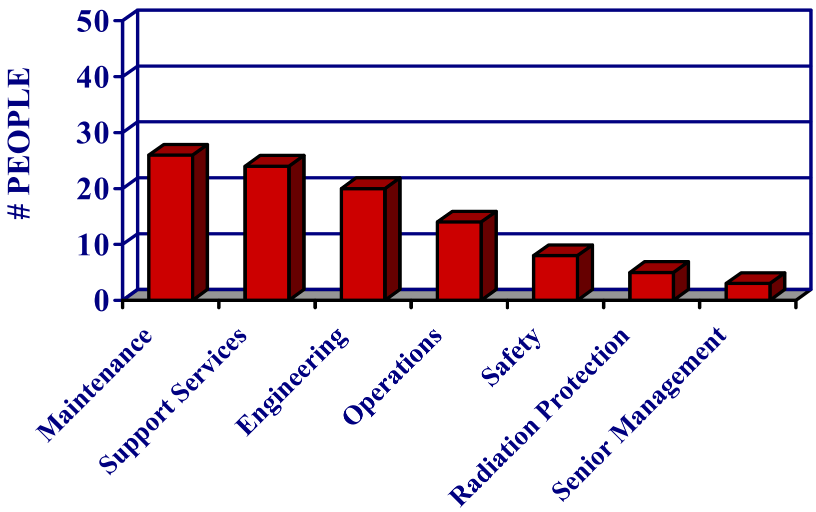


FIG. 7. US 1-Unit average expected attrition over the next 5 years.

Figure 8 below reflects distribution of 1-unit NPPs expected retirements, by group. At 1-unit NPPs the Maintenance and Engineering areas combine to make up 49.5 percent of all expected retirees, a slightly higher percentage that those at 2-unit NPPs.

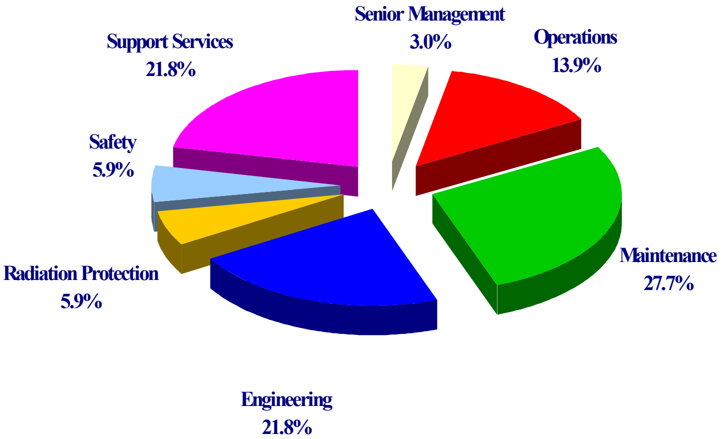


FIG. 8. 1-Unit plants' distribution of expected 5 year attrition.

Figure 9 reflects the survey results for expected replacement approaches at 1-unit NPPs over the next five years. On average, these U.S. NPPs plan to hire new employees to replace less than half of those personnel who will retire. Only a very small number, about 3 percent, are expected to be replaced by contractors. One third of personnel retirements at 1-unit U.S. NPPs are expected to be overcome by technology improvements, improved processes, or the reduction of work scopes. The attrition survey results that have been reported in Figures 2 through Figure 9 represent a state of the industry in the U.S. Individual NPP's conditions, of course, vary significantly.

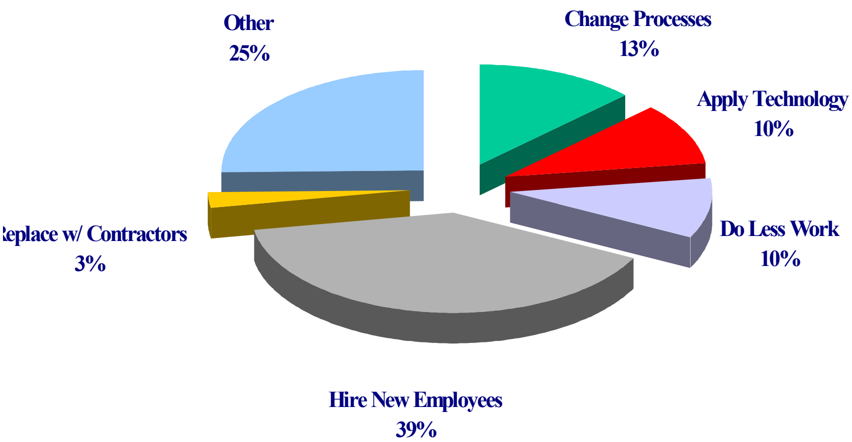


FIG. 9. Planned attrition replacements at 1-Unit plants.

Figure 10 below shows the potential cumulative personnel retirements at an actual 1-unit and 2-unit U.S. NPPs. The rate of attrition builds more rapidly at the 2-unit NPP, reaching 27% of employee staffing by the year 2010. At the 1-unit NPP, the attrition level has only reached 13% in the same period. However, this particular 1-unit NPP will experience a rapid growth in attrition due to retirements later, beginning in the year 2012. From then through the year 2017, this plant will see an additional 45% of their employees reach retirement eligibility.

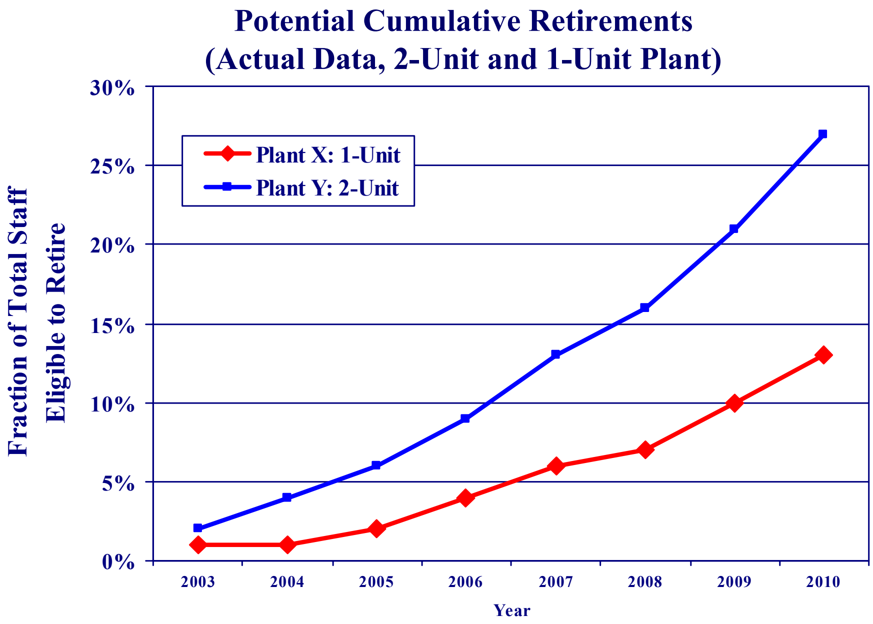


FIG. 10. Potential cumulative retirement (actual data, 2-Unit and 1-Unit plant).

4. Knowledge Retention Approaches

To offset these impending losses of personnel due to retirements, many U.S. NPPs have changed policies and planning approaches. Such approaches include career planning for young workers and potential hires, targeted strategies to compete for new workers, more focus on compensation and less on retirement for new hires, and more “people-friendly” programs. Some of these programs include:

- Flexible work schedules (non-standard start and stop times each day).
- Educational opportunities (tuition re-imbursement).
- Stock grants/profit sharing.
- Job rotations (job switching for a specified period).
- 4 day work weeks (10 hour days instead of 5 days at 8 hours each).

In 2002, Goodnight Consulting, Inc. published the results of a survey regarding NPP work shifts and schedules. Slightly more than half of the survey respondents had 5 day work weeks with 8 hour schedules for their non-rotating shift workers. However, many of these NPPs also offer flexible start times, allowing each non-shift employee to determine their daily start time.

About 45 percent of the U.S. NPPs offer alternate work schedules. Specifically, about one quarter have a “4-10s” schedule. “4-10s” are typically Monday through Thursday, 10 hours per day, with every Friday off from work. About one-fifth of the NPPs have a “9-80s” schedule. “9-80s” are typically 9 hour days for 8 consecutive work days, 8 hours on the 9th day, and the 10th day off. Thus, every other Friday is a non-work day.

Another U.S. approach to overcoming smaller staffing levels includes industry resource and experience sharing. For example, industry groups such as the American Nuclear Society (ANS), the Nuclear Energy Institute (NEI), and the Institute of Nuclear Power Operations

(INPO) have become successful at developing forums for information and experience exchange. The ANS sponsors several conferences and embedded topical meetings each year to provide a forum for technical and business practice information exchange. The NEI has sponsored and manages the development of the Standard Nuclear Performance Model (SNPM), a common set of nuclear work functions, activity definitions, and activity-based cost approaches. NEI also sponsors functional teams from across the industry and encourages the participation of all plants to develop a set of industry best practices for each of the elements of the SNPM. INPO, which is partially staffed by on-loan plant employees who bring their own experience to peer team inspections and assessments, develops an informal industry experience knowledge base as these individuals gain experience from these team activities and take their acquired knowledge back to their home plant at the end of a two year exchange.

Unintentionally, the U.S. nuclear power industry has also developed reservoirs of knowledge and experience through industry consolidation. Five years ago in the U.S., there were 43 companies operating nuclear plants; today there are only 26, a 40% reduction (only one reactor was deactivated). As U.S. nuclear operating fleets have grown, they have created a new reservoir of technical and experiential knowledge. This reservoir, however, is not formally structured or industry-based. Examples of the results of this consolidation are occurring within the fleets of nuclear plants operated by one company.

Older fleets, including Duke, Entergy, Exelon, Progress Energy, and TVA, have developed internal peer teams to take advantage of best practices and shared technical experience. Additionally, when unusual technical issues arise, there is a greater depth of technical staff to be brought together to approach the problem. This also creates the development of new knowledge that is then available for the rest of the fleet.

Separately, two major U.S. nuclear plant alliances have formed that share both knowledge and personnel. The Strategic Teaming And Resource Sharing (STARS) alliance which includes Callaway, Comanche Peak, Diablo Canyon, Palo Verde, The South Texas Project, and Wolf Creek. The Utilities Service Alliance (USA), which includes Columbia, Cooper, D.C. Cook, Fermi-2, Ft. Calhoun, Susquehanna, and Wolf Creek. These alliances were formed, among other reasons, to take advantage of potential economies of scale in common functions, and increase leverage with large scale purchasing. Both alliances are currently claiming annual savings of approximately $1 Million USD at each plant directly attributable to alliance relationships. Both alliances are reporting limited resource sharing, mostly for refuel outage support and unusual engineering technical issue resolution support.

Another approach being pursued in the U.S. is specialized alliances. Several U.S. NPPs are considering forming an engineering services company. These plants recognize the potential for limited engineering and technical personnel availability due to the aging workforce. They are contemplating a plan where two or more plants would form an alliance with a vendor service company. Such an arrangement would allow a flexible, more responsive, engineering and technical services organization that applies economies of scale and shared expertise to operate with fewer personnel.

5. Knowledge Transfer

Knowledge transfer in the U.S. nuclear power industry is in its infancy. Most NPPs have maintained their standard training programs and have not take a strategic, systematic approach to knowledge transfer. However, there are a few exceptions. For example, one NPP has developed a mentoring program in conjunction with major capital projects. Omaha Public

Power District's Ft. Calhoun Station, in Nebraska, has 6 major capital projects over the next 5 years: Steam Generator Replacement, Pressurizer Replacement, Vessel Head Replacement, Extended Power Uprate, Dry Cask On-site Storage, and Life Extension. They have created a Major Projects department reporting to the Nuclear Vice President, staffed with a former senior manager.

The organization is partially staffed with senior engineers who will likely retire within the next five to seven years. These engineers will serve as mentors for newly hired engineers. The newly hired engineers in the department will become the system and component experts for their respective areas. Thus, the tacit knowledge for existing plant systems can be transferred in conjunction with the development of new technical expertise.

In some areas, tacit knowledge transfer is becoming programmatic. For example, Progress Energy's NPPs have a unique position titled "Director of Site Operations" or "DSOs." These DSOs are organizationally placed between a plant manager and the site vice president. This organizational approach at this utility is intended to develop potential new site vice presidents, and also provide "bench strength" for their leadership team. Other examples include in the U.S. nuclear power industry include:

- Assistant Plant Manager position at the Tennessee Valley Authority
- Internal manager rotations
- Senior Reactor Operator (SRO) license requirement for some leadership positions
- Operators rotating to become training instructors
- Maintenance craft internally transferring to become training instructors, work package planners, or plant work week schedulers
- Engineers internally transfer to become qualified plant operators

Other knowledge transfer approaches include broad, coordinated training programs. The South Texas Project Nuclear Operating Company (STPNOC) operates the South Texas Project, a 2500 MW(e), 2-unit nuclear plant south of Houston, Texas. STPNOC and Brazosport College in Brazoria, Texas have developed a relationship that facilitates training that is targeted for current and future nuclear plant employees. Brazosport College provides specific training programs for workers from a variety of industries in the region. Some of these programs directly support the South Texas Project NPP:

- Computer Software.
- Web-Based Training and Computer-Based Training Design.
- Core Competency Development.
- Leadership.
- Diversity.
- Team Development.
- Safety/Technical Skills.
- Customer Service.
- Communication.
- ISO 9000.

Another coordinated approach has a specific linkage between a single plant and a local college. The FirstEnergy Nuclear Operating Company (FENOC) operates the Perry and Davis-Besse plants in Ohio, and the Beaver Valley nuclear plant in Pennsylvania. FENOC and the Lakeland Community College in Kirtland, Ohio have developed the following coordinated educational program to support the Perry NPP:

- In partnership with Lakeland, students can achieve a two-year accredited Associate of Technical Studies degree with a focus on Nuclear Engineering Technology. This program prepares students for employment in selected areas within the nuclear plant.
- A 10-week field experience at the Perry Nuclear Power Plant is required. Students are exposed to a variety of specializations within the nuclear power plant, and utilize the skills learned during their fist two semesters.
- An Edison Electric Institute baseline test for the nuclear power industry and a background and drug test coordinated through FENOC must be passed to qualify for the program; Lakeland also requires placement tests in English, reading and math.

6. Workforce Planning

Work force planning activities are relatively new in the U.S. nuclear power industry. Until very recently, most U.S. NPPs had only a small human resources staff, which did not typically perform organizational development activities, workforce planning, or ascension planning. A few plants and companies began to perform these activities within the last few years, including AmerenUE's Callaway plant and TVA. These plants and companies have progressed and lead the industry in the U.S. in these areas. Within the last two years, several other plants have begun to work on attrition planning, including Detroit Edison's Fermi-2 and the South Texas Project Nuclear Operating Company.

Several nuclear companies have also begun modeling attrition to support future staffing plans. In the past, most U.S. plants used industry staffing benchmarking to help set staffing, and therefore, cost goals. The result was the identification of variances between a plant's staffing levels and the industry benchmarks. Approaches to correct for the variances were essentially tactical planning, always trying to keep pace. Recently, several companies have begun to develop strategic staffing plans, applying current benchmarking, modeling for future benchmarking and attrition, and applying the results as part of overall strategic plans.

7. Conclusions

Impending attrition in the U.S. will significantly impact nuclear plant operations and planning. The aging workforce in the U.S. nuclear power industry will create universal attrition problems, particularly in maintenance and engineering. These two areas require highly developed skills sets that require a combination of training and on the job experience. There is a likely shortfall of personnel in these two areas that will develop within the next 5 years, and beyond. Overcoming the potential lack of personnel will require a combination of actions, including:

- Identifying and planning for the potential personnel shortages.
- Identifying opportunities for staffing reductions where possible.
- Attracting, hiring, and retaining new personnel.
- Training these personnel, both technically and experientially.
- Conducting workforce planning analyses to identify and plan for potential personnel shortages.
- Identification of opportunities for process improvements, technology applications, and the reduction of unnecessary work.
- Using workforce planning models that apply the plants' expected attrition and overlays key elements such as historical attrition causes, future capital programs, and potential outsourcing or alliance opportunities.

Annex B

SUMMARY OF TVAN'S KEY LEADERSHIP PROGRAMME

1. Introduction

One of TVA Nuclear's (TVAN's) challenges is to respond to increasing competition and deregulation in the electric utility industry while still ensuring safe plant operation. Nuclear plant performance is improving across the industry, and leadership is challenging TVAN to be ahead of the competition. Key elements to meeting this challenge include strategic visioning, knowledge and learning management, competitive analysis to identify improvement opportunities, aggressive goal setting, and ensuring an appropriate culture. Also key to meeting this challenge is the development of a program that ensures future diverse leaders are developed for the organization and ready to meet the challenges of a competitive marketplace.

The TVAN Key Leadership Program is designed to help TVAN meet the challenges of a competitive marketplace and continue to set the standard for excellence in the nuclear industry. The objectives of the program are to ensure TVAN's Key Leadership positions can be readily filled by qualified internal candidates and that leadership teams are appropriately balanced. The major features of the Program are as follows:

- A panel of TVAN executive management (Key Leadership Panel) which meets quarterly to interview and select new candidates, review and monitor current candidate progress, and evaluate mentor effectiveness. The Panel also considers the individual attributes of candidates to ensure leadership teams have a balance of characteristics.
- An objective assessment, by trained external consultants, of candidate leadership competencies. This assessment provides insight into psychological and behavioral aspects of individual and team effectiveness. Personal Development Guides (PDG'S) are prepared based on assessment results.
- Mentors who provide coaching, feedback, and input into the candidates' development and progress.
- Individual development plans used to set goals and measure progress.
- Dedicated Organization Development Consultant who provides assistance to mentors in the candidate development process.

2. Key leadership panel

A Key Leadership Panel administers the TVAN Key Leadership Program. Specifically the Key Leadership Panel does the following:

(1) Ensure at least one key leadership candidate exists for each identified position or that appropriate action is initiated to identify or recruit an appropriate candidate.
(2) Ensure that leadership teams will be appropriately balanced prior to making selections for permanent placement.
(3) Recommend mentors for candidates.
(4) Determine progression paths for Key Leadership positions.
(5) Review the individual development progress of each candidate and assess their readiness for target management positions.
(6) Consider the addition or removal of candidates from the program, as needed.
(7) Ensure an adequate representation of women and racial minorities in the candidate pool.
(8) Make necessary adjustments to the program to correct any deficiencies.

3. Personal development guide

The Personal Development Guide (PDG) is prepared through an assessment process which focuses on personal characteristics, or *competencies,* essential to effective leadership in TVAN. Each Key Leadership candidate has a PDG prepared which provides insight into psychological and behavioral aspects of individual and team effectiveness. The PDG is used by the Key Leadership Panel to assist them in providing input to the candidate's Individual Development Plan (IDP) and as a reference in reviewing the candidate's profile in context of the overall TVAN Key Leadership Team.

The PDG provides feedback for individual and team attributes as listed below.

Individual Attributes

(1) Problem-Solving and Thinking.
(2) Emotion and Motivation.
(3) Interpersonal Relations and Communications Style.
(4) Understanding of Self and Others.
(5) Work and Leadership Characteristics.

Team Attributes (*how will this candidate balance the team?)*

The Key Leadership Panel developed attributes deemed important to team success. Key Leadership candidates are assessed on these attributes in an effort to build a team which reflects a balance of characteristics. Prior to permanent placement of candidates, the Panel reviews individual candidate attributes and then determines if the candidate can effectively contribute and add balance to the team. This approach enhances team communications and helps the team avoid team pitfalls such as "group think."

The TVAN team attributes which are assessed are as follows:

(1) Passionate/Dispassionate.
(2) Strategic/Tactical.
(3) Data Driven/Intuitive.
(4) Comfort/Discomfort with Ambiguity.
(5) Short term/Long term Results.
(6) Risk averse/Calculated Risk Taking.
(7) Innovative/Conventional Thinking.

Experience has shown that team dynamics significantly affect the quality of project outcomes. Teams with a diversity of perspectives produce more insightful and creative recommendations, whereas teams with a single perspective tend to be far less innovative and insightful.

4. Mentor assignments

The Key Leadership Panel assigns a mentor to each Key Leadership candidate. Mentors must be able to demonstrate the same characteristics as required for the candidates. They should also demonstrate a high level of commitment to contributing their time and talent as a mentor, excellent ability to provide coaching and feedback, ability to encourage problem solving and risk taking, and good listening skills.

5. Individual development plans

Each Key Leadership candidate has an individual development plan (IDP) customized to his/her individual career goals and development needs. Each plan addresses enhancing management and technical skills to the extent needed by the candidate. Each Key Leadership position has a defined progression path. The mentors work closely with the candidates in determining where they fit on the Progression Path Chart and what additional experiences, if any, are required. Each candidate then prepares an IDP, in consultation with the mentor.

6. Mentor coaching

In an effort to improve the overall performance of mentors assigned to Key Leadership candidates, an OD HR Consultant was assigned to work full time in formal engagements with the mentors. The role of the OD Consultant is as follows.

- Provide guidance and coaching to mentors assigned to TVAN Key Leadership candidates.
- Facilitate discussion between mentors and Key Leadership candidates regarding development opportunities and resources.
- Assist in looking strategically at the organization's Key Leadership development needs and making recommendations to close the gaps.

7. Candidate feedback

Semi-annually, Key Leadership candidates are surveyed to determine how well the Key Leadership Program is meeting their needs and expectations. A summary report is prepared and presented to the Key Leadership Panel.

Additional candidate feedback is received by doing the following:

- TVAN Executives routinely contact candidates to gather information about their Key Leadership experiences. Specific questions are asked about their mentoring experience and developmental opportunities.
- During the quarterly Key Leadership Panel meetings candidates are asked by the Panel to provide feedback on the Key Leadership Program.
- Each quarter, prior to meeting with the Key Leadership Panel, candidates are interviewed by an OD Consultant about the Key Leadership Program. Some candidates are more open about the program when this approach is used.

The Key Leadership Panel is very interested in receiving honest feedback about the program, and enhancements are made based on the feedback received.

8. Cost savings

Cost savings have been realized in 3 major areas as a result of the Key Leadership Program.

- Focus on internal placements has substantially reduced external recruiting costs.
- Ensuring depth in pipelines has reduced the risks of interruptions due to a lack of continuity of leadership.
- The program enhances personnel retention because candidates have predefined progression paths.

9. Keys to success

The keys to success for TVAN's Key Leadership Program are as follows:

- Chief Nuclear Officer and Senior Executive championship, as well as direct involvement and ownership in delivery.
- A development culture which supports the time and resources needed for development, coaching, and mentoring.
- Internal professional support provided to mentors.
- Teams with a balance of characteristics.
- TVAN senior staff modeling the desired behaviors.

Annex C

SUCCESSION MANAGEMENT IN NUCLEAR ELECTRIC/BRITISH ENERGY

Nuclear Electric/British Energy has formal succession management arrangements, which have evolved over the years to meet the needs of the company. Whilst they are an ongoing process, the arrangements are most manifest in an annual review which results in an overall succession plan for the company. The process embodies a twin-track approach of reviewing existing managers whilst also identifying younger staff with significant potential. These younger staff are allocated into one of two groupings: those identified as having director level potential, who have their development managed centrally, and those considered to have management potential, the development of whom is managed by the business unit to which they belong, with support from the center as requested. The staff in both these groupings are kept under review and, if the circumstances warrant it, there may be movement between the two groupings.

The aim of Succession Management is to ensure the company has sufficient experienced, qualified and tested staff to provide succession to senior, and other key, posts.

It has three main perspectives:

— Posts — generation of succession plans to cover identified posts in the short (1 year) and medium (2–5 years) term
— Individuals — identification of those individuals with potential, who's development needs to be managed
— Skill areas/vulnerabilities, including managerial and technical competences where the company needs to take action.

The succession arrangements include six key processes, as illustrated in Figure 1. These are described briefly below:

(1) Company succession review process:
- this is a bottom-up business unit, division, company-wide review;
- to develop and maintain local, divisional and company wide succession plans;
- to establish overall succession health of the business;
- to identify new nominees for senior management development;
- to provide input to other processes described below.

(2) Developing staff with significant potential. This involves:
- putting nominees through assessment centers to validate their potential;
- developing personal development plans;
- managing learning opportunities;
- considering career moves (direct nomination for specific opportunities)
- mentoring;
- identifying/organizing appropriate external training/development activities.

(3) Developing existing managers:
- running assessment and development centers to create/enhance action plans;
- identifying/organizing appropriate external training/development activities;

(4) Resourcing senior posts:
- nominating candidates for vacancies from existing databases of competent staff;
- organizing interviews;
- involvement of succession management process owners in interview panels for senior positions.

(5) Providing support to local development:
- providing guidance and advice;
- coordinating/facilitating secondments, moves, job swaps, etc.;
- provision of assessment and development centers to support local succession arrangements.

(6) Input to company development:
- influencing company initiatives;
- data on capability of organization to accommodate different organizational patterns.

While much of the focus of the process is on people and their potential, an important element of the review process is to gather data on potential development opportunities which exist, or are likely to arise, in the various parts of the organization.

Various tools are used to support the process. One example, (Figure 2), is that of the experience profile required for a Director level appointment.

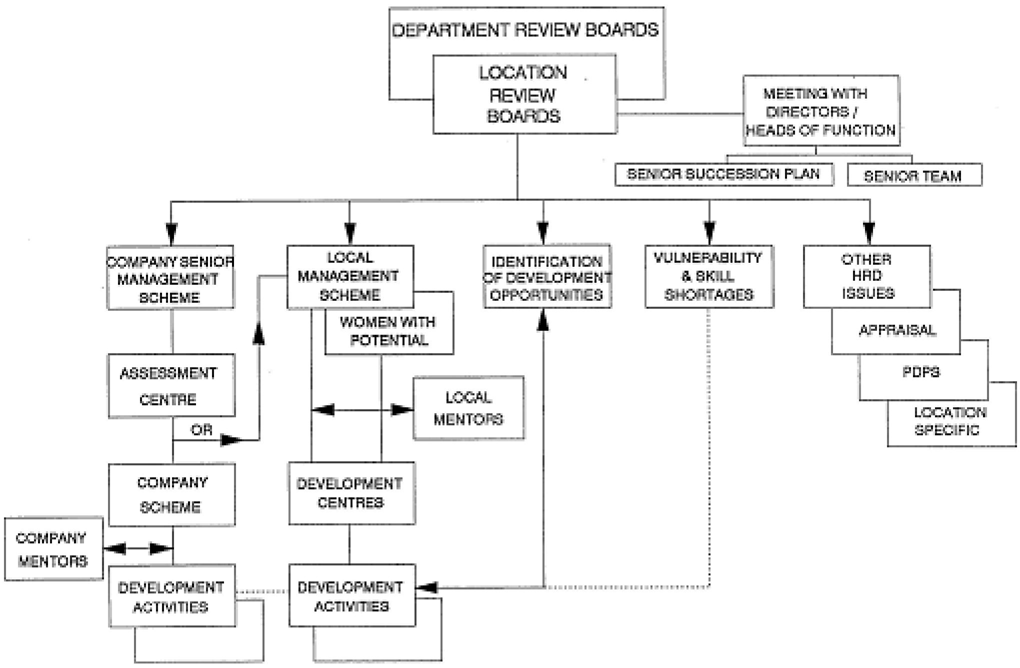
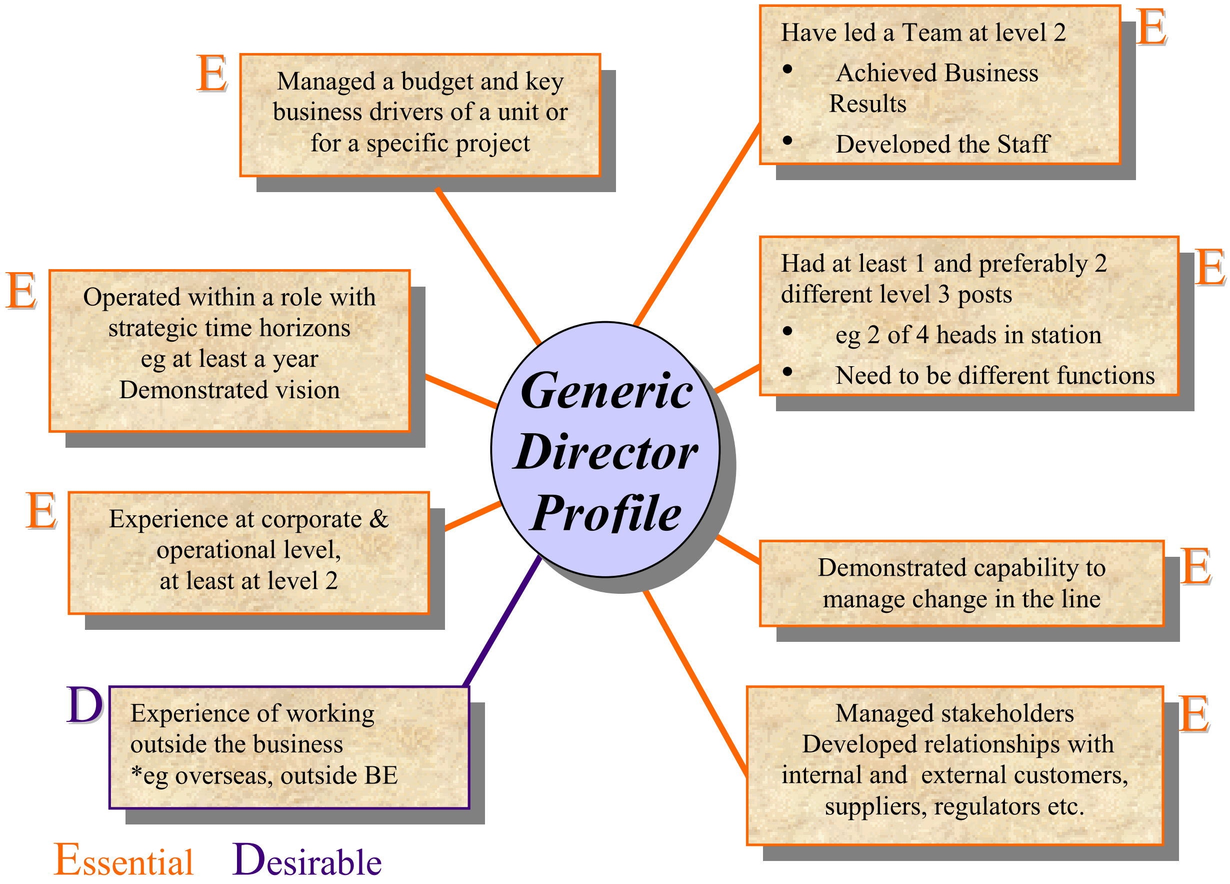


FIG. 1. Succession processes.



Notes

This profile should be used in conjunction with post/competence profile of a specific role/s to help plan relevant development or consider suitability of candidates.

FIG. 2. Example profile.

Annex D

NUCLEAR AND RADIOLOGICAL SKILLS STUDY (2 October 2002)

Executive Summary: Report of the Nuclear Skills Group

1. Introduction

The ability to apply nuclear and radiological technology has a key role in the health sector (approximately 30 million radiology examinations are carried out every year), plays a principal part in national defence, is essential for the continued operation of existing nuclear power stations (which currently make up approximately 23% of the UK's generating capacity), is essential to nuclear and radiological clean up, and is needed to support a wide spectrum of research, development and manufacturing activity. The recent PIU Energy Review also spoke of "good grounds for taking a positive stance to keeping the nuclear option open"; the availability of skilled people being key to such a policy.

Concern exists, however, that a shortage of people with the skills needed to apply nuclear and radiological technology is developing. Prompted by assessment of the international situation by the OECD/NEA, a survey of the national nuclear skill base has been conducted under the direction of the Nuclear Skills Group, chaired by Professor John Chesshire. The skills study has been a good example of effective joint working between a number of Government departments (the study being co-sponsored by DTI, HSE, MoD, DH, and DfES), industry, academia and professional institutions.

The survey has identified that the health sector currently has a shortage of people with radiological skills and although the nuclear sector does not have an immediate overall shortage, a number of 'hot spots' exist in disciplines such as safety case production and radiological protection. Postgraduate education and apprentice training are also in a fragile state, raising concerns about future workforce development.

Conservative estimates suggest that the sector will require around 50,000 recruits over the next 15 years, excluding potential demand from new build, equivalent to just under 60% of the current skilled population, and this demand must be satisfied from the wider engineering and physical science sector at a time when:

"The 'disconnect' between the strengthening demand for graduates (particularly in highly numerate subjects) on the one hand, and the declining numbers of mathematics, engineering and physical science graduates on the other, is starting to result in skills shortages." [1]

This report outlines the measures that have been taken to quantify the problem, looking up to 15 years into the future, and sets out a number of recommendations to avert potential skill shortages developing in the future.

2. The key issues

Promotion of the Skill Sector: Engineering and physical sciences are unpopular fields of study and unpopular career choices for young people; and nuclear and radiological

[1] SET for success: The supply of people with science, technology, engineering and mathematics skills. The report of Sir Gareth Roberts' Review. April 2002

technologies are unpopular choices in this unpopular field. Action to encourage more young people into these sectors is urgently needed.

Underpinning of Essential Learning Pathways: The learning pathways required to develop the skills needed by the sector must be defined and a means devised of underpinning those pathways.

Underpinning Education Institutions: The education and training institutions, colleges and establishments needed to service the above learning pathways must be identified and a means of ensuring their viability established, otherwise the infrastructure to deliver essential training will be lost.

3. Background

The ability to apply nuclear and radiological technology has a key role in the health sector, plays a principal part in national defence and is fundamental to the operation of the United Kingdom's existing nuclear power stations. It is also essential for nuclear and radiological clean up and is needed to support a wide spectrum of research, development and manufacturing activity. The ability to manage the technology is also fundamental to keeping the option open for construction of new nuclear power stations, as considered in the recent PIU Energy Review. Concern exists, however, that a shortage of skilled people is developing that could undermine the ability of the nuclear and radiological sector (defined below) to operate, the potential shortage lying in all roles: practitioners, educators, trainers and regulators.

This concern has been expressed both nationally and internationally. International concern is articulated in the OECD report "Nuclear Education and Training: *a cause for concern?*" (2000), and evidenced by the recent IAEA Senior Level Meeting on the 'Management of Nuclear Knowledge" (June 2002). Nationally, the NII's report "Education and Research in British Universities" (2001, revised 2002) assessed the strength of one element of the UK sector and identified a situation of "ageing academics, ageing facilities and no undergraduate courses with significant nuclear content".

The OECD report contained the recommendation that "Governments should engage in strategic planning of education and manpower, integrated with human resource planning, to encourage young students into the industry". The Nuclear Skills Group (NSG) was therefore formed to assess the national situation and formulate a series of recommendations to overcome any potential shortfalls.

4. Skills Study

The NSG commissioned two reviews to provide evidence upon which to base their recommendations and to act as a foundation for future work:

- A skills audit to quantify the size and form of the sector today; and
- A foresight study to consider the factors that may affect the sector over the next 5, 10 and 15 years.

In addition, a wide range of individuals from within the nuclear, radiological and education fields, and from other Government departments, were consulted to ensure that the study was based on a broad consensus of opinion and that the recommendations made were consistent with more widely based initiatives.

5. Nuclear and Radiological Sector

The sector encompasses organisations that apply nuclear and radiological technology as a primary purpose (power generation, health, defence, and nuclear clean up[2]) and also those that apply radiological technology as a secondary purpose (eg non-destructive examination, pharmaceuticals etc). The audit has identified a current (2002) population of approximately 135,000 skilled people, of which around 64% are primary users and 36% secondary users.

SKILLED POPULATION	POPULATION	%	POPULATION	%
PRIMARY USERS	86,000	64%		
HEALTH			30,000	22%
DEFENCE, POWER GENERATION, FUEL CYCLE & CLEAN UP			56,000	42%
SECONDARY USERS	49,000	36%	49,000	36%
TOTAL	135,000	100 %	135,000	100 %

Of the primary users, a distinction can be made between the health sub-sector, which comprises predominately medical diagnosticians and therapists supported by medical physicists and clinical scientists, and the power generation, defence and nuclear clean up sub-sector, which comprises engineers and physical scientists.

The Health sub-sector can be further subdivided into users of radiological techniques for diagnosis and therapy, typified by radiologists and radiographers, and the clinical scientists, engineers and technicians who design, maintain and specify how to operate radiological equipment. The health sub-sector has a population of approximately 25,000 radiologists and radiographers and around 5,000 clinical scientists, engineers and technicians.

The Defence, power generation, fuel cycle and clean up sub-sector can also be sub-divided into 'client' and 'support' organisations, the support organisations comprising contractors, educators, researchers and regulators, the population of these groups being 46,000 and 10,000 respectively.

6. Future Trends

Foresight — Primary Users

Considering Primary Users of the technology, while trends in the health sub-sector could be judged fairly readily, the main uncertainty arose from how the defence, power generation, fuel cycle and clean up sub-sectors would evolve. A range of plausible scenarios were therefore considered, the following 'seasons' being postulated:

[2] Encompassing the fields of decommissioning, waste management and environmental remediation.

- **Autumn:** Operation of extant equipment to the end of design life, but not replaced, followed by nuclear and radiological clean up.
- **Winter:** Abandonment of nuclear or radiological technology, leaving nuclear clean up as the core of the industry.
- **Spring:** The ‘autumn’ scenario, but with equipment replacement.
- **Summer:** Significant expansion of nuclear or radiological technology.

he nature of the problem in each scenario is the same: to attract recruits from the wider national pool of engineers and physical scientists at a time when engineering and physical sciences are increasingly unpopular career choices. The sector therefore faces the challenge of recruiting from a potentially diminishing pool of suitable recruits. Nuclear clean up is common to all scenarios and the rate at which it can be pursued will be limited by the availability of skilled people. The recruitment and retention challenge is also likely to be differentially affected by the season, eg the winter scenario is likely to be compounded by skilled persons being attracted out of the industry to other UK and international sectors.

Indicative Scenario — Primary Users

Indicative numbers of the accumulated total of skilled primary users likely to be demanded by the sector over the next 5, 10 and 15 years are given in Table 1 for one illustrative scenario in which:

- Health grows by 10% every 5 years[3];
- Work on nuclear clean up doubles over the 15–year period, in addition to taking on station closures;
- The current power station closure programme is implemented, but new build is not pursued; and
- Defence and the Fuel Cycle remain status quo.

[3] Noting that the Health Sector already has a 10% shortage of radiologists and radiographers. Audit Commission review of national findings – Radiology – July 2002.

Table 1

TABLE 1
INDICATIVE SCENARIO – PRIMARY USERS
Sector Supply - Accumulated Retirements

Based upon the age profile of the current Primary User population, the accumulated number of skilled people likely to retire from the sector over the next 5, 10 and 15 years are:

RETIREMENTS – LOSS OF SUPPLY	Over 5 years 2002 – 2007	Over 10 years 2002 – 2012	Over 15 years 2002 – 2017
HEALTH	3,700	6,600	9,600
DEFENCE, POWER, FUEL, & CLEAN UP	6,400	14,500	22,600
TOTAL RETIREMENTS	**10,100**	**21,100**	**32,200**

Sector Demand – Accumulated Retirements, Shortage and Growth

Although the scenario assumes that power generation will decline, health and nuclear clean up grow, giving rise to overall sector growth. The health sub-sector already has a skill shortage and to accommodate this, sector growth and retirements, the total accumulated demand could be as high as:

PRIMARY USER DEMAND	Now	Over 5 years 2002 – 2007	Over 10 years 2002 – 2012	Over 15 years 2002 – 2017
RETIREMENTS		10,100	21,100	32,200
SHORTAGE	3,000	3,000	3,000	3,000
GROWTH		4,900	8,900	14,800
TOTAL DEMANDS	**3,000**	**18,000**	**33,000**	**50,000**

The breakdown of the above, accumulated, demands are:

SUB-SECTOR DEMAND	Over 5 years 2002 – 2007	Over 10 years 2002 – 2012	Over 15 years 2002 – 2017
HEALTH			
Radiologists and Radiographers	8,000	13,000	18,000
Clinical Scientists	1,600	2,600	3,600
DEFENCE, POWER, FUEL, & CLEAN UP			
Professional and Associate Professional [i]	4,450	10,000	15,500
Skilled Trade, Process Plant and Machine Operator [ii]	2,250	4,900	7,850
Others [iii]	1,700	2,500	5,050
TOTAL DEMANDS	**18,000**	**33,000**	**50,000**

i. 'Professional and Associate Professional' refers to a person qualified to Level 4 and 5 in the National Qualifications Framework, typically having a minimum qualification of a Bachelors degree.

ii. 'Skilled Trade, Process Plant or Machine Operator' refers to a person with a vocational or occupational qualification at Level 3 or below in the National Qualifications Framework.

iii. Others include the remainder of the population, principally Administration and Secretariat.

Impact — Graduates

To put these figures into perspective, 15,500 graduates required by the power, fuel, defence and clean up sub-sectors over the next 15 years equates to approximately 1,000 graduates per year. Of these, 700 are replacements for retirements and 300 are a response to growth of nuclear clean up. By comparison, the sector's 2001 graduate recruitment target was approximately 560[4].

Considering the major engineering and physical science disciplines from which these graduates must be recruited (mechanical, electrical, electronic, civil and chemical engineering, physics and chemistry), in 1994 some 18,000 students were accepted to study these subjects at Higher Education Institutes. By 2001 this figure had fallen to 13,250, a fall of 26% in eight years. Noting also that these figures do not take account of students who fail to graduate or choose an alternative career on graduation, if these trends continue, of a rising demand and a falling supply, the nuclear and radiological sector may be seeking to recruit the equivalent of 10% of all UK engineering and physical science graduates in 10 years' time, even though the nuclear sector constitutes less than 1% of the national labour market engaged in engineering activity[5].

Impact — Apprenticeships

The indicative scenario also demonstrates that some 7,850 people with skilled trades skills will be required over the 15-year period, highlighting the need for apprenticeships. Such schemes are of paramount importance as they not only deliver people with the required skilled trades, but also provide an alternative entry route for people that may attain higher positions through career development. Despite their importance, a recent review of apprenticeship training led by Sir John Cassells[6] identified that:

"England does not currently have a strong apprenticeship system. It stood in danger of not having an apprenticeship system at all following the collapse of the previous system in the 1970s and 1980s. There is a real sense in which apprenticeship remains marginal within our education and training system… The reasons it is so are that it has been inconsistently delivered; poorly managed; and poorly known about and understood."

7. Unpopularity of Engineering and Physical Sciences

Engineering and physical sciences are unpopular fields of study, both academic and vocational. However it is from this pool of students that the nuclear sector must recruit. Unless this trend is reversed, the nuclear sector will face the challenge of recruiting from a diminishing pool of potential recruits. The general unpopularity of engineering and physical science has been recognised in the recent review conducted by Sir Gareth Roberts[7], which identified that:

"The 'disconnect' between the strengthening demand for graduates (particularly in highly numerate subjects) on the one hand, and the declining numbers of mathematics,

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[4] Estimate of the number of graduates that nuclear and radiological sector employers sought to recruit in 2001.

[5] Labour Market Statistics - September 2002: 7.85 million people engaged in Energy & Water, Construction, Manufacturing, and Transport & Communications.

[6] Modern Apprenticeships – the way to work. Report of the Modern Apprenticeship Advisory Committee. Chairman, Sir John Cassels. Sept 2001.

[7] SET for success: The supply of people with science, technology, engineering and mathematics skills. The report of Sir Gareth Roberts' Review. April 2002.

engineering and physical science graduates on the other, is starting to result in skills shortages."

The IAEA have also recognised this issue, as identified at a recent IAEA conference on managing nuclear knowledge[8]:

"There is a general difficulty in attracting young people into the field of nuclear engineering and physical sciences: the courses seem too difficult; upon graduation the jobs are uninteresting and the pay is too low, and there is a view that only the 'least attractive' people go into these fields. It was also pointed out "before we can educate new people in this field, we must first attract them to the field; and engineers themselves are lousy marketers!"

8. Sector Issues

People interviewed in the skills audit and foresight studies reiterated the above concerns and the research identified that while some skills shortages exist today, the greatest shortages being in the areas of medicine, science, technology and regulation, it was anticipated that these shortages would increase in coming years and would extend into the areas of operations and management. The foresight exercise identified several factors affecting this, but three recurrent themes were:

Poor Communication: The importance of communication was emphasised, both in encouraging people into the skill sector and encouraging the wider public to take a rational view of the application of nuclear and radiological technology. In particular it was emphasised that the media and public raise emotional concerns to which the nuclear and radiological sector invariably counter with logic, but rational argument often cannot counter emotional fears.

Poor Co-ordination: The potential for skills shortages is generally recognised and several initiatives exist to address the problem, but these tend to be uncoordinated, hence their collective effect is not as great as it should be.

Apparent Indecision: Indecision in an industry will discourage recruitment and having many policies under consideration will appear to potential recruits as indecision, eg 'keep the nuclear power option open' or 'implement safe-store and defer decommissioning'.

9. Current 'Hot Spots'

A number of skill 'hot spots' have been identified in the sector now, including:

- **Health Sub-Sector**: Shortages currently exist in all health sub-sector occupations, with a national shortage of radiologists and radiographers of 10% being identified[9] and local shortages as high as 30% being reported in some disciplines. A number of Health Service workforce development plans exist, including 'The Cancer Plan' and the 'Strategy for the Professions in Healthcare Science'. These place emphasis on diagnosticians and therapists, but equal attention must be paid to the workforce development of clinical scientists, engineers and technicians.

[8] Meeting of Senior Officials on Managing Nuclear Knowledge. 17-19 June 2002. International Atomic Energy Agency, Vienna International Centre, Austria.
[9] Audit Commission review of national findings – Radiology – July 2002: Identifying a mean vacancy rate for radiologists and radiographers of 10%.

- **Radiological Protection**: Health physics describes the skill sets needed to apply techniques and procedures to protect people from the effects of radiation and is an essential function for all primary and secondary users of radiological technology. Health physicists have been recognised as a shortage category for many years but evidence suggests that poor marketing of career opportunities is hampering recruitment. Career development paths also encourage people to leave their specialisation, principally into higher management, so compounding shortages. But good people with drive are unlikely to remain in a field where people from another discipline hold key management positions.
- **Radiochemistry:** Radiochemistry is essential for the production of radioactive samples used in countless medical procedures and is an important building block in nuclear and radiological clean up. BNFL's support for the Manchester radiochemistry department has corrected, in part, a decline in radiochemistry research but the question remains about what is required: a focal point upon which radiochemistry research is concentrated or a centre of excellence supporting satellite departments that achieves diversity across the research sector?
- **Regulation:** The age profile of NII inspectors exhibits a definite age skew, which, if unchecked, will result in a skill shortage within 5 to 10 years. This is due to NII's need to recruit people with significant nuclear experience. Most recruits will be over 35, so automatically skewing the age profile, and NII are faced with a perpetual challenge of how to attract a small cadre of experienced people from within the sector.
- **Nuclear Education in HEIs**: A common view amongst employers is that they need generalist engineers and physical scientists who can be given specialist in-house training in nuclear technology. As a consequence, there is a low demand for specialist nuclear education in HEIs. This has two effects:
  - The ability to deliver postgraduate nuclear education is diminishing and will be lost if corrective action is not taken.
  - The ability to deliver nuclear modules in undergraduate education is diminishing; hence few undergraduate students are exposed to the challenges a career in the sector may offer.
- **Modern Apprenticeships**: Vocational education not only provides the skilled trades required by the sector, but also provides an alternative entry route for professionals and associate professionals through continuous professional development, many engineers in the sector today having entered through the apprenticeship route. However, vocational education has declined in recent decades, which is detrimental to the sector.
- **Safety Case Writing**: The nuclear sector has always had a strong safety culture and has evolved comprehensive safety practices including the application of written safety cases. The adoption of written safety cases is becoming more widespread in industry and, as a result, there is increased competition for good safety case authors. This is an example of skills developed in the nuclear sector being deployable in other sectors but without reciprocal transfer.
- **Criticality Assessment**: Criticality assessment is unique to the nuclear sector but, with the decline of nuclear research, fewer faculties exist to educate such people and there is less incentive for individuals to acquire those skills.
- **Nuclear Safety Research**: There is increased reliance on expertise and facilities abroad, especially on water reactor technology.

- **Control and Instrumentation**: Control and Instrumentation is key to all process engineering; hence the nuclear sector experiences stiff competition for such skilled people.
- **Numerate Graduates**: There is a migration of people with high quality mathematical modelling skills to the finance and insurance sectors, or to scientific consultancies, which have the ability to pay high salaries for those skills.
- **Project Management**: A decreasing number of people have both the skills to project manage a major development and an appropriate appreciation of nuclear issues.
- **Corporate Capabilities**: A number of corporate capabilities exist in only limited numbers, eg the design and manufacture of nucleonic detectors or the design and manufacture of large pressure vessels.

10. Future Programme

The future programme must focus on three strategic issues:

Promotion of the Sector: Promotion of engineering and physical science in general, and of nuclear and radiological technology in particular, to encourage recruitment into the skill sector.

Underpinning of essential Learning Pathways: Definition and underpinning of the essential learning pathways needed to develop the skills required to apply nuclear and radiological technology.

Underpinning of Education Institutions: Measures to underpin the education and training establishments needed to support the above learning pathways.

Three closely linked functions, but with subtly different aims, are training, education and research. In addressing the required learning pathways and educational institutions a distinction must be made between these three functions and measures taken to ensure a correct balance is maintained. In this report the distinction is considered thus:

Training: The development of skills that enable people to perform predictable tasks.

Education: The advancement of an individual's fundamental understanding of a discipline, enabling that person to develop processes or consider situations beyond predictable limits.

Research: The expansion of fundamental understanding of a discipline to enable the person to explore new possibilities within a field to produce new diagnostic techniques, more efficient processes, or safer operations

Annex E

ASSURING A CAPABLE WORKFORCE THROUGH PARTNERSHIPS BETWEEN NUCLEAR UTILITIES AND POST-SECONDARY EDUCATIONAL INSTITUTIONS*

1. Introduction

Though the trends vary from country to country, there are challenges emerging globally to traditional staffing patterns at nuclear power plants (NPPs) and other highly technical working environments. A companion problem is assuring that requisite knowledge, skills, and attitudes (KSAs) are retained and enhanced by those remaining in the workforce even as those individuals are being depended upon in the transfer of critical KSAs to a new generation of workers. This annex posits that these are interrelated challenges that can be addressed through effecting both internal and external partnerships. Selected successful examples are cited as are a variety of related references.

2. Character of the challenges being faced

The headline of the “Money” section of The Birmingham News (Alabama, USA) on October 5, 2003, dramatically stated the challenge being confronted by many businesses worldwide: Fewer skilled workers ahead. Like a roadway warning that there is a bridge out ahead, the article by Cheryl Hall of The Dallas Morning News quotes Roger Herman, a well-known workplace forecaster who heads the Herman Group of Greensboro, North Carolina, USA, as saying, “The party’s over. We’re [the USA] now entering a repeat crisis of the late 1990s. We expect to be totally back into the warm-body syndrome” — where hiring anyone with a pulse will do — “ by the latter part of 2004.” The article goes on to cite the “double-whammy” impact of increased attrition of current workers and the greatly reduced availability of qualified replacement workers. The article also cites the skilled worker retention problems being experienced even in China — where sheer numbers of workers are not the problem — to emphasize the multiple factors involved in this complex issue.

The article referenced above is representative of increasing recognition of the challenges that companies are having retaining and hiring sufficient qualified workers to properly operate their businesses. Other factors influencing this phenomenon include the following:

- An ageing workforce with enormous tacit knowledge that needs to be retained
- A more diverse and more transient worker pool requiring new management sensitivities
- A workplace comprised of four age cohorts with differing attitudes and values
- Workers wanting more meaning and purpose in their work
- Asset-based revenue strategies that often ignore human and intellectual capital
- Inverse workforce trends in U.S. service (up) and manufacturing sectors (down)

* This annex was prepared by Mr. Lawrence B. Durham, Sterling Learning Services, Inc. Birmingham, Alabama, USA.

Even as the trends reported above are unfolding, nuclear power plants (NPPs) in the U.S. are being influenced by other more optimistic circumstances.

- Even after 9/11, public opinion of the need for NPPs continues to improve.
- NPP utilities are more attentive to demographic, economic, and political factors.
- Public relations and planning initiatives of the NPP utilities have improved.
- There is renewed support for national energy independence including the use of nuclear generation to produce hydrogen for energy applications.
- Regulatory groups are more conciliatory.
- New generation plant initiatives are active.
- Businesses are focusing more on human capital as their primary productive asset.

The principal focus of this paper is to explore ways by which business and industry in general and NPPs in particular might more effectively focus on human capital as their primary productive asset. Since the 1990 publication of Peter Senge's signal work, The Fifth Discipline, much has been written and many corporate initiatives have been undertaken to develop "learning organizations". There has also been a great deal of misunderstanding concerning just what a "learning organization" is and the profound cultural shifts required to sustain the requisite changes in how the individuals who comprise organizations think and interact. Not only must the basic processes that govern how an organization functions become systematic, the mental models employed by its inhabitants must change to facilitate continuing dialogue and individual as well as corporate learning. Effecting and sustaining such change processes can result in learning's becoming a fundamental business practice and, therefore, a driver of shareholder value.

3. The evolving definition of training

One paradigm shift that is required to nurture a learning organization is to stop confusing an organization's having a training department with its being a learning organization. This fact has become increasingly recognized within the NPP community as utilities have created sub-groups and matrix organizations to focus on human performance in the broadest sense – as a driver of plant performance. While personnel training has historically been considered as both the cause of and the solution to most problems, non-training interventions are now being increasingly used — with and without training — to improve performance. As a result, the skill sets of traditional trainers are requiring expansion to include new and different tools and capabilities. Indeed, trainers are evolving to performance consultants as they learn how to move beyond classrooms, simulators, laboratories, and structured in-plant exercises to assisting with problem analyses and best response determinations to close gaps between observed and desired performance. Often this approach can be achieved through enhanced intra-organizational communication and collaboration. The widespread use of inter-discipline task teams is one example of such cooperation. Frequently, however, current plant staff members do not possess the skills and knowledge to address more complex circumstances. In some cases, assistance from external resources can be useful to augment current capabilities and to teach company personnel techniques for handling future situations of a similar nature. In other instances, the disposition of matters by outsourcing is more cost-effective. Externally administered employee assistance programs provide an illustration of this type of partnership.

Within the traditional training arena, the landscape is changing rapidly to include an increased use of outsourcing. Some best-practice companies are even certifying suppliers of training just as they would producers of safety-related plant components. Such an approach towards ensuring quality training is consistent with NNP industry standards. In Report 2002 of International Comparisons: Annual Accounting of Worldwide Patterns in Employer-Provided Training, Michael J. Marquardt and his associates reported for the American Society for Training and Development (ASTD) that of businesses considered "training investment leaders," greater than 80 percent use four-year colleges and universities for some type of training services and in excess of 60 percent use two-year community and junior colleges for those services. Those same businesses devoted greater than three percent of their total payroll to training and accomplished approximately 40 percent of their total training in settings other than instructor-led classrooms.

4. Benefits of industry-educational partnerships

Based on the ASTD data presented above, those leading companies obviously consider training partnerships with post-secondary educational institutions to be good business. Through such relationships, business and industry gain and maintain a steady flow of workers while post-secondary education gains financial, curriculum, and student recruitment support. Additionally, business and industry reduce overhead associated with redundant in-house training programs and post-secondary education fulfills its mission to meet the learning needs of its varied constituencies. These partnerships are truly "win-win" pacts.

5. Evolving definition of post-secondary education

The movement to a knowledge-based economy in the U.S. has provided the motivation and the technological means for post-secondary educational institutions to adapt a new educational paradigm. Institutional fiscal difficulties have often led faculties to emerge from curriculum design time warps and accreditation pseudo-constraints. Academic creativity and customer needs have melded to forge exciting new initiatives. The principal characteristics of these new models of post-secondary education include the following:

- More lifelong re-skilling and learning.
- Less institutionalized resistance to change.
- More sophisticated information and telecommunication technologies.
- Fewer barriers to 24/7 access from anywhere.
- More effective public-private partnerships.
- More collaboration with business and industry.

6. Examples of working partnerships

The following programs are illustrative of the viability of partnerships between industry and post-secondary education. Contacts for further information should be made directly to the respective educational institutions.

- Millstone Station and Three Rivers Community College, Connecticut, USA
  Associate Degree in Nuclear Engineering Technology
- Wolf Creek Nuclear Operating Company and Flint Hills Technical College, Kansas, USA
  Associate of Applied Science in Power Plant Technology
- Perry Nuclear Power Plant and Lakeland Community College, Cleveland, Ohio, USA
  Associate of Applied Science Degree in Engineering Technology
- Calhoun Community College, Decatur, Alabama, USA

Associate of Applied Science in Aerospace Technology (developed with Boeing)

- Energy Providers Coalition for Education (EPCE) – a consortium of electric utilities working with Bismarck State College in North Dakota, USA
- University Network of Excellence in Nuclear Engineering (UNENE) – an alliance of Canadian nuclear power utilities, four universities, research and regulatory agencies; *Master's Degree in Nuclear Engineering recently begun at McMaster University*
- University of Ontario Institute of Technology: Bachelor of Engineering in Nuclear *Engineering; Bachelor of Science in Radiation Physics*; partnership with Durham College and Ontario Power Generation (and others)
- FirstEnergy Corporation (Akron, Ohio, USA), Transmission & Distribution Group: Accredited Power Systems Institute; grants associate degrees to educate and recruit future employees; five Ohio educational partners (two-year colleges); New Jersey partner planned
- The University of Tennessee – Knoxville: Maintenance Reliability Center; brings together several universities and numerous diverse industries to collaborate on practical research of direct, applied interest to participating industries which provide funding
- Selected degree programs via distance learning (There are many others.)
    - University of Phoenix: extensive online academic programming; scattered campuses, but virtual campus available anywhere, anytime to registered students; programs fully accredited
    - Excelsior College (formerly Regents College): extensive online academic programming; credit for experience geared to U.S. Navy nuclear power program and to NPP training programs accredited by the National Nuclear Accrediting Board
    - The University of Tennessee — Knoxville: *M.S. in Nuclear Engineering* and *Certificates in Nuclear Criticality Safety and in Maintenance and Reliability Engineering*; frequent web cast colloquia on nuclear topics

7. Where to from Here?

The spread of knowledge management and 24/7 accessibility to programs designed to enhance current job capabilities or provide original knowledge for workers should result in a continued re-examination of traditional academic and business practice models. This, in turn, should result in a further convergence of traditional training with knowledge management and learning technology. Increased attention will be necessary to the retention and retraining of current workers; to the recruitment of new workers; and, to incentive and reward systems that balance work-life quality with regulatory, human performance, plant safety, and production expectations.

Established standards, processes, and legal protection for intellectual property rights should receive increased attention as efficiency and cost-effectiveness are sought while balancing individual rights and corporate responsibilities. Corporate good-will relationships should be established from universities down to kindergarten level. Increased training business process outsourcing (BPOs) should be initiated with both public and private post-secondary institutions. Mutually beneficial partnerships should be established between companies and their employees (or their bargaining units), their local schools, their communities, and even between companies competing for workers.

7. Summary and lessons learned

1. Collaboration between industry and post-secondary education can be successful.

- Improved information exchanges are needed.
- Industry needs to know services and products available from educational institutions.
- Educational institutions need to know industry requirements.
- Shared funding arrangements work out better since all parties have ownership.
- Binding contracts should be used to assure accountability.

2. Change management will be necessary.

- Accreditation processes and regulatory requirements will be invoked as barriers.
- Benchmark successful initiatives to address such pseudo-barriers.
- "Win-win" educational partnerships have proven to be effective when the will to change exists.

3. A good business case can often be made to outsource training.

- Yet, internal needs and external standards must still be respected and met.
- These are not mutually exclusive conditions.
- Training managers can complement human resource strategy planning and supply-chain staff procurement processes.

4. Because knowledgeable and safe employees are a company's most valuable assets, they are therefore the company's principal competitive edge!

- Company policies, procedures, and practices must be worker sensitive.
- It is much less expensive to retain a current employee than to recruit and train a new one.
- A satisfied current employee is a company's best recruiter of new employees.
- Demographic data are clear – shortages of highly skilled technical workers are a reality.
- The ageing workforce dictates prompt attention to prevent critical tacit knowledge loss.
- The most successful companies will be those that best manage their intellectual capital.

Annex F

EDUCATION AND TRAINING IN NUCLEAR ENGINEERING AND SAFETY

Summary

The need to preserve, enhance or strengthen nuclear knowledge is worldwide recognized since a couple of years. Within the 5th framework program the European Commission supports the European nuclear higher education network. The ENEN contract started on Jan 1, 2002 and lasts for 24 months. The Commission support for this "accompanying measure" amounts to € 197 716.

Based upon a year-long extensive exchange of views between the partners of ENEN, consisting of a representative cross section of nuclear academic institutions and research laboratories of the EU-25, a coherent and practicable concept for a European Master of Science in Nuclear Engineering has emerged. The concept is compatible with the Bologna philosophy of higher education for academic education in Europe. Pursuing the sustainability of the concept, the ENEN partners organized themselves in a non-profit-making association.

Within the 6th framework program, the Commission services favourably evaluated the proposal: "Nuclear European Platform of Training and University Organisations". The objectives of the NEPTUNO co-ordination action are to establish a fair dialogue and a strong interaction between the academic and the industrial world and to bring all nuclear education and training activities under a common strategy of the ENEN type. The present proposal schedules for 18 months and the Commission earmarked a financial contribution of € 830 619.

1. Introduction

The need to preserve, enhance or strengthen nuclear knowledge is worldwide recognized since a couple of years.

"Although the number of nuclear scientists and technologist may appear to be sufficient today in some countries, there are indicators, e.g. declining university enrollment, changing industry personnel profiles, dilution of university course content, and high retirement expectations, that future expertise is at risk." [1]

"Today, the priorities of the scientific community regarding basic research lie elsewhere than in nuclear sciences. Taken together, these circumstances create a significantly different situation from three to four decades ago when much of the present competence base was in fact generated. In addition, many of the highly competent engineers and scientists, who helped create the present nuclear industry, and its regulatory structure, are approaching retirement age. These competence issues need to be addressed at Community level and a well designed Community research and training program should play a role that is more important than ever before. This is an area where the concept of an European research area should be further explored." [2]

"In September 2002, the (IAEA) General Conference noted that the need to preserve, enhance or strengthen nuclear knowledge arises irrespective of the future expansion in the applications of nuclear technologies, and requested the Director General to note the high level of interest of Member States in the range of issues associated with preserving and enhancing nuclear knowledge in the process of preparing the Agency's programme. [3]

2. FP5 project, ENEN — European Nuclear Engineering Network; FIR1-CT-2001-80127

Within the 5th framework program the European Commission supports the European Nuclear Engineering Network. The ENEN contract started on Jan 1, 2002 and lasts for 24 months. 22 academic institutions and research laboratories participate in the project. The Commission support for this "accompanying measure" amounts to € 197 716. [4]

The objectives of the ENEN-project are to produce a handbook of best practices defining the major elements for a European network for nuclear engineering education and to perform pilot sessions on nuclear engineering education. The project is a step towards farther reaching objectives e.g. the conservation of nuclear knowledge and expertise, the creation of a European higher education area and the implementation of the Bologna declaration and the enlargement of the European Union.

2.1. European Master of Science in Nuclear Engineering

Based upon a year-long exchange of views between the partners of ENEN, consisting of a representative cross section of nuclear academic institutions and research laboratories of the EU-25, a coherent and practicable concept, for a European Master of Science in Nuclear Engineering (EMSNE) has emerged. The concept is compatible with the Bologna philosophy of higher education for academic engineers in Europe (a Bachelor of Science after 6 full-time semesters, and a Master of Science after a further 4 full-time semesters). In addition, the EMSNE approach can accommodate the presently existing (variety of) educational systems in the EU-25 members and candidate-member states, as well as the Bologna implementation in some countries, where Master degrees will be granted after a 2-semester program beyond the Bachelor.

The full curriculum leading to the degree of Master of Science in Nuclear Engineering (MSNE) is composed of course units formally recognized by ENEN.

- A MSNE can only be granted after having obtained a full-time load of ten semesters beyond secondary level.
- A minimum of two semesters equivalent must be obtained in strictly nuclear subjects composed of a set of core-curriculum courses complemented with nuclear electives and a project work/thesis in a nuclear domain.

Students register in one ENEN-accredited "home" institution and acquire the required credits in ENEN-institutions of their choice. The home institution grants the formal degree of Master of Science in Nuclear Engineering, based upon the formal recognition of credits, very much similar to the ERASMUS philosophy. ENEN, on behalf of its members, grants the quality label *European* Master of Science in Nuclear Engineering if at least on semester equivalent (might include project work or thesis) have been followed at an ENEN-member institution other than the home institution.

Because of the different meaning of the words "undergraduate, graduate and post-graduate" in UK and US contexts, these terms are preferentially not used in the ENEN terminology. It is advised to talk about Bachelor, first Master, additional Master always with the number of credits or full-time semesters required, mentioned.

2.2. Pilot sessions on nuclear engineering education

To demonstrate the feasibility of European nuclear education schemes, a three weeks course, called "Eugene Wigner" course for nuclear reactor physics experiments, was successfully organized from April 28 to May 16, 2003. Some 20 postgraduate students from about 10 different European, including accession countries, participated in nuclear reactor physics experiments, organized jointly by four universities. Students performed reactor physics experiments on research- and training reactors in respectively Vienna, Prague and Budapest. One week of theoretical lecturing at Bratislava university introduced or refreshed the knowledge to perform the nuclear reactor physics experiments. The ENEN partners rated the course between 6 to 8 credits or an equivalent student load of some 180 to 240 hours. Students got a certificate of participation. Individual marks are transmitted to the home professors.

The course on Nuclear Thermal Hydraulics organized within the Belgian academic postgraduate program in nuclear engineering, is organised in a highly modular way and taught in English to facilitate and exchange participation of European students. The course, scheduled for October 20-31, 2003, makes full use of the laboratory facilities and infrastructure of the Belgian Nuclear Research Centre. The course is rated 6 credits or an equivalent student load of some 180 hours. A written examination, prepared by the course staff, is foreseen at the home university on November 21, 2003. The copies are send back to and graded by the teaching professor, who transmits the individual marks to the home professors. The final mark remains the responsibility of the home professor.

In a similar way also the course on Nuclear Reactor Theory is organised from November 17-28, 2003. The course rates 8 credits or an equivalent student load of some 240 hours. The examination is scheduled for December 19, 2003. Mid September, some 20, about half regular Belgian Students and the other half "ENEN" students registered for each course.

2.3. The ENEN association

Pursuing the sustainability of the concept, the ENEN partners organized themselves in a non-profit-making association: the European Nuclear Education Network. The first General Assembly is scheduled for November 11, 2003.

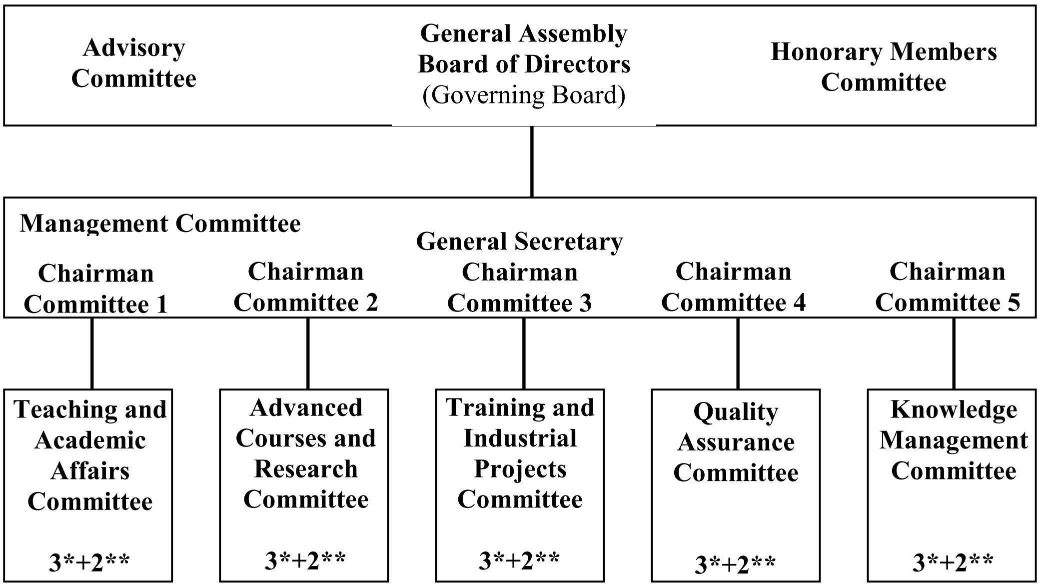
The main objective of the ENEN network is the preservation and further development of higher nuclear education and expertise.

The basic objectives of ENEN are:

- to deliver a European master of science degree in nuclear engineering and promote PhD studies;
- to promote exchange of students and teachers participating in the network;
- to establish a framework for mutual recognition;
- to foster and strengthen the relationship with research laboratories, industry and regulatory bodies;
- to meet these objectives, the ENEN network;
- promotes and further develops the collaboration in nuclear education of engineers and researchers for nuclear industry and regulatory bodies;

— ensures the quality of nuclear academic engineering education and training;
— has to increase the attractiveness for engagement in the nuclear field for studnts and young academics.

A "Board of Directors" elected by the General Assembly and a "Management Committee" manage the ENEN association. The Management committee is constituted by the General Secretary, appointed by the Board of Directors and the Chairmen of the five different working committees.



The ENEN network consists of effective and associated members. The effective members are academic institutions providing high level scientific education in the nuclear field. The associated members have a firmly established tradition of relations with members in the field of nuclear education, research and training. New members are elected by the general assembly, by a majority of two-thirds of the votes cast, on recommendation of the Board of Governors. The general assembly is made up of all members.

3. Education and training in nuclear engineering and safety

Within the 6th framework program, the Commission services favourably evaluated the proposal: "Nuclear European Platform of Training and University Organisations". The objectives of the NEPTUNO co-ordination action are to establish a fair dialogue and a strong interaction between the academic and the industrial world and to bring all nuclear education and training activities under a common strategy of the ENEN type. The present proposal schedules for 18 months and the Commission earmarked a financial contribution of € 830 619.

In the area of knowledge management the Consortium considers:

— Workshops to disseminate the experience gained by the "education" community under FP5 and FP6, in particular, amongst the "training" community.
— Pilot sessions for education and training along the lines of what has been done under the ENEN project. To evaluate the pilot sessions and their funding scheme.
— To draft, edit and distribute a series of textbooks for education and training.

— To produce guidance documents describing best practices for: qualification of common curricula, accreditation mechanism and mobility for students and teachers.
— To perform consultancy services in connection with specific education and training activities proposed in other Euratom FP6 projects.

4. International co-operation

The International Atomic Energy Agency supports networking of education and training. The IAEA sponsored participants in the ENEN pilot courses and representatives participate in the ENEN progress meetings.

OECD-NEA recognises the ENEN achievements as relevant progress against the recommendations made in the publication, "Nuclear education and training: Cause for Concern?".

ENEN participates as a driving member in several of the working groups of the recently inaugurated World Nuclear University initiative. [5]

5. Future work

The "European Nuclear Education Network" association emerged as a non-profit common legal entity out of the FP5 ENEN project. The legal entity is open for academic institutions and corporate bodies committing themselves to support the ENEN association and having a firmly established tradition of relations with members in the fields of education, research and training. Within the project the ENEN partners came to a consensus on: qualification of common curricula, an accreditation mechanism inspired by the Bologna declaration and a mobility scheme for students and teachers. The present-day ENEN working field is nuclear engineering education. In the nearby future, ENEN pursues a closer interaction between education and training communities. Future extensions towards nuclear medicine and radiation protection, nuclear or radio-chemistry, nuclear applied sciences (accelerators, instrumentation and measurement) may be envisaged. A European Master of Science in Nuclear Science and Engineering may result. Likewise, ENEN promotes exchange of students and instructors for advanced courses in the framework of PhD programmes.

6. ENEN partners

Belgian Nuclear Research Centre (B), Budapest University of Technology and Economics (HU), Check Technical University (CZ), Institut "Josef Stefan" (SI), CEA-INSTN (F), Kungl Tekniska Högskolan (S), K.U.Leuven Research and Development (B), Consorzio Interuniversitario per la Ricerca Tecnologica Nucleare (I), Universiteit Gent (B), Slovak University of Technology (SK), Swiss Federal Institute of Technology Zürich (CH), Delft University of Technology (NL), Helsinki University of Technology (SF), Atominstitut der Österreichischen Universitäten (A), Université Catholique de Louvain (B), University of Birmingham (UK), University Politehnica of Bucharest (RO), Universidad Politecnica de Madrid (E), National Technical University of Athens (EL), Technische Universität München (D), Ustav jaderného vyzkumu REZ (CZ), Centre of Technology and Engineering for Nuclear Projects (RO).

Potential NEPTUNO – partners: Belgian Nuclear Research Centre (B), Budapest University of Technology and Economics (HU), Check Technical University (CZ), Institut "Josef Stefan" (SI), CEA-INSTN (F), Kungl Tekniska Högskolan (S), K.U.Leuven Research and Development (B), Consorzio Interuniversitario per la Ricerca Tecnologica Nucleare (I), Universiteit Gent (B), Slovak University of Technology (SK), Swiss Federal Institute of Technology Zürich (CH), Delft University of Technology (NL), Helsinki University of Technology (SF), Atominstitut der Österreichischen Universitäten (A), Université Catholique de Louvain (B), University of Birmingham (UK), University Politehnica of Bucharest (RO), Universidad Politecnica de Madrid (E), National Technical University of Athens (EL), Technische Universität München (D), Ustav jaderného vyzkumu REZ (CZ), Centre of Technology and Engineering for Nuclear Projects (RO), Tecnatom (E), University of Stuttgart (D), VTT Technical Research Centre of Finland (SF), Lappeenranta University of Technology (SF), Instituto Tecnologico e Nuclear (P), Nuclear Department, HMS Sultan (UK), Uppsala University (S), Technical University of Sofia (BG), University of Ljubljana (SI), ISaR Institute for Safety and Reliability (D), Paks Nuclear Power Plant (HU), GfS Gesellschaft für Simulatorschulung (D), PENTRAC Pan-European Nuclear Training Centers Association (HU), University of Manchester (UK), European Nuclear Society.

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[1] OECD/NEA, "Nuclear education and training: Cause for Concern?", OECD 2000, ISBN 92-64-18521-6

[2] "Strategic issues related to a 6th Euratom Framework Programme (2002-2006)". Scientific and Technical Committee Euratom. EUR 19150 EN. Pag.14.

[3] "Strengthening the Agency's Activities related to Nuclear Science, Technology and Applications". IAEA. GOV/2003/53-GC (47)11, August 11, 2003.

[4] http://www.sckcen.be/ENEN

[5] http://www.world-nuclear-university.org

Annex G

DETERMINATION OF TECHNOLOGICAL KNOW-HOW OF ELETRONUCLEAR-STATUS 2003*

1. Introduction

ELETRONUCLEAR , owner and operator of nuclear power plants in Brazil, has, as a condition for safe and reliable operation, to master the respective technology, which is a complex task, as it is universally considered as a high-level technology.

This technology was absorbed and consolidated along the last 30 years by the Nuclear Engineering Company NUCLEN and the Nuclear Directorate of the Utility FURNAS , and, after 1997, by the new company ELETRONUCLEAR, which resulted from their merging.

Due to aging, the bulk of the technical personnel of ELETRONUCLEAR is foreseen to leave in the next 5 to 10 years (Fig.1).

Therefore, systematic measures were started to be taken in order to preserve the essential technological know-how necessary to operate the existing plants (Angra 1 and 2) and to resume the construction of the next plant (Angra 3). A special project was established in January, 2001 for this purpose. Its first aim was to identify more precisely the extent and location of the existing know-how, as it was originally organized by two companies with different methods and cultures. Afterwards, the gaps in the essential know-how should be identified and solutions to fill in these gaps correspondingly proposed, which would comprise both short term, as well as long term, solutions.

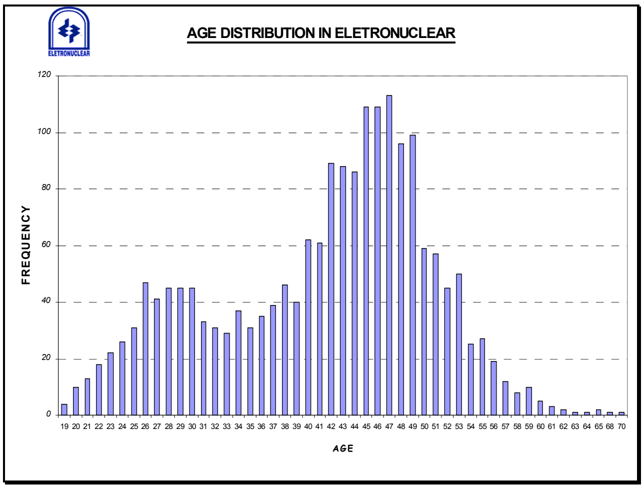

FIG. 1. Age distribution in ELETRONUCLEAR (technical areas-2001).

A multidisciplinary team was set-up to implement the Project and cooperation established to obtain a sound technical basis, both in Brazil and abroad (especially EPRI, USA).

* This annex was prepared by Mr. W. Lepecki, consultant, Knowledge Management, to ELETRONUCLEAR, Rio de Janeiro, Brazil.

The methodology adopted was as follows:

- A Classification Systematics (taxonomy) was established in order to classify the know-how necessary for the activities of the company.
- Correspondence was established between the Company's Organizational Units and the items of the taxonomy.
- The managers of these organizational units were asked to evaluate the status of the know-how for the items under their responsibility.
- For this purpose, know-how was defined as made up of a formal (documented) and an informal (in the heads of people) component.
- An electronic questionnaire was prepared according the above definition and distributed on-line to the responsible managers.
- The evaluation prepared by each manager required the approval of his hierarchical superiors.

A total of 557 questionnaires were distributed among 41 managers. Of this total, 92% were completely filled in and approved within the allotted time of two months.

The results are stored in a data bank, which allows to issue several types of reports, according to various criteria. Using the data bank, analyses can be performed and proposals for action prepared. These reports are created on-screen, either by a central administrator — for the whole company — or by the managers -for their respective organizational units. Thus, one can, for instance, identify areas that are weak in documentation or personnel, such identification being very precise as to the nature of the weakness, and the concerned know-how item.

It is to be remarked that in addition to an evaluation of the present status, an estimate for the near future (up to 5 years) was also made, to identify potential cliff-edge effects.

A second phase of the Project was performed in 2002 with the objective of analysing the know-how gaps and the necessary measures to solve them.

A third phase is under way in 2003, consisting of elaboration of proposals in order to institutionalize Knowledge Management as a regular activity of the company (considering that this project was the first step by ELETRONUCLEAR in the area of Knowledge Management). These proposals should contemplate cooperation with Universities and Research Institutes to make available in a permanent way the necessary know-how.

2. Methodology

Formal and Informal Know-How

The systematic approach adopted to identify the technological Know-How is schematically represented in Fig. 2.

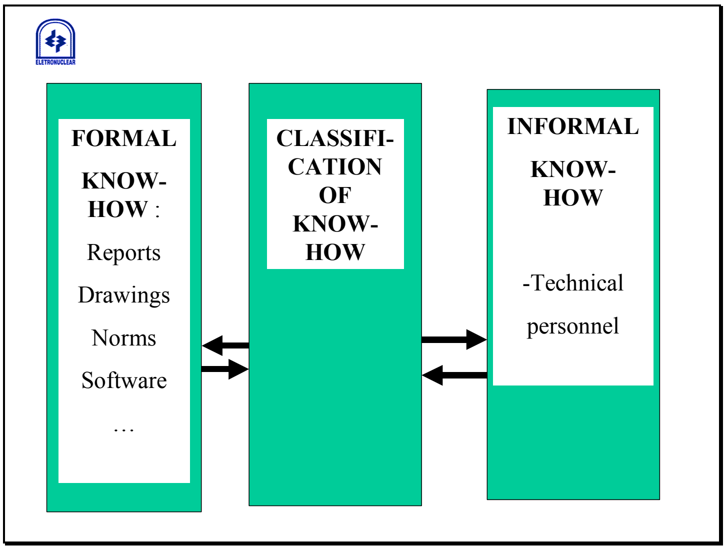

FIG. 2. Systematic approach for identification of know-how in ELETRONUCLEAR.

The Formal Know-How (or Explicit Knowledge) refers to documented technical information and is composed of :

- Reports & Technical Documents
- Drawings
- Norms, Standards & Technical Specifications
- Computer Codes/Software
- Other.

The Informal Know-How (or Tacit Knowledge) depends on the adequate availability of Personnel, both qualitatively as well as quantitatively, to apply the formal Know-How to the activities of the Company.

Know-How Classification System (Taxonomy)

Although there exist in ELETRONUCLEAR several classification systems in use, none was directly applicable to the purpose in mind. Thus, it was preferable to create a new one, with the specific aim of identifying the Know-How needed for the activities of the Company. This was organized in consultation with the Directors, Managers and Specialists. A decimal classification system was used. At the first level there were four items, viz.:

(1) Know-How for Plant Engineering: Plant Design and Support of Plant Operation
(2) Know-How for the Physical Execution of the Plant
(3) Know-How for Plant Operation
(4) Know-How for General Support Activities of the Company.

Within each of these items, other successive sub-divisions were defined (Table 1).

Table 1: Number of items in each level of the Classification System

Level	Number of Items
1	4
2	50
3	238
4	243
5	34
6	2

Thus, for example, the first items of Level 2 of the Classification System look as follows (Fig. 3):

1. **KNOW HOW PARA A ENGENHARIA DE PROJETO E DE APOIO A OPERAÇÃO**
   KNOW-HOW FOR PLANT ENGINEERING: PLANT DESIGN AND SUPPORT OF PLANT OPERATION

1.1. **Projeto de Sistemas Mecânicos**
Mechanical Systems Design

1.2. **Projeto Mecânico**
Mechanical Design

1.3. **Projeto Elétrico**
Electrical Design

1.4. **Projeto de Instrumentação & Controle**
Instrumentation & Control Design

(Etc. ......)

FIG. 3. Example of Level 2 of Classification System.

In this approach, the responsibility for the Know-How is not identified at the individuals' level, but at the level of Organizational Units of the Company. Therefore for each item of the Classification System there was defined a responsible Organizational Unit. It was up to the management hierarchy to assess the Know-How. This correspondence was fixed after detailed discussion and after final approval of the hierarchy up to the top technical level.

3. The survey

The Electronic Questionnaire

Due to the time limitation of the Project and its ample scope (the whole technical area of the Company), it was considered that the best method for the Know-How Survey would be through a self-evaluation based on electronic questionnaires to be filled-in on-line, which would form, automatically, a data bank, ready to yield all sorts of reports and analyses.

The Questionnaire lay-out reflects the systematic approach for identification of Know-How as described in III. This can be seen in Fig. 4.

The Questionnaire is divided into the two blocks Technical Information ("Informação Tecnológica") and Personnel Capability ("Pessoal Capacitado"), which are subdivided as described in II. These two blocks are evaluated according to a system of Grades ("Gráu") and

Weights ("Peso"): the first column is for the situation Today ("Hoje") and the second one, for the situation In ~ 5 years ("em ~5 anos"). There are drop-down boxes with the allowed Grades and Weights. Weighted averages are calculated automatically. The only written text that is required is contained in the Comments ("Comentários") box.

4. 4. 1 - Desenvolvimento de Aplicações	DIVI.X
Preenchimento :	
Aprovação :	

Know-How existente	**Hoje**			**em ~5 anos**		
	1 Grau	**2 Peso**	**3 [1x2]**	**4 Grau**	**5 Peso**	**6 [4x5]**
Informação Tecnológica						
- Relatórios e Documentação Técnica	NA	0	NA	NA	0	NA
- Desenhos	NA	0	NA	NA	0	NA
- Normas e Especificações Técnicas	NA	0	NA	NA	0	NA
- Códigos de Computador / Softwares	NA	0	NA	NA	0	NA
- Outros (especificar em comentários)	NA	0	NA	NA	0	NA
Grau A - Informação Tecnológica (média ponderada)	NA			NA		
Pessoal Capacitado						
- Qualitativamente	NA			NA		
- Quantitativamente	0			0		
Grau B - Pessoal Capacitado (média aritmética)	0.0			0.0		
Comentários (opcional)						

FIG. 4. The original electronic questionnaire (in Portuguese). It is shown in a state ready to be filled in. It is addressed to the Taxonomy Item 4.4.1.

Grades and Weights

The Grade assigned to the Know-How level reflects the evaluation made of its situation within the Organization Unit responsible for this item. The Weight reflects the importance of that particular aspect of Know-How (e.g. Reports, Drawings…) for the Taxonomy Item in question. Grades range from 0 to 4 and Weights from 0 to 3, in order of increasing Grade or Weight.

Approval Approach

The Questionnaire is automatically directed on-line to the lowest hierarchical level for filling-in. However, it must be approved by the hierarchy up to (but excepting) the Company Director level.

The Project Coordinator is able to follow on-line the progress of the survey being filled-in. The result of the process, after the two months allowed for it, was that 92% of the questionnaires were filled in and approved - see Table 2.

Table 2: Final status of the questionnaires

Not filled-in	10	2%
Filled-in but not approved	10	2%
Partially approved (not by all levels)	22	4%
Totally approved	515	92%
TOTALS	557	100%

4. Survey results

Table II shows the statistical results of the survey. These results (especially the 92% response rate) show that the survey can be trusted as reflecting the evaluation of the plant know-how by the Company management.

Data Storage

The results of the survey are stored in an electronic data bank. This allows the creation of a variety of reports, according different criteria, from which analyses can be performed and action proposals can be produced. These reports are created on-line and can be seen directly on the screen of the users, who are the mangers at different levels, each viewing the respective Organizational Unit, up to the Directors level.

Data Presentation Formats

There are three formats in which the data are presented:

- The filled-in Questionnaires
- Data bank
- Excel Spreadsheet.

The choice is made by the user, on-screen, through the Intranet.

The *Filled-in and Approved Questionnaires* are important in the sense that they are a record of the original answer. But they are bulky and awkward to handle. See example in Fig. 5.

Know-How Tecnológico da Eletronuclear

Este documento é confidencial de propriedade da Eletronuclear, reprodução proibida)

Representante : AIF.A (MANUEL)

Escolha a operação (Ajuda!) ==> ○ Retornar ○ Não aprovar

4. 4. 5 - Gerenciamento Eletrônico de Documentos						AIF.A
Preenchimento : Manuel Magarinos Torres (22.08.2001)						
Aprovação : Eduardo Grand Court (22.08.2001)						
Know-How existente	**Hoje**			**em ~5 anos**		
	1 Grau	**2 Peso**	**3 [1x2]**	**4 Grau**	**5 Peso**	**6 [4x5]**
Informação Tecnológica						
- Relatórios e Documentação Técnica	2	3	6	1	3	3
- Desenhos	NA	0	NA	NA	0	NA
- Normas e Especificações Técnicas	2	2	4	1	2	2
- Códigos de Computador / Softwares	1	3	3	0	3	0
- Outros (especificar em comentários)	NA	0	NA	NA	0	NA
Grau A - Informação Tecnológica (média ponderada)	1.6			0.6		
Pessoal Capacitado						
- Qualitativamente	2			1		
- Quantitativamente	1			1		
Grau B - Pessoal Capacitado (média aritmética)	1.5			1.0		
Comentários (opcional)						

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FIG. 5. The filled-in and approved questionnaire.

The *Data Bank* allows us to show the data in a more synthetic format, not occupying much physical space on the screen or printed paper. But the most important characteristic of the Data Bank is the screening tool, which allows us to screen the data according to pre-established criteria, which are chosen by the user. The following choices can be made:

- Time horizon: Present or Future (~5 years)
- Grades: Maximum or Minimum limits
- Know-How Item: "Reports", "Drawings", "Personnel", etc.

This allows to produce a map of the weak (or strong) points in great detail, the definition of "weak" or "strong" being made by the user as needed. For example, one can show such a selection for weak areas for the item "Norms & Standards", weak meaning, e.g. Grades with a Maximum of 1.

In addition, it is possible to assign an index - from 1 to 3 — reflecting the degree of importance of the Taxonomy Item for the Company (how "essential" this particular Know-How item is).

The *Excel Spread-sheet* format is used when space is important. The resulting data presentation is in a very compact form.

5. Analysis

In order to identify the gaps of know-how, "gap" was defined as such item of know-how (according the know-how taxonomy) which was evaluated as having a Grade of maximum 1(scale 0-4), a Weight (for the O.U.) of minimum 3 (scale 0-3), and in addition was assigned by the Directors as having priority 3 for the company (scale min1-max3).

Applying these criteria to the Data Bank, one obtains a mapping of the gaps, which can be represented on the screen or printed out.

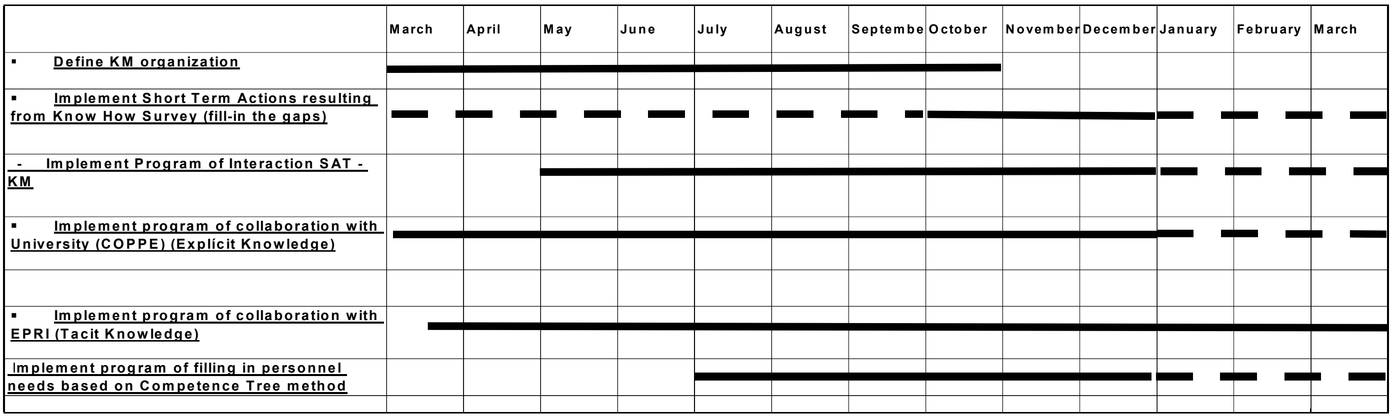

FIG. 6. The work program for 2003/04.

Having the Gap Map, it was asked from the managers to suggest solutions to fill in these gaps. The solutions were, e.g. acquisition of reports or computer codes, personnel training, personnel recruitment, etc. A complete Solution Map was thus available for filling in the know-how gaps. The Map was elaborated in two time horizons: situation now and in ~5 years.

6. Knowledge management as a permanent activity

There are two kinds of motivations for ELETRONUCLEAR to introduce Knowledge Management as a permanent activity:

Objective Motivations

Loss of experienced personnel (see item I).

Formal Motivations

ELETRONUCLEAR is subject to decisions of the National Council for Energy Policy. This organ mandated that, in order to assure approval for starting construction of the next NPP, Angra 3, a Knowledge Management (KM) program should be initiated within ELETRONUCLEAR.Thus, KM was included in a formal way among the strategic objectives of the Company.

The following measures to introduce KM as a routine activity are under way:

— Designation of an O.U. to be responsible forKM
— Creation of a KM Coordination Committee
— Work program for an initial period (2003/4)
See Fig 6.

The last-but-one item of the 2003/04 Program, a Pilot Project in Tacit Knowledge elicitation organized in cooperation with EPRI, due to its importance, is described in the Appendix.

7. Cooperation

This work was the first by ELETRONUCLEAR in the field of Knowledge Management. Although the work was performed with ELETRONUCLER's own staff, discussions with persons and institutions acquainted with this relatively new field, especially in the nuclear area, were very important for the implementation of the Project. In particular, the following persons' cooperation was very instrumental to the attainment of its objectives:

- A. Pawlik, Director (2001), NESI, IAEA, Vienna.
- Bernard Roche and Pascal Rioual, from EDF, France, in connection with the work described in [2].
- Professors Marcos Cavalcanti and Elizabeth Gomes, CRIE - COPPE , Rio de Janeiro, Brazil (Knowledge Management program at the Engineering Graduate School of the Federal University of Rio de Janeiro), authors of [3].
- Jean Pierre Sursock, Madeleine Gross, Tom Ayres, David Ziebell and Lewis Hanes, of EPRI, in connection with the work described in [4], [5], [6] and [7].
- Jerry Landon, TVA, EPRI in connection with the work described in [8].

8. Conclusions

The objective set by ELETRONUCLEAR's Directors, made at the beginning of 2001, of determining which was the status of its Technological Know-How, and what were the risks of losing the essential one, was achieved.

An electronic tool was created and successfully applied. Using this tool, a self-evaluation by the management was made. Cooperation by the managing staff proved to be very good and was, of course, essential for the good results achieved.

The work was executed by ELETRONUCLEAR's own staff, supported by external cooperation, both national and international.

The corresponding electronic data bank allowed to produce analytical reports according several criteria, pointing to possible solutions for the Know-How bottlenecks which were thus determined. This is the object of work under way. As a result, Knowledge Management will be established as a permanent activity, to assure the most valuable resource of the company, its own knowledge.

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[7] "Capturing and Using High-Value Undocumented Knowledge in the Nuclear Industry: Guidelines and Methods", EPRI, Palo Alto, CA: 2002. 1002896.
[8] J. Landon, "Capturing Knowledge Before it Walks Out of the Door - A Case Study of a Knowledge Management Response to Attrition", presented at the Tennessee Quality Conference 2001, February 26-27, 2001.
[9] Lepecki, W., "Determination of Technological Know-How of ELETRONUCLEAR", 2002 IEEE 7h Conference on Human Factors and Power Plants, Scottsdale, Arizona, USA (September, 2002).
[10] Hanes,L.(EPRI), correspondence dated Oct.2, 2003.

Appendix

Programmed Eletronuclear-EPRI Project: Valuable Knowledge Capture and Use

The loss of valuable undocumented expertise has been identified as a major problem facing Eletronuclear. Eletronuclear and EPRI have maintained a close working relationship during the last three years during which EPRI created an innovative process and methods for eliciting and capturing valuable undocumented knowledge. At the same time Eletronuclear performed a major project to identify valuable expertise expected to become unavailable in the near future.

Eletronuclear and EPRI expect to launch a pilot project in early 2004 to apply the process and methods for knowledge capture and use developed by EPRI and documented in a recent report [7].

The possible pilot project will permit Eletronuclear to become familiar with the EPRI process and methods, train some of its personnel in the process and methods, and develop Knowledge Modules (KMs) containing valuable expertise that may be used in the future.

It is expected that knowledge will be elicited from several experts identified by Eletronuclear. EPRI will provide training and participate with Eletronuclear personnel in eliciting tacit knowledge, validating it for accuracy, and formatting the expertise into KMs. Eletronuclear personnel with support from EPRI will integrate the KMs into the Eletronuclear infrastructure for use by others when needed. For example, the KMs may be incorporated into training programs, procedures, decision aids used by workers as they perform their tasks, etc.

The results of the pilot project will be one or more validated KMs for each expert with the results incorporated into the infrastructure for use by others when needed. In addition, Eletronuclear personnel will receive training in use of the EPRI knowledge capture and use process and methods. These personnel will be able to continue the elicitation process following completion of the pilot project.

Annex H

Knowledge Retention: Preventing Knowledge From Walking Out the Door

An Overview of Processes and Tools at the Tennessee Valley Authority

Introduction

The Tennessee Valley Authority has developed, piloted, and deployed a process to capture the undocumented knowledge of employees nearing retirement. This process -- and associated tools and support -- enable line managers to:

1. Identify critical "at risk" knowledge and skills, esp. that associated with impending attrition.
2. Evaluate the risk associated with losing this critical knowledge and skills and focus on areas of greatest risk.
3. Develop, implement and evaluate actions (documentation, mentoring, training, reengineering, sharing expertise, etc.) for managing this risk.

Results:

An effective approach to addressing a critical organization need.
Process and tools for line managers to manage their workforce.
Integration of staffing, training, job & organization redesign, process improvements and other responses.

Who is the Tennessee Valley Authority?

- ✓ America's largest power producer
- ✓ 13,000 employees

The Tennessee Valley Authority (TVA) is America's largest public power company. Founded by Congress in 1933, TVA's mission is to achieve "excellence in public service for the good of the people of the Tennessee Valley by supporting sustainable economic development, supplying affordable, reliable power, and managing a thriving river system."

Today, TVA's 13,000 employees serve a seven-state region and operate and maintain 11 fossil (coal-fired) plants, 29 hydroelectric dams, three nuclear plants, four combustion-turbine plants, a pumped storage facility and 17,000 miles of transmission lines.

TVA provides some of the nation's lowest-cost and most reliable electric power.

The Challenge

- ✓ An aging workforce nearing retirement
- ✓ 30-40% eligible in the next 5 years
- ✓ Impending loss of critical, specialized knowledge
- ✓ Need for a process to identify staffing, training, job and organization redesign, etc. responses

TVA, like many other companies, is facing the imminent retirement of a large portion of its workforce. This is due to the demographics of the so-called "baby boom generation" and past downsizing efforts that prevented restocking the employee development "pipeline."

Attrition, primarily in the form of retirements, may cost TVA 30-40 percent of its workforce over the next five years. These experienced employees possess much unique, undocumented knowledge. The retention and transfer of this critical knowledge is critical to TVA's future efficiency and effectiveness.

This impending "brain drain" is especially relevant given the nature of TVA's work – 85% of our non-management employees are in positions requiring technical education, training, or both. Some highly-specialized, highly technical employees have emerged over the years – employees whose knowledge is critical to the operation and maintenance of our plants and transmission facilities, and whose knowledge is not adequately documented.

Many of these employees *literally* built the plants and facilities which they now operate and maintain.

Like other utilities -- and industry in general -- TVA has streamlined and flattened over the years, and "natural" understudies have disappeared in the process. Further, the average age of the TVA work force is older than the national and industry averages. The average age of a TVA employee is slightly more than 46 years (compared to an electric utility industry average of about 43 years and a national average worker age of 40).

Replacement planning is further influenced by the relatively long lead time required for training – many power operations jobs require 2 to 4 years of training before an employee is qualified.

Business Drivers

- ✓ Significant pressure to lower labor costs
- ✓ Increasing competition for a shrinking pool of candidates
- ✓ Continued low-cost, safe, reliable power requires a capable workforce
- ✓ Pressure to shorted the "time to competence" of new employees

TVA's success depends upon developing and maintaining a highly skilled workforce. Knowledge retention provides a systematic approach to ensuring that the critical knowledge of TVA's veteran employees is transferred to the workforce of the future. It directly supports TVA's critical success factor— "To develop workforce capabilities to be the supplier and employer of choice."

Further, TVA attrition challenge is driven by several factors:

- TVA's delivered cost of power is highly influenced by its ability to effectively manage labor costs. Managing this cost of power is critical in an increasingly deregulated electric utility industry.
- There is intense competition for qualified workers. The U.S. Department of Labor predicts a growing shortage of qualified candidates to fill jobs during first quarter of the 21st Century.
- TVA's ability to retain and grow its customer base in a competitive environment is dependent on maintaining a highly-skilled, knowledgeable, well-trained, productive, motivated, diverse and high-performing work force.
- TVA's long-term success requires that we develop workforce capabilities to become the supplier and employer of choice. We must recruit, retain, and reward top talent, while maintaining or reducing labor costs.
- Much of TVA's technical knowledge is undocumented "tribal" knowledge.
- Staffing will continue to be tight. Not all positions will be filled. And the "time to competence" of new employees must be minimized.

The Response

A simple process of :

- ✓ What?
- ✓ So What?
- ✓ Now What?

Since 1999, TVA has developed and refined a simple process to identify at risk knowledge, assess the risk, and mitigate the impact of critical knowledge loss. The process has been deployed in several divisions and plants with excellent results, and is being implemented enterprise-wide in 2003.

Supported by various aids and tools, the process allows line managers to answer three fundamental questions:

1. Specifically, what knowledge is being lost? ("What?")
2. What are the business consequences of losing each item of knowledge? ("So what?)
3. What can we do about each item? ("Now what?")

What?
Specifically, what knowledge is being lost?

The first step is designed to identify positions and/or people where the potential knowledge loss is greatest and most imminent. It includes ratings of:

Time until retirement
Criticality of position.

✓ Who is nearing retirement?

TVA does something few employers due when planning for attrition – <u>we ask</u>!

Yearly (beginning in 1999), TVA surveys employees to ask them when they plan to retire. Employees increasingly understand that this information is driving planning and the labor "pipeline" and is not being used to make individual personnel decisions. About 80% complete the voluntary questionnaire.

Coupled with an overall estimate of the position's criticality (provided by the employee's manager), this retirement estimate drives a "knowledge risk factor" which identifies areas where immediate knowledge retention action is required.

✓ What unique knowledge or skill do they have?

The next step is to interview the incumbents and their supervisors to learn the job's specific "knowledge content." Since it's important to identify both explicit and implicit (that is, tacit, undocumented) knowledge, the interviews include four kinds of questions:

General questions like 'What knowledge will the TVA miss most when you leave?" The answers pointed to higher-order kinds of knowledge such as problem analysis and trouble shooting or deep understanding of the idiosyncrasies of a piece of equipment.

Task questions such as how to conduct specific tests or operate certain pieces of equipment.

Fact or information questions focus on what the employee knows and generate lists of contacts, maps, manuals, and other information.

Pattern recognition questions ask about lessons learned and insights about what's likely to go wrong and how to fix it.

Based on these interviews, TVA compiles a list of potential "knowledge loss items" for the job. The next step is to analyze their importance and decide on the appropriate action to take to manage knowledge loss through attrition.

So What?
What are the business consequences of losing each item of knowledge or skill? Which ones are <u>most</u> critical to our core business?

This phase of the process focuses on narrowing the long list of knowledge items down to the critical few that truly require action. Again, the screening is based on several questions:

What is the relative <u>importance</u> of this knowledge?
What is the relative <u>immediacy</u> of knowledge loss?
What is the <u>cost</u> and <u>feasibility</u> of recovering this knowledge, if lost?
How difficult is it to <u>transfer</u> this knowledge?

As a result of this analysis, TVA knows which issues to ignore, which it can correct with minor effort, and which require extraordinary or immediate action, either because that knowledge can be lost rapidly or the organizational consequences would be severe if someone with that specific knowledge suddenly left the organization. The final step is to choose the most effective tactics for capturing or preserving such knowledge and then take action.

Now What?
What can we do about each item?

Once the focus is on the knowledge and skills that are truly critical, specific plans are established to retain the knowledge/skill or to lessen the impact of losing it.

In some cases, it might mean assigning a new employee to shadow the employee who's going to retire or cross-training someone who's currently in a different job. Sometimes, it means documenting a procedure or process that's never been written down. Or perhaps it requires setting up a brown bag lunch twice a week where systems engineers can get together to discuss their work and problem-solve together. Some pieces of knowledge can even be eliminated by engineering them out. If "Lee" is the only one left who knows how to fix some ancient piece of equipment, it may make more sense to replace that equipment than to try to replace Lee's arcane know-how.

TVA's process considers a host of possible responses:

- Codification & documentation (procedures, checklists, inventories, etc.)
- Engineer it out (change processes, update equipment, use "smart" tools and technology, eliminate task, etc.)
- Education & training (including classroom, simulator, OTJ, one-to-one coaching/mentoring, etc.)
- Establish alternative resources (outside contractors, retirees as consultants, "find and buy" hires, shared expertise with other plant or divisions, communities of practice or other professional networks, etc.)

Finally, responding to the attrition challenge requires an ongoing monitoring and evaluation of knowledge retention plans. This attention institutionalizes the process, and keeps the knowledge retention plans current. Attrition information is updated annually in the Business Planning process, and new attrition dates are added to existing KR information to identify any new critical risk areas. Additionally, areas are identified that may require total or partial reassessment. For these areas, the process begins again.

Process Delivery
- ✓ Line managers responsible
- ✓ HR enables through processes, tools, and consultation
- ✓ Web-based tools, forms, and checklists

Philosophically, TVA is committed to the principle that line managers are responsible for managing their resources – including their people resources. Human Resource's contribution is to enable line management to do this by providing processes, tools, and consultation. The knowledge retention process illustrates some of these enabling features:

1. Processes, tools, forms, checklists, etc. which are focused on meeting critical business issues.
2. "Self-service," intranet-based systems which provides managers access to the tools, forms, etc.

Results
- ✓ Annual self-identification of retirement plans
- ✓ 2,000+ positions assessed for uniqueness/criticality
- ✓ Specific risks and needed responses identified
- ✓ Process and outcome evaluation

Annually, TVA requests all of its 13,000+ employees to provide, voluntarily, an estimate of their retirement/attrition plans. Several of TVA's divisions (plants) have used this information as an input to the knowledge retention process. These divisions estimated the uniqueness and criticality of the knowledge and skills of their workforce (some 2,000 employees) and determined where the risk of knowledge loss was greatest. For these positions, critical knowledge was inventoried and action plans developed to preserve and transfer it – or lessen the impact of its loss. Preliminary results suggest that the process effectively focuses attention and action planning on the most critical knowledge loss issues.

Some of the issues and responses have included:

- "Byron" – the steamfitter foreman. Byron can assess the possible internal corrosion of feedwater pipes by tapping them "with a certain wrench in a certain spot in a certain way" and listening for "certain sounds." How to retain this? Byron has been asked to coach several other employees on his methods and a permanent videotaped demonstration of Byron performing several tests has been retained.

"Donna" – the corporate staffer who had been the "expert" for years on several critical reports which are prepared just once a year. Would Donna's "corporate memory" leave with her? No. Donna had her own detailed files, checklists, documented precedents, etc. She just needed to pass these records on (with some explanation) to her successor.

"Ron" – the systems engineer. Plant managers marveled at Ron's knowledge of several critical systems and were concerned about losing his expertise. Further analysis, however, showed that, for each system, there were two or three other engineers who knew the system nearly as well. Losing Ron would be unfortunate but he wouldn't be taking unique knowledge with him.

Improved documentation, training, and coaching have been needed in many cases. As the examples above indicate, however, often alternative resources have been found to exist. The process is effective even when it identifies what we don't need to worry about!

Ongoing program evaluation is focused on two areas:

"Process" indicators including the numbers of positions/incumbents assessed and action plans developed and executed, and line manager feedback.

"Outcome" indicators of steady (or improving) organization and individual performance in spite of attrition and a "reloading" of TVA's workforce.

What makes this approach effective?

- ✓ A concrete response to a critical organizational issue
- ✓ Line management ownership. HR enables.
- ✓ Voluntary employee participation
- ✓ Integrates staffing, training, job design, etc. responses
- ✓ Recognizes that all at-risk knowledge is NOT equal
- ✓ Fit with organization culture

Several factors have combined to make this process effective. Most important, it addresses a real organization issue. It's not an "HR program." Rather, it is method and set of tools which enable line management to respond to an emerging issue that they care deeply about.

Employees also care about TVA and many of them have been concerned about the impact of the impending "brain drain." This process provides employees the opportunity to self-identify their attrition/retirement plans. And to do so in a safe way. Further, front-line employees identify the critical knowledge and skills that they may be taking out the door with them. And other employees get involved in actually capturing this information.

Neither line management nor front-line employees care if responding to the knowledge loss challenge is a "HR program" or not. This knowledge retention process integrates relevant HR responses (training, recruitment and staffing, etc.) and responses that are traditionally not HR functions (process and procedure documentation, re-engineering, etc.).

It is critical to respond to impending knowledge loss. But, given limited resources, it is equally important to focus on the most critical positions and types of knowledge. This process allows managers to analyze their risk and determine where these critical areas are. Finally, the structure and quantitative "feel" of these tools fit TVA's engineering culture.

Replicability

- ✓ Highly replicable
- ✓ Process and tools easily adapted
- ✓ Numerous requests from other companies for information and advice

For organizations facing attrition and associated knowledge loss, this process is highly replicable. The simple logic of "What? So What? And Now What?" is easily translated. The tools can be easily adapted to the culture and language of another organization. And the range of responses can help line managers in any enterprise determine the most appropriate methods of responding to their particular challenges.

There is ample evidence of the wide-spread interest in this issue and TVA's response:

- TVA's work has been recognized as a "best practice" in knowledge retention by the American Productivity & Quality Center.
- Numerous agencies (e.g., US Army Corps of Engineers, NRC, FERC, DOE) and corporations (e.g., John Deere, Chevron, World Bank) have contacted TVA for information and advice.

At least one organization (Palo Verde Generating Station) has begun piloting our process to prevent their critical knowledge and skills from "walking out the door."

For Additional Information

About the Strategic Positioning of Knowledge Loss Initiatives
Phil Reynolds, COO Operations Support, plreynolds@tva.gov

About the process and tools
Ed Boyles, COO Work Force Planning, jeboyles@tva.gov
Jim Buttram, Shared Resources, jbbuttram@tva.gov
Jerry Landon, TVA University, grlandon@tva.gov
Jill Wallace, COO OS HR Operations, kjwallace@tva.gov

About the web-enabled HR Processes and tools
Dick Brabham, Program Initiatives, erbrabham@tva.gov

Annex I

BENCHMARKING KM IN BRITISH ENERGY POWER & ENERGY TRADING*

1. Introduction

At the time the British Standard Guide to Good Practice in Knowledge Management (PAS 2001) was published, I was a few months into the research phase of a work-based distance-learning MSc degree in Information Management with the School of Information Studies at the University of Central England. The plan was to benchmark the KM practices of British Energy's Power and Energy Trading subsidiary BEPET, against a readily available, published benchmark standard. Being reasonably priced, easily accessible and, most importantly, impartial, PAS 2001 fitted the bill.

2. The study

Research showed that benchmarking KM was found to be quite a novel concept, particularly using PAS 2001 in any way. As the Guide provides a comprehensive overview of KM and all its practices, and being under a tight time constraint, I felt I needed to focus on a few key 'benchmarkable' areas for the research. After looking around for something suitable, I decided to base them on the Performance Categories from the Telios/KNOW Network's annual MAKE Awards. Not only would these provide a basis for drawing information from PAS 2001, but they also, through the recent winners, supplied a ready-made list of best practice companies to further compare BEPET against.

The key areas used in the study were:

- Creating an enterprise knowledge culture
- Top management support for managing knowledge
- Developing and delivering knowledge-based products and solutions
- Maximising enterprise intellectual capital
- Creating an environment of knowledge-sharing
- Establishing a culture of continuous learning
- Managing customer knowledge to increase loyalty/ value.

It was felt that these categories were clearly relevant to the study overall and so were applied (successfully and quite easily) to the design of the benchmarking exercise. To further compliment the study, a knowledge audit of BEPET was also carried out, and best practice company profiles based on five of the MAKE award winning companies were drawn up with the aim of matching them against the findings of the benchmark survey.

3. Benefits to be gained

It was felt that there were many benefits to be gained by the organisation through the conduct of such an investigation. As PAS 2001 states "Knowledge is now widely considered to be a company's key resource, and its effective use is vital for business success" and so one of the main benefit of the research to BEPET was the potential it brought with it to introduce

* This Annex was prepared by Simon Carpenter, Knowledge & Information Officer, British Energy Power & Energy Trading

best-practice KM practices into the Division. Through reading PAS 2001, it was felt that the study could bring many improvements, some of which might be:

- Individual employees being better informed and more effective
- Improved teamwork
- Innovation would increase
- Continuous learning would be better facilitated and supported
- That stakeholder relationships would be improved

Using case studies of some of the MAKE awards winners would enable BEPET to benefit from the experience of others, and from the current advice of leading KM practitioners. The study also allowed the close examination of an area of business practice not generally practicably possible due to time and cost constraints. And importantly, it gave scope for further benefits to the rest of British Energy, and the wider information and knowledge communities beyond the company, as the findings were disseminated and published.

4. Collecting the data and the findings

For each category, between 5 to 10 best practice statements were drawn from PAS 2001 (with the KM and business jargon removed where necessary) and a staff survey was compiled. The survey asked BEPET employees to agree or disagree on a scale of 1 to 5 whether they thought the statement truly reflected the current practice in the company. As an example, 'The Working Environment' section from the survey is shown below, with the statements being drawn from Section 2.2 in PAS 2001 "Establishing the right culture for success in KM".

Section A: The BEPET working environment

A1. People are encouraged to work together in BEPET.

Strongly disagree Strongly agree

□	□	□	□	□	○
1	2	3	4	5	no opinion

A2. There is a culture of trust here.

Strongly disagree Strongly agree

□	□	□	□	□	○
1	2	3	4	5	no opinion

A3. The hoarding of knowledge is actively discouraged.

Strongly disagree Strongly agree

□	□	□	□	□	○
1	2	3	4	5	no opinion

A4. In BEPET knowledge-sharing means power.

Strongly disagree Strongly agree

□	□	□	□	□	○

	1	2	3	4	5	no opinion

A5. We have the correct balance between electronic and face-to-face knowledge sharing.

Strongly disagree					Strongly agree	
	□	□	□	□	□	○
	1	2	3	4	5	no opinion

A6. In BEPET I feel like a small cog in a big machine.

Strongly agree					Strongly disagree	
	□	□	□	□	□	○
	1	2	3	4	5	no opinion

The survey response rate was 40%, and following it five semi-structured interviews with a sample of BEPET staff were arranged.

5. Some general thoughts on the study

In the context of a general survey, it proved difficult to take into account different perceptions of individual staff and their awareness of issues. For example, the benchmarking survey included the highly subjective, but essential in terms of the benchmarking process, statement "There is an 'Open Book' approach to all information". It was recognised that each person will have their own their own view on the information that is shared to the staff by the management, and how important or otherwise it is for them to know about everything that is going on in the business.

Also, it was not possible to include all areas within PAS 2001. So where no KM initiative existed, that area was left out of the survey. This meant that in the results phase, a judgement was made on their relative importance and a suitable score was factored in. An example of this is how the lack of a content management system in BEPET took 50% off the benchmarking score for that section. However, more time could have produced a more accurate method.

BEPET KNOWLEDGE SHARING SURVEY

Section A: The BEPET working environment

A1. People are encouraged to work together in BEPET.

Strongly disagree				Strongly agree	
☐	☐	☐	☐	☐	○
1	2	3	4	5	no opinion

A2. There is a culture of trust here.

Strongly disagree				Strongly agree	
☐	☐	☐	☐	☐	○
1	2	3	4	5	no opinion

A3. The hoarding of knowledge is actively discouraged.

Strongly disagree					Strongly agree
☐	☐	☐	☐	☐	○
1	2	3	4	5	no opinion

A4. In BEPET knowledge-sharing means power.

Strongly disagree				Strongly agree	
☐	☐	☐	☐	☐	○
1	2	3	4	5	no opinion

A5. We have the correct balance between electronic and face-to-face knowledge sharing.

Strongly disagree				Strongly agree	
☐	☐	☐	☐	☐	○
1	2	3	4	5	no opinion

A6. In BEPET I feel like a small cog in a big machine.

Strongly agree				Strongly disagree	
☐	☐	☐	☐	☐	○
1	2	3	4	5	no opinion

BEPET KNOWLEDGE SHARING SURVEY (Continued)

Section B. The BEPET culture

B1. We have a flat management structure.

Strongly disagree				Strongly agree	
□	□	□	□	□	○
1	2	3	4	5	no opinion

B2. Influence is obtained through being part of a network not through position.

Strongly disagree				Strongly agree	
□	□	□	□	□	○
1	2	3	4	5	no opinion

B3. There is a culture of accountability.

Strongly disagree				Strongly agree	
□	□	□	□	□	○
1	2	3	4	5	no opinion

B4. Ownership of responsibility in BEPET is shared.

Strongly disagree				Strongly agree	
□	□	□	□	□	○
1	2	3	4	5	no opinion

B5. We are rules - not values - based.

Strongly agree				Strongly disagree	
□	□	□	□	□	○
1	2	3	4	5	no opinion

B6 Cynicism is not a problem.

Strongly disagree				Strongly agree	
□	□	□	□	□	○
1	2	3	4	5	no opinion

BEPET KNOWLEDGE SHARING SURVEY (Continued)

B7. Cross functional teams are commonplace.

Strongly disagree				Strongly agree	
□	□	□	□	□	○
1	2	3	4	5	no opinion

B8. We are encouraged to have an entrepreneurial outlook.

Strongly disagree				Strongly agree	
□	□	□	□	□	○
1	2	3	4	5	no opinion

B9. There is an "Open Book" approach to all information.

Strongly disagree				Strongly agree	
□	□	□	□	□	○
1	2	3	4	5	no opinion

B10. The BEPET focus is on the entire workforce and not just on "key" employees.

Strongly disagree				Strongly agree	
□	□	□	□	□	○
1	2	3	4	5	no opinion

B11. Everything we do is geared towards offering more to our customers and stakeholders.

Strongly disagree				Strongly agree	
□	□	□	□	□	○
1	2	3	4	5	no opinion

B12. We happily replicate the good ideas of others.

Strongly disagree				Strongly agree	
□	□	□	□	□	○
1	2	3	4	5	no opinion

BEPET KNOWLEDGE SHARING SURVEY (Continued)

Section C. Our management

C1. There is a strong commitment at management level to change the organisational culture and begin to create values that will encourage knowledge sharing across departmental boundaries.

Strongly disagree				Strongly agree	
□	□	□	□	□	○
1	2	3	4	5	no opinion

C2. Senior management in BEPET don't "walk the knowledge sharing talk" enough.

Strongly agree				Strongly disagree	
□	□	□	□	□	○
1	2	3	4	5	no opinion

C3. Our knowledge sharing strategy is aligned with our IT strategy.

Strongly disagree				Strongly agree	
□	□	□	□	□	○
1	2	3	4	5	no opinion

C4. Our knowledge sharing strategy is aligned with our overall business strategy.

Strongly disagree				Strongly agree	
□	□	□	□	□	○
1	2	3	4	5	no opinion

C5. We are not incentivised and rewarded for knowledge sharing and innovative working.

Strongly agree				Strongly disagree	
□	□	□	□	□	○
1	2	3	4	5	no opinion

BEPET KNOWLEDGE SHARING SURVEY (Continued)

Section D. The BEPET knowledge flows

D1. Where does the information you need to do your job come from? (Please tick relevant box[es])

Own knowledge □
From within own team □
From other BEPET dept/team(s) □
Name(s) and % for each ……………………………………………………
From other part(s) of BE □
Name(s) and % for each …………………………………………………….
From an external source(s) □
Name(s) and % for each …………………………………………………….

D2. In what form is it?

Unwritten □
Electronic □
Hard copy □

D3. What types of information do you have stored? (Please list major forms)

…………………………………………………………………………………….

…………………………………………………………………………………….

D4. In what form is your stored information?

Electronic □ Which drive(s) ……………………………..
Hard copy □

D5. Who are the main customers for your information?

Own team □
Other BEPET dept/team(s) □ Name(s) and % for each …………………...
Other part(s) of BE □ Name(s) and % for each …………………...
External company □ Name(s) and % for each …………………...

D4. In what form do you pass information to them?

Verbal □
Electronic □
Hard copy □

BEPET KNOWLEDGE SHARING SURVEY (Continued)

Section E. Information content management

E1. I deliver the right knowledge to the right people at the right time at the right cost.

Strongly disagree Strongly agree

☐	☐	☐	☐	☐	○
1	2	3	4	5	no opinion

E2. There is a minimum standard of quality in operation, so users can have confidence in the knowledge content that I share.

Strongly agree Strongly disagree

☐	☐	☐	☐	☐	○
1	2	3	4	5	no opinion

E3. Pet.com enables me to be better informed than I would otherwise be.

Strongly disagree Strongly agree

☐	☐	☐	☐	☐	○
1	2	3	4	5	no opinion

E4. Pet.com enables internal processes to be more streamlined.

Strongly disagree Strongly agree

☐	☐	☐	☐	☐	○
1	2	3	4	5	no opinion

E5. Pet.com helps integrate new staff quickly by giving them access to the organisation via a single interface.

Strongly disagree Strongly agree

☐	☐	☐	☐	☐	○
1	2	3	4	5	no opinion

Section F. Intellectual Capital

F1. We have a formalised process of idea generation in place.

Strongly disagree Strongly agree

☐	☐	☐	☐	☐	○
1	2	3	4	5	no opinion

BEPET KNOWLEDGE SHARING SURVEY (Continued)

F2. We have access to the ideas and innovations of others in BEPET.

Strongly disagree				Strongly agree	
□	□	□	□	□	○
1	2	3	4	5	no opinion

F3. We have the autonomy to formalise our own ideas, give them visibility and champion them.

Strongly disagree				Strongly agree	
□	□	□	□	□	○
1	2	3	4	5	no opinion

F4. All feasible ideas are rewarded (even if they are not commercialised)

Strongly disagree				Strongly agree	
□	□	□	□	□	○
1	2	3	4	5	no opinion

F5. We are allowed time to participate in innovative activities

Strongly disagree				Strongly agree	
□	□	□	□	□	○
1	2	3	4	5	no opinion

F6. There are opportunities available for healthy debate within working groups.

Strongly disagree				Strongly agree	
□	□	□	□	□	○
1	2	3	4	5	no opinion

F7. There are opportunities in existence where we can share our unwritten knowledge.

Strongly disagree				Strongly agree	
□	□	□	□	□	○
1	2	3	4	5	no opinion

BEPET KNOWLEDGE SHARING SURVEY (Continued)

F8. Old or irrelevant knowledge is weeded out to avoid clogging up our office and systems.

Strongly disagree Strongly agree

□	□	□	□	□	○
1	2	3	4	5	no opinion

G. Learning

G1. There is a culture of continuous learning in BEPET.

Strongly disagree Strongly agree

□	□	□	□	□	○
1	2	3	4	5	no opinion

G2 Learning here is something that's done by you rather than to you.

Strongly disagree Strongly agree

□	□	□	□	□	○
1	2	3	4	5	no opinion

G3. All we learn through work is able to be leveraged when serving the customer or stakeholder.

Strongly disagree Strongly agree

□	□	□	□	□	○
1	2	3	4	5	no opinion

G5. Learning tools. Have you used any of the following in BEPET? (Please tick relevant box[es]

- Good practice knowledge bases □
- E-learning tools (e.g. training courses delivered and administered on-line across an intranet) - □
- Bulletin boards/ discussion databases □
- Expert network/ collaborative tools □

BEPET KNOWLEDGE SHARING SURVEY (Continued)

H. Customer/ stakeholder relations

H1. We have effective customer/ stakeholder relationship management practices.

Strongly disagree Strongly agree

☐	☐	☐	☐	☐	○
1	2	3	4	5	no opinion

H2. We know our customers and stakeholders (i.e. their strategies and business drivers/ changes and their service and enquiry patterns).

Strongly disagree Strongly agree

☐	☐	☐	☐	☐	○
1	2	3	4	5	no opinion

H3. Client collaborative tools

Have you used any of the following in BEPET when dealing with customers or stakeholders? (Please tick relevant box[es])

- on line presentations ☐
- text messages ☐
- application sharing ☐
- shared whiteboard ☐
- voting tools ☐
- instant messaging ☐
- video or audio conferencing ☐

J. Other comments

…………………………………………………………………………………………………
…………………………………………………………………………………………………
………………………………………………………………………

K. And finally would be willing to take part in a follow-up interview please?

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This bibliography was compiled by Mr. Lawrence B. Durham, Sterling Learning Services, Inc., Birmingham, AL, USA

CONTRIBUTORS TO DRAFTING AND REVIEW

Barroso, H.	International Atomic Energy Agency
Beeley, P.	HMS Sultan School, United Kingdom
Bastos Ferraz, H.L.	International Atomic Energy Agency
Boyles, J.E.	TVA, United States of America
Carnes, W.E.	U.S. Department of Energy, United States of America
Carpenter, S.	British Energy, United Kingdom
Compton, S.	Oakridge Associated Universities, United States of America
Duffour, O.	EDF, France
Durham, L.	Sterling Learning Services, United States of America
Goodnight, C.	Goodnight Consulting, Inc., United States of America
Lester, P.A.	Oakridge Associated Universities, United States of America
Kossilov, A.	International Atomic Energy Agency
Lepecki, W.	Eletronuclear, Brazil
Lester, P.A.	Oakridge Associated Universities, United States of America
Haapalehto, T.	OECD/NEA
Friberg, M.	TVO, Finland
Flury, H.	Kernkraftwerk Gösgen, Switzerland
Flury, P.	Nuclear Safety Inspectorate, Switzerland
Kim, L.	International Atomic Energy Agency
Mazour, T.	International Atomic Energy Agency

Consultants Meetings

Toronto, Canada: 24–28 June 2002
Tennessee, United States of America: 7–11 October 2002

Technical Meeting

Vienna, Austria: 20–23 October 2003