Human Resources for Nuclear Power Expansion

A. Introduction

The *Nuclear Technology Review 2009* had a short section on human resources for nuclear power. It indicated there were no good estimates of the human resource requirements associated with the Agency's high and low growth projections for nuclear power and that data were scarce on the number of trained people and the capacities of relevant programmes around the world. It also stressed that the situation is different in different countries.

Since then, more data have become available, more programmes have been put in place, and there is more information. Over the past several years, the IAEA has worked with universities and other educational and training organizations in Member States to address future workforce demand development and the quality and quantity of education and training programmes to support nuclear power. IAEA activities have focused on curricula for nuclear education, on networking among universities and on internet platforms for nuclear education. University networks that are supported include the World Nuclear University (WNU), of which the IAEA is a founding supporter, the European Nuclear Education Network Association, the Asian Network for Education in Nuclear Technology and other national and regional initiatives. The Agency also supports the development of policies and strategies in nuclear education and training. It fosters strong regional and inter-regional nuclear education networks. It facilitates the harmonization of curricula and promotes the awareness and use of nuclear facilities and simulators to enhance education and training. It also provides consultancy services to address issues related to nuclear education and training.

Several Agency technical meetings in 2008 and 2009 reviewed the status of nuclear education in over thirty Member States and five educational networks. In 2010, the Agency will publish a technical report entitled *Status and Trends and Best Practices in Nuclear Education*, which will consolidate information from many different countries.

This additional documentation for the *Nuclear Technology Review 2010* includes selections from different categories of countries, i.e. countries with existing nuclear programmes that are continuing to expand, countries with programmes that have only recently renewed expansion plans, countries with phase-out policies, and countries whose nuclear programmes are growing rapidly. This additional documentation provides information on the status and challenges of the selected countries.

B. Summary information on selected countries

B.1. Argentina

Argentina's nuclear power programme developed rapidly in the 1960s and 1970s. Since then until recently, it has been largely on a plateau. Two nuclear power plants are in operation, providing 6.2% of the country's electricity. Atucha-1 was connected to the grid in 1974 and Embalse in 1983. Construction started on a third reactor, Atucha-2, in 1981. Construction was halted in the 1990s and re-started in 2007. A feasibility study is underway for a fourth reactor intended to start operation around 2015. Argentina is also developing a prototype small (25 MW(e)) pressurized water reactor called CAREM. There are five operational research reactors.

As a result of the number of current projects, the demand in Argentina for qualified nuclear engineers has increased in recent years. However, even during the past two decades of slow global growth in nuclear power, graduates of Argentina's principal nuclear training institute, the Balseiro Institute, never had difficulties securing jobs in the nuclear field. In particular, graduates from the Balseiro Institute played important roles in designing and constructing research reactors for INVAP, an Argentina based company that exported research reactors to Algeria, Egypt, Peru and, recently, Australia. At present, INVAP is the world leader in designing and building research reactors. Graduates of the Balseiro Institute also found employment in the nuclear medicine sector and at the country's uranium enrichment demonstration plant, as well as in non-nuclear fields such as scientific satellites and airport radar systems.

The Balseiro Institute runs three degree programmes — in nuclear engineering, mechanical engineering and physics. It also offers a postgraduate certificate in technological applications of nuclear energy, master's degrees in physics, medical physics and engineering, and PhDs in physics, engineering sciences and nuclear engineering. The Institute takes students from all Latin American countries, most commonly Bolivia, Brazil, Chile, Colombia, Ecuador and Peru. It has special agreements with Argentina's most important technological companies, both nuclear and non-nuclear. Approximately 10% of the Institute's students have fellowships from these companies. In September 2009, the Balseiro Institute became part of the IAEA's network of Collaborating Centres, which helps develop human resources for nuclear technology.

Specific training in metallurgy and materials science started in the Materials Department of the Constituyentes Atomic Centre (CAC) of the National Atomic Energy Commission (CNEA) in 1955. In 1993, this spawned the Sabato Institute through an agreement between CNEA and the San Martín National University (UNSAM) to train students in materials science and technology. This institute is an efficient mechanism for technology transfer and supplying specialists to institutions and companies involved in research and development or producing high-technology products. These include nuclear enterprises like Embalse, Atucha-2, CONUAR, which manufactures nuclear fuel elements, and Fabricación de Aleaciones Especiales, which manufactures zircaloy tubes for fuel elements.

Since 1993, the Sabato Institute has graduated 80 materials engineers, 115 masters of science, 38 PhDs and 20 graduates with certificates in non-destructive testing. About 75% of these graduates are working in Argentina, with the remaining 25% completing studies or working abroad. In Argentina, in addition to the nuclear enterprises mentioned above, many graduates from the Sabato Institute join CNEA research groups on mechanical properties, irradiation damage, hydrogen damage, diffusion, electron microscopy, corrosion, phase transformation, defect theory and continuous mechanics.

A third institute, the Dan Beninson Institute of Technology, was created more recently, in 2006, and offers postgraduate certificates in radiochemistry and nuclear applications, and in nuclear reactors and the fuel cycle.

B.2. China

A survey conducted on behalf of the Chinese Commission of Science, Technology and Industry for National Defence during 2004–2005, based on China's 11th National Plan (2006–2010), estimated that approximately 20 400 additional graduates and 'high' professional staff would be needed in the nuclear field (10 000 nuclear technology applications graduates, 8169 nuclear energy industry graduates, and 2235 professionals for nuclear power plant operations, assuming 96 nuclear professionals per 1000 MW(e) unit). This was based on China's plans for 40 GW(e) of new nuclear power on-line by 2020, with a further 18 GW(e) under construction. China therefore estimated (in 2005) that each year 1200 students should graduate in nuclear engineering and technology.

There has also been some consideration of a target of 70 GW(e) of new nuclear power on-line by 2020, with 32 GW(e) under construction. China estimates this would require a 30% increase in industry professional staff (11 030, up from 8169, allowing an additional 5% for retirement and alternative employment) and a doubling of plant operating staff (4500 from 2235). This gives a total of 25 500, 5100 more than for the 40 GW(e) estimate.

From 1998 to 2006 China had only one nuclear specialization for undergraduates, nuclear engineering and technology. However, in 2007, the Ministry of Education added five other undergraduate specializations, nuclear technology, radiation protection and environment engineering, nuclear chemistry and fuel engineering, nuclear reactor engineering, and nuclear physics. There are now 23 universities offering nuclear related specializations for undergraduates.

In 2007, there were 1483 undergraduates enrolled in nuclear courses. In 2008, this rose to 1957, of which 1151 were in nuclear engineering and technology, 219 in nuclear technology, 200 in radiation protection and environment protection, 183 in nuclear chemistry and fuel engineering, 80 in nuclear reactor engineering, and 124 in nuclear physics.

China, like some North American and European countries, faces challenges in attracting students into specialist nuclear power fields. The biggest demand for the industry is in the field of nuclear engineering and technology, where enrolment currently matches demand. However, demand for graduates in nuclear chemistry and the fuel cycle is the hardest to fulfil, mainly because the investment needed to establish the necessary faculties is large and in some universities, due to the difficulty in attracting students, the specialization has been cancelled. This has been identified as a priority area for the next national plan.

In 2009, China held its first National Meeting on Improving Education and Training for Chinese Nuclear Power Industry Personnel, supported by the IAEA. Its objective was to ensure that the different universities complement, rather than compete with, each other in terms of the range of nuclear related specializations offered. This is intended to become a regular event and eventually to include technical schools and industry training centres.

B.3. France

As of 1 January 2010, France had 59 operating reactors, one more under construction and produced three quarters of its electricity from nuclear power.

In its continuing use of nuclear power, France faces numerous challenges, including the operation and maintenance of its existing array of reactors, waste management, the decommissioning of obsolete reactors, and research and development for future nuclear systems.

These activities mean that all participants in the French nuclear industry must continually update their approaches and skills, with respect to both domestic and worldwide nuclear power development. This requirement calls for the hiring and training of thousands of scientists and engineers each year in France and its partner or customer countries.

An estimated 40% of the nuclear power staff within Électricité de France (EDF) (more than 4000 engineers and executives in operations, engineering and R&D) will retire within the next ten years. In addition to replacing retirees, EDF will need additional engineers for international projects.

In the past four years, EDF has therefore increased its recruitment levels substantially. In the nuclear field, EDF recruits 500 engineers per year in the different technical domains (operations, design processes, neutron and thermohydraulics physics, civil engineering, structures and materials, chemistry and environment, calculation codes and signal processing, instrumentation and control, etc.). EDF has also developed an internal 'nuclear academy' to train and qualify newly hired staff together with staff recruited from other parts of EDF, which will cover basic knowledge and nuclear culture training and more specialized job training.

AREVA has anticipated the nuclear revival by hiring more than 20 000 new staff members over the past four years, to achieve close to 50 000 nuclear staff in 2010, in line with market forecasts. AREVA also has developed in-house training programmes for new recruits: "The Campus Cycle", for all new managers and engineers, is designed to develop group culture and networks, to develop an understanding of AREVA's businesses, the main technologies and development prospects, and to consolidate the nuclear and occupational safety culture; "The Plants Cycle" is focused on engineers and designed to provide an overview of AREVA's technology and core business and develop a collective working habit.

In order to ensure the availability of necessary human resources, the government established in 2008 the French Council for Education and Training in Nuclear Energy (CFEN) chaired by the High Commissioner for Atomic Energy. It includes representation from the nuclear industry, higher education institutes and research organizations: its mission is to improve the balance between the education options being offered, the number of students and the needs of industry.

Over the next ten years, domestic and international nuclear power activities in France will call for the recruitment of about 13 000 engineers with Master of Science or PhD degrees, and 10 000 science technicians and operators with Bachelor of Science degrees. The chief employers will be EDF, AREVA, GDF SUEZ, national agencies such as the National Agency for Radioactive Waste Management (ANDRA), sub-contractors, R&D agencies such as the French Atomic Energy and Alternative Energies Commission (CEA), and the technical safety organization, Institute for Radiological Protection and Nuclear Safety (IRSN).

In France in recent years about 25 000 students have graduated annually with an engineer's or master's degree. In 2006 about 300 of them graduated in nuclear engineering or a closely related field. This figure will reach 900 by July 2010, a three-fold increase over four years. In addition about 100 students per year obtain a PhD in nuclear energy science. The number of technicians graduating with a nuclear or closely related bachelor of technology degree currently amounts to about 450 per year.

Accordingly, a number of new nuclear related academic programmes have been opened. Two of them have been designed for international enrolment as they provide their courses in English. One is a new international Master in Nuclear Energy Science, run by a consortium of several academic institutions (Paris-Sud University, ParisTech, Supélec, École Centrale Paris and the National Institute of Nuclear Science and Technology (INSTN)) with the support of several industrial establishments (EDF, AREVA, GDF SUEZ). This training is aimed at French and non-French graduates holding a good bachelor's degree in the sciences. To foster the international dimension of this programme, the classes are conducted in English. Lasting for two years (around 1000 hours of training), the course will provide the knowledge required to pursue a successful career in the nuclear industry. The curriculum has a number of different modules: a foundation course in nuclear sciences, applied knowledge (e.g. safety and radiation protection) focusing on the nuclear industry, and a wide choice of specializations: engineering, design, operations, decommissioning and waste management, and the fuel cycle. An internship in the industry and the submission of a master's thesis to secure the degree will complete the programme. The whole programme became fully operational in September 2009 (90 students, more than 50% non-French coming from 19 countries).

The second programme is an international Master of Materials Science for nuclear energy at the Grenoble Institute of Technology, in partnership with EDF, INSTN, and McMaster University in Canada.

The nuclear industry also set up new education and training programmes. For example, AREVA is involved in the creation of the European Nuclear Energy Leadership Academy. Its Corporate University has a network of correspondents and collaborators in Germany (e.g. Munich University of Technology and Karlsruhe Institute of Technology), North America (e.g. Massachusetts Institute of Technology, Stanford University and Harvard University), South Africa (North-West University), Latin America, China and India.

Finally, France has also played a leading role in the launch, by the European Nuclear Education Network (ENEN) Association, of the European Master of Science in Nuclear Engineering (EMSNE), with participating universities in most EU member countries.

B.4. Germany[1]

There are currently 17 reactors operating in Germany. In 2008, they produced 29% of Germany's electricity. The future prospects for nuclear power in Germany are in flux. In 2002, the Bundestag voted to phase out nuclear power, allowing an average lifetime of about 32 years for each operating reactor, but with the provision that kilowatt-hours could be traded between reactors. Based on recent planning, the remaining reactors would have to be shutdown between 2010 and 2022 (although the provision for trading kilowatt-hours makes it impossible to project precise shutdown dates). The new government elected in September 2009 has stated its commitment to rescind the phase-out policy and

[1] This section borrows heavily from Ref. [V-2].

reconsider nuclear power as a 'bridging technology'. At the time of writing, the possibility of rescinding the phase-out policy was still under discussion.

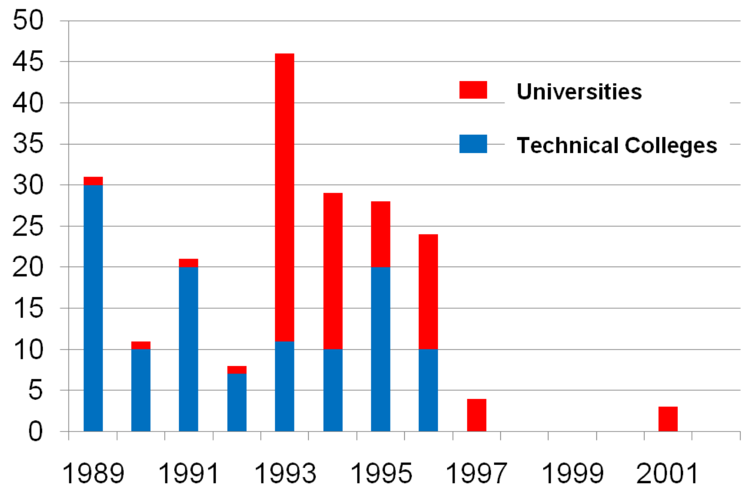

FIG. V-1: Graduates in nuclear technology in Germany [V-3].

Partly as a result of the phase-out policy, there have been declines in the numbers of students and educational programmes in nuclear fields. A 2004 analysis of nuclear education concluded that the number of academic institutions teaching nuclear related matters was expected to decline from 22 in 2000 to 10 in 2005 and only five in 2010 [V-4][2]. As shown in FIG. V-1, the number of graduates receiving diplomas in nuclear technology dropped from 46 in 1993 to zero in 1998. From 1998 through 2002, only two students graduated in a nuclear technology.

In order to try to combat this decline, the Alliance for Competence in Nuclear Technology (Kompetenzverbund Kerntechnik) was created in 2000, representing nuclear research centres, universities, technical support organizations and federal ministries. In 2009, the Karlsruhe Institute of Technology also established the AREVA Nuclear Professional School, which enrols 30 PhD students at a time, who are paid by AREVA and guaranteed a job when their training is completed [V-5].

B.5. Hungary

Hungary operates four reactors at the Paks nuclear power plant, which provide 37% of the country's electricity. In 2008, the thermal power of Paks was uprated by 8%, and the plant submitted a preliminary plan to extend the operation of its reactors beyond their original retirement dates of 2012–2017. In March 2009, Hungary's parliament approved a decision in principle to construct two new reactors at Paks.

Hungary therefore needs new nuclear experts to replace retiring personnel in nuclear related organizations; to serve as new personnel to allow for the extension of the lifetimes of the existing Paks reactors; and to serve as new personnel to construct and operate the new reactors.

In 2006, the Hungarian Atomic Energy Authority conducted a survey to assess future workforce needs in the energy sector. It did not assess specific needs for nuclear power, but it included responses from five nuclear organizations which can be analysed separately. Overall, only 23 companies completed the survey, and it is estimated that real energy sector needs may therefore be twice or three times the estimates collected in the survey.

[2] Updated data are not available to check whether these forecasts have been realized.

Of 16 707 people employed by the respondents, 3881 had completed higher education in scientific and technical subjects. The age distribution of these employees is shown in FIG. V-2. It is very close to, indeed a little younger than, the age distribution for a hypothetical stable workforce in which all employees start working at 25 and retire at 60 [V-6].

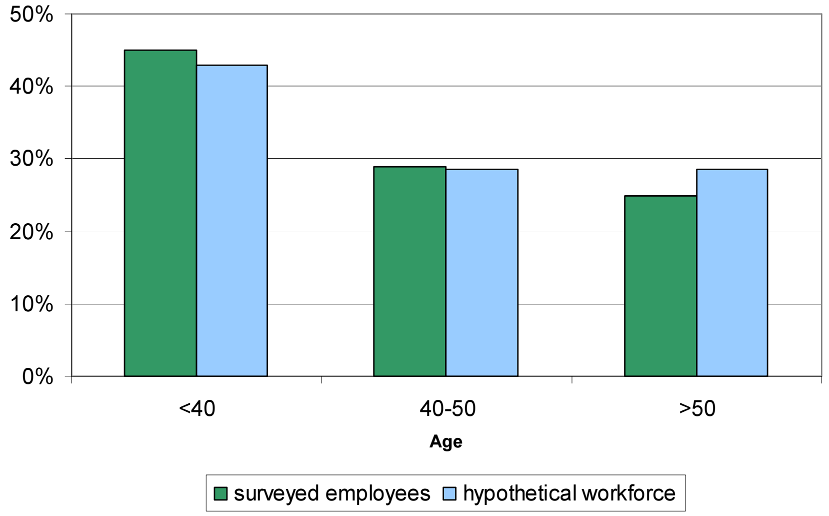

FIG. V-2: Age distribution of surveyed employees with higher education in science or technology (dark green) and a hypothetical stable workforce in which all employees work from 25 to 60 (light blue).

For the five nuclear organizations that were surveyed, Table V-1 shows the percentage of employees who are due to retire within ten years. In the hypothetical workforce described above the percentage would be 29%. Thus four of the five nuclear organizations have larger retirement cohorts than those of a hypothetical workforce, and the Paks nuclear power plant, at 44%, has the largest percentage of all.

Table V-1. Percentage of employees with higher education in science or technology who are due to retire within ten years

Paks nuclear power plant	44%
Research Institute for Electric Industry (VEIKI), Division of Nuclear Power	42%
Hungarian Atomic Energy Authority	39%
Radioactive Waste Treatment Ltd	31%
Budapest Research Reactor	23%

The results for all 23 survey respondents estimated a need, over the next ten years, for approximately 1120 new employees with higher education in science or technology. A little more than half would need bachelor of science degrees. The rest would need master of science degrees. Again, because of the limited survey response, the real need might be twice or three times as much.

The decision in principle for new units at Paks came after the survey, so workforce needs for the new reactors were not included in the responses. Separate estimates of workforce needs for two new units at Paks have, however, been made [V-7]. During the construction period, a direct work effort estimated at 11 000–13 500 person-years would be needed, plus an indirect workforce of about

16 500–20 300 person-years. The indirect workforce includes those not directly involved in the construction, but who deliver components, for example, or are otherwise indirectly involved.

After construction, an estimated 700–800 people would be needed for everyday operations and maintenance, about 30% of whom would need higher education. The new reactors will create additional work for the Hungarian Atomic Energy Authority and technical service organizations (TSOs), but it is difficult to estimate how much, particularly before the technology has been chosen.

Five universities in Hungary offer nuclear related courses. The Budapest University of Technology and Economics (BME) has the largest number of graduates with nuclear related degrees. In addition, the Paks nuclear power plant has its own education and training centre. This centre has a full-scale simulator for operator training and a maintenance training centre for technicians and maintenance workers.

All five universities cooperate with the nuclear industry. The broadest cooperation is between BME and Paks. BME offers a continuing education programme for professionals and serves as a TSO for Paks. Paks funds a foundation for BME to, among other things, promote student mobility, provide special scholarships, cover student travel expenses for conferences, and award scholarships and prizes recognizing exceptional work.

B.6. India

India plans a rapid expansion of nuclear power. At the end of 2009, it had 18 reactors in operation (3984 MW(e)) and 5 under construction. Projections made in 2004 included 29.5 GW(e) of installed nuclear power in 2022 [V-8], and higher numbers have been cited more recently: Indian Prime Minister Manmohan Singh, in opening the International Conference on Peaceful Uses of Atomic Energy in New Delhi in September 2009, said India could potentially install 470 GW(e) by 2050. Estimates based on adding 20 GW(e) of nuclear capacity by 2020 indicate that by 2017 India would need to add 3700 nuclear engineers, compared to an estimated 3180 today [V-9].

To support its expansion plans, the Indian Department of Atomic Energy (DAE) has established a number of new institutes and educational programmes to augment its ongoing, well established nuclear training programmes (i.e. the one-year orientation course for engineering graduates and science postgraduates and the two-year DAE graduate fellowship scheme), mainly at the master’s degree and PhD level, including:

- the Homi Bhabha National Institute in 2005, an umbrella for ten existing R&D and education institutions;
- the National Institute of Science Education and Research in 2007; and
- the Centre for Basic Sciences at the University of Mumbai in 2007.

The Nuclear Power Corporation of India Limited (NPCIL), the country’s sole constructor and operator of nuclear power plants, also has its own nuclear training centres close to nuclear power plant sites. The majority of training for non-graduate technical staff as well as for new engineering graduates and other technical staff is provided through these centres.

More recently, some Indian universities too have begun courses in nuclear engineering, e.g. in 2008, the Jawaharlal Nehru Technological University started a two-year master’s course in nuclear engineering for candidates holding engineering degrees in mechanical, chemical, civil or metallurgy fields.

B.7. Japan

Japan is the world’s third largest producer of electricity from nuclear energy. It has plans both to further expand production and to expand its exports of nuclear related products and services.

The Nuclear Energy Human Resource Development Council of Japan is responsible for the medium and long term development of human resources for the Japanese nuclear industry. In April 2009, it published a report entitled *Efforts for Nuclear Energy Human Resource Development* [V-10], based on interviews and surveys of industry, educational and research institutions, students and new employees.

Around 700–800 students major in nuclear subjects at the graduate level every year: 200–300 of those go on to further education, and some 500 find employment. About 40% of the 500 (i.e. 200) are employed by nuclear industry. Utility companies employ around 100 graduates every year, about 20% of whom majored in nuclear or related subjects. Manufacturers employ around 100–150 graduates every year, about 10% of whom majored in nuclear or related subjects. The report expressed no immediate concerns about the number of new graduates Japan was producing, but the survey gave rise to concerns about the quality of the graduates, particularly because the quality of education on nuclear subjects was seen to be weakening. FIG. V-3 indicates that the total number of nuclear related subjects in nuclear related university departments was reduced by half between 1979 and 2007. In the area of nuclear reactor physics, the number fell by two thirds. In the area of experiments and practical training, the number fell by 80%.

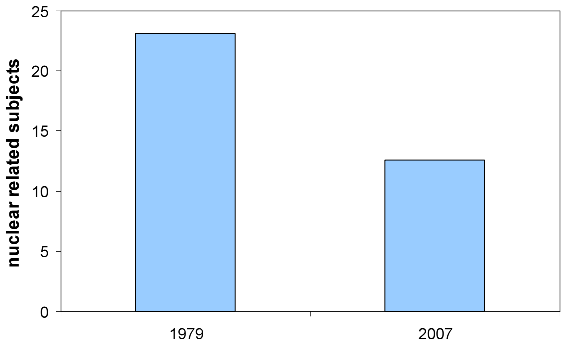

FIG. V-3: Total number of nuclear related subjects in nuclear related university departments in Japan.

The following actions have been adopted as a result of the survey findings:

For government:

- to implement nuclear human resources development programmes and continue to support activities in education; and
- to support energy and environment education at elementary and junior and senior high schools.

For universities:

- to assure that education incorporates industry needs;
- to assure, through strict management of educational curricula, the quality of master course students; and
- to develop young researchers in the area of basic engineering and technology.

For industry:

- to develop human resources through on-the-job training;
- to promote self-development by providing incentives for additional qualifications; and
- to cooperate with and support schools and universities.

B.8. United Kingdom

The UK nuclear energy industry currently has just over 10 GW(e) of installed capacity and employs 44 000 people (24 000 core nuclear staff and approximately 20 000 contractors) of which 7500 are employed directly in electricity generation.

In 2009, a national survey was conducted by Cogent[3] [V-11] to address a lack of data to support long term skills planning. The survey identified three important skills drivers for the immediate future:

- an ageing workforce driving a demand for replacement skills;
- a shift in needed skills toward decommissioning; and
- new demand for skills to operate a fleet of new nuclear power stations.

If no new nuclear power reactors are built, and if current reactors are retired on schedule, the total workforce is estimated to decline by 58% by 2025. This in fact is the model that has driven workforce planning in the UK in recent years. However, subsequent to a 2008 Government energy review [V-12], the private sector announced intentions to build at least 12 GW(e) of new nuclear power capacity. This would create 4600 new jobs in generation alone.

These jobs would require diverse skills as shown in FIG. V-4. One of the largest categories is maintenance, where the majority of staff would not be university graduates, but vocationally qualified technicians.

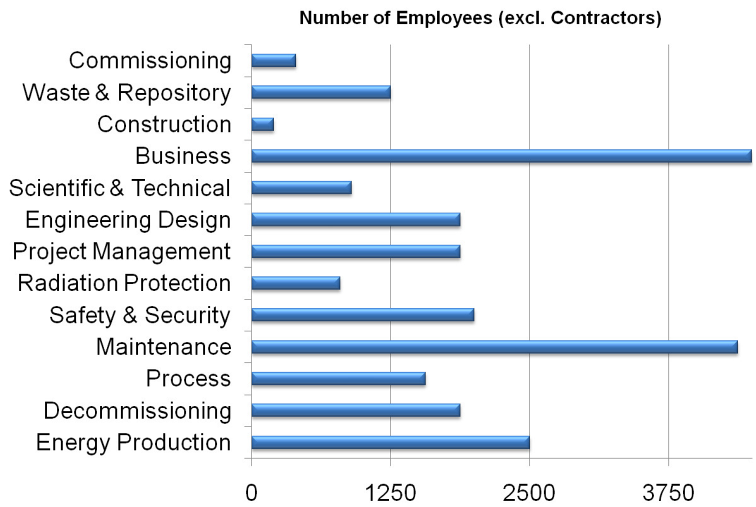

FIG.V-4: Job contexts for core nuclear industry staff

However, over the past 20 years, the UK has seen a dramatic reduction in the availability of traditional engineering apprenticeships, which would have been the 'feedstock' for maintenance and similar jobs. The National Skills Academy for Nuclear was established in 2008, at the request of nuclear industry employers, to address the key skills and training challenges facing the industry, but it is still too early to say whether it will be successful in meeting the needs of the industry.

A number of UK universities have also joined the European Nuclear Education Network (ENEN) Association, which, as noted earlier, launched a European master's degree in nuclear engineering in 2005 to help alleviate the predicted shortage of professional staff.

B.9. United States of America

[3] Cogent is the Sector Skills Council (SSC) for the Chemicals and Pharmaceuticals, Oil and Gas, Nuclear, Petroleum and Polymer Industries. It is licensed by the UK Government to provide employers in the sector with the opportunity for coherent leadership and strategic action to meet their skills needs.

The ageing workforce is also a key driver of recruitment needs in the USA. The Nuclear Energy Institute (NEI) biennially conducts a workforce analysis for the US nuclear power industry. Its 2009 survey is in progress. Its 2007 survey, for which 20 out of 26 utilities supplied data (representing 85% of utility employees), indicated that the age profile of the workforce has become older (see FIG. V-5):

- in engineering only 13% of employees were under 33 years old (compared to an expected value of 25% for a hypothetical stable work force of 22- to 62-year olds);
- in operations only 14% of employees were under 33 years old;
- in maintenance only 6% of employees were under 33 years old; and
- in radiation protection only 4% of employees were under 33 years old.

The survey also found that, for skilled trades, there were indications of increased shortages in welders, ironworkers and pipefitters.

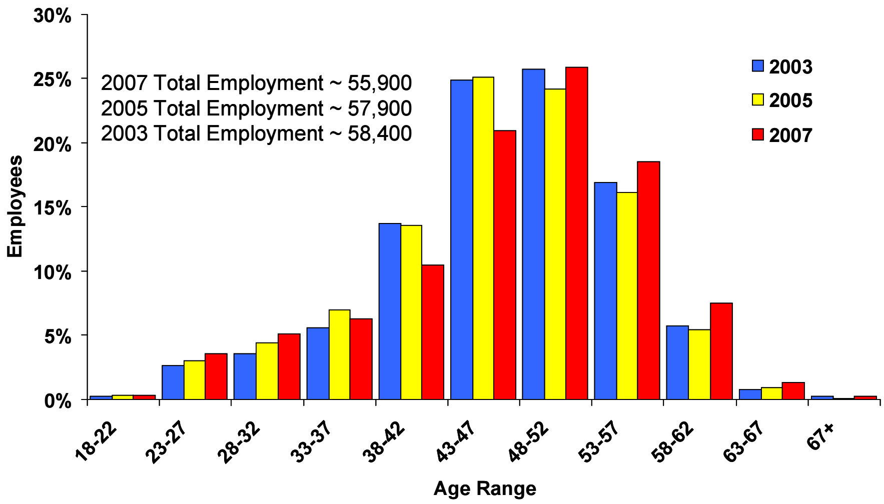

FIG. V-5: Age profiles of the workforce in the US nuclear power industry.

Many of the recent studies in the USA focus on university education. Funding for university nuclear science and engineering education relies heavily on government support, historically from the Department of Energy (DOE) and currently from the Nuclear Regulatory Commission (NRC). After the Three Mile Island and Chernobyl accidents, as the construction of new plants ceased, student enrolments in nuclear engineering programmes declined and DOE funding was steadily reduced. By the mid 1990s, anticipating a possible resurgence in nuclear energy, the DOE began reinvesting to rebuild the nuclear energy education infrastructure. The results of this reinvestment, in terms of increased student numbers can be seen in FIG. V-6 [V-13].

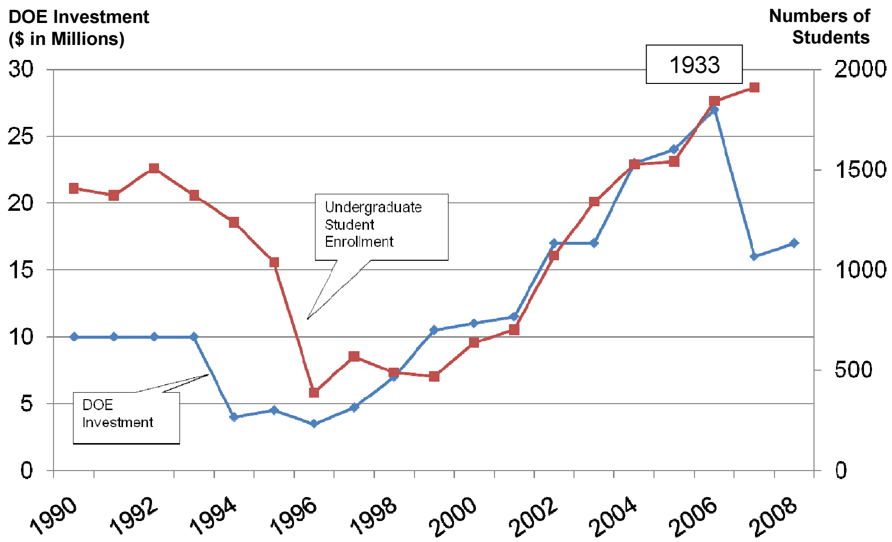

FIG. V-6: Undergraduate enrolments in nuclear engineering and DOE investments in university programmes

Approximately 450 bachelor's degrees were granted in nuclear engineering in 2008, of which an estimated 60% continued with further education and 25% were hired by vendors and regulators, meaning that fewer than 100 were available to be hired by utilities. This is well short of utility estimates according to which approximately 500 new graduate recruits will be needed each year just to cover retirements and attrition. Building new nuclear power plants will require even more new recruits [V-14].

In those areas where government or other support has not been forthcoming, the situation is worse. FIG. V-7 highlights the decline in the number of PhDs awarded annually in nuclear chemistry. This is a very specialized area, but one which is fundamental for research and development.

The USA has had some success with partnering and outreach programmes, particularly in the area of associate's degrees, which are two-year degrees for skilled workers. In these programmes, utilities work with local educational institutions to develop programmes targeted at meeting the utilities' needs. FIG. V-8 indicates that, typically for the USA, staff with associate's degrees make up around 70% of the workforce. An example of such a programme is the Nuclear Power Institute (NPI), a partnership between Texas A&M University, three US nuclear utilities and several other four-year universities and two-year community colleges. NPI is developing curricula to meet the full breadth of utility needs and has a significant outreach programme to engage high schools, teachers and students and attract students to nuclear power programmes.

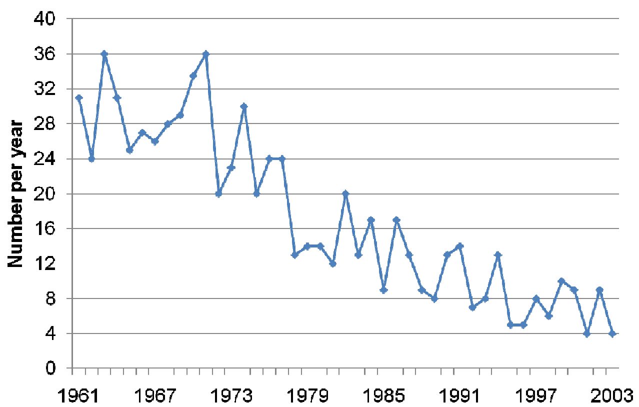

FIG. V-7: PhDs awarded annually in nuclear chemistry in the USA [V-14].

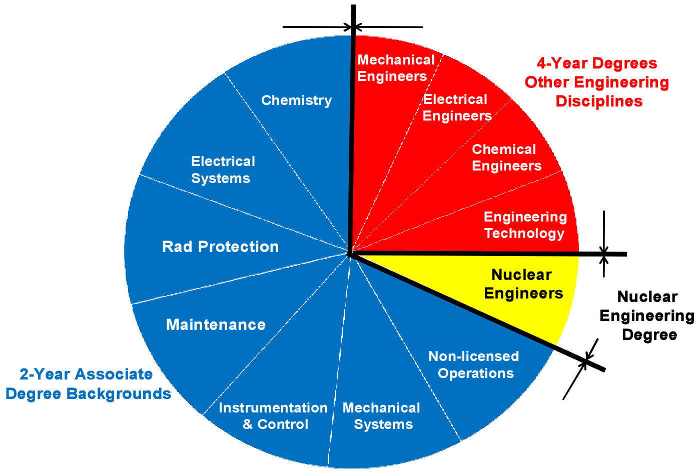

FIG. V-8: Example of distribution of disciplines for the nuclear workforce.

C. Concluding remarks

As noted at the outset, the basic conclusions on human resources for nuclear power have not changed from the *Nuclear Technology Review 2009*. The concerns about possible shortages of qualified people remain although the situation is different in different countries. For countries with expanding nuclear power programmes the challenge is to scale up existing education and training in order to have the required qualified workforce on time. Countries planning to supply nuclear technology to others not only have to meet their national human resource needs but must also be able to transfer education and training capacity together with the technology they transfer. Countries embarking on nuclear power will need to rely significantly on their technology supplier to help provide qualified people for construction, licensing and start-up until their national capacities to train comparable workforces domestically are established.

Assembling and analysing the data for more comprehensive conclusions on global human resources for nuclear power will require an international effort. With cooperation from the OECD/NEA, the World Association of Nuclear Operators, the World Nuclear Association, the Nuclear Energy Institute and Los Alamos National Laboratory in the USA, the Japan Atomic Energy Agency, the Cogent Sector Skills Council in the UK and others, the IAEA announced the launch of such an effort at the International Conference on Human Resource Development for Introducing and Expanding Nuclear Power Programmes, in March 2010 in Abu Dhabi. It is planned that, as a result of this initiative, the following activities will be undertaken at a global scale: a survey of human resources at existing nuclear power plants, including contractors and suppliers; a survey of the demand and supply of human resources for nuclear regulatory bodies; a survey of educational organizations and programmes that support nuclear power; the development of workforce planning tools for countries considering or launching new nuclear power programmes; and integration of the above into an accessible database that can be used to model global or national supply and demand of human resources.

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