6

The Necessity, Actual Situation and Challenges of Human Resources Training in the Nuclear Field

RYOTA OMORI
Environment and Energy Research Unit

1 Introduction

In recent years, there have been internationally shared concerns about the training of human resources and the inheritance of technologies. Atomic energy-related organizations in Japan and abroad are undertaking investigations on the actual concerns and reviewing measures to be taken against them[1-4]. In the background of these concerns, there are to be found the aging personnel in the nuclear field and the young generation turning away from atomic energy in society. A report[2] published by the International Atomic Energy Agency (IAEA) presents these concerns as follows:

"Many of the personnel working in the nuclear field are aging and close to their mandatory retirement age. On the other hand, there are only a few young personnel of high quality who have the intention of entering into the nuclear field. In universities and colleges, there are decreasing numbers of students studying atomic energy-related subjects. Furthermore, nuclear education programs have been closed in an increasing number of universities and colleges."

In Japan as well, people have a stronger interest in these problems. Especially this year, more and more active discussions are being made on the problems of human resources in the nuclear field, particularly in the reports published by Japanese organizations including the Japan Atomic Industrial Forum, Inc. (JAIF) as well as various technical magazines and symposiums[4-7].

On the other hand, the nuclear industry in Japan has been diminishing in scale. It is difficult to predict if this industry will largely develop in the short and medium terms, while there are various views on its long-term outlook. Under these circumstances, it seems that any clear consensus has yet to be reached on the grounds for the necessity of training human resources in the nuclear sector, the concrete concepts in which human resources should be trained, and the actions to be taken in training.

Considering various factors such as the trend of the nuclear industry, therefore, this article discusses the necessity from which the Japanese government should commit in the training of human resources in the nuclear field and the concepts in which human resources should be trained. Furthermore, it describes the actual situation of efforts made by the Japanese government and universities in training human resources and discusses the challenges that the future policies for training human resources should cope with.

Here, the author defines the scope of "human resources in the nuclear field (atomic energy-related human resources)." The "nuclear field" may be defined as the nuclear power generation-related field (in a narrow sense), or otherwise as the nuclear field including also the use of radiation, quantum beams and nuclear fusion (in a wide sense). However, this article mainly covers the problems of human resources in the nuclear power generation-related field (in a narrow sense). This is simply due to the author's awareness of certain problems. Some of the discussions and statistical data as described in this article may cover the nuclear field in a wide sense.

"Human resources" may include a variety of personnel such as researchers and engineers in charge of services such as research and development, and plant designing;

technicians in charge of repairing plants; and officials responsible for regulations and disaster prevention in the local and central governments. However, this article mainly focuses on researchers and engineers. For detailed information concerning the problems of technicians, refer to references 4 and 8.

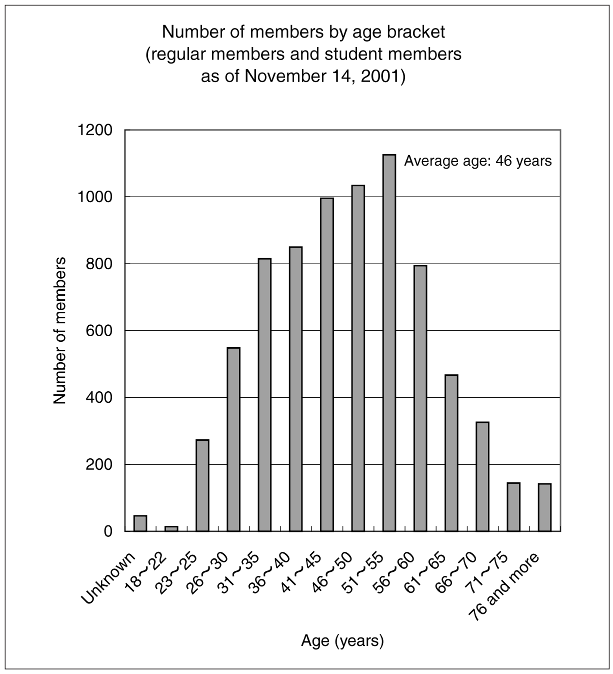
As the background necessary to consider the problems of human resources in the nuclear field, Chapter 2 in this article describes the actual situations of the nuclear industry diminishing in scale and having aging personnel, and Chapter 3 describes the results of investigations made in Japan and the U.S. on the balance between the number of university students specializing in atomic energy and the number of recruits being sought by companies. Based on this information, Chapter 4 discusses the government's necessity for training human resources in the nuclear field and the concrete concepts in which human resources should be trained. Chapter 5 describes the actual situations of nuclear education in universities and colleges, Chapter 6 describes those of nuclear education and research assistance by atomic energy research institutions and related organizations, and Chapter 7 provides information about those of education and training and the existing qualification system for technical personnel in the nuclear industry. Finally, Chapter 8 discusses the challenges that the future policies for training human resources in the nuclear field should cope with.

2 Diminishing scale and aging personnel in the nuclear industry

2.1 Japan's nuclear industry diminishing in scale

In recent years, the nuclear industry in Japan has been diminishing in scale. In this regard, the Long-Term Program for Research, Development and Utilization of Nuclear Energy in 2000[9] describes as follows: "The nuclear industry in Japan is entering its maturing period. In recent years, a decreasing tendency has been observed both in the number of researchers, engineers and technicians and the expenditure for atomic energy-related research activities. In the future, therefore, it may be more and more difficult to maintain the number of human resources and the level of technological force as before."

Figure 1:Age-bracket distribution of Atomic Energy Society of Japan membership



Source: Provided by the JAES

A report[3] published by the Japan Atomic Industrial Forum, Inc. (JAIF) also describes as follows: "In our country, atomic energy-related personnel in private-sector companies increased from about 28,000 in 1973 to more than 60,000 in 1992, and afterwards maintained a stable level of employment until 1995. However, power companies have since begun to decrease their equipment investments including the construction of nuclear plants as well as their research and development costs. The Japanese government also has reduced its nuclear R&D costs year by year since the peak reached in 1995. Under these circumstances, the number of atomic energy-related personnel in private-sector companies decreased to less than 60,000 in 1996 and further to about 54,000 in 1999" (partly omitted).

2.2 Aging personnel in the nuclear field

In the nuclear field, aging personnel is observed behind the concerns about the inheritance of technologies. Figure 1 shows the age-bracket distribution of the Atomic Energy Society of Japan (AESJ's) membership as of November 14, 2001. Of the membership, about 40% belonged to the nuclear industry, about 40%

to research institutions such as the JAERI and the JNC, and about 20% to universities and colleges. The age bracket of 51 to 55 years showed the peak number of members, and the number of members was much smaller as the age bracket lowered. Thus, this figure shows that a large part of the membership was remarkably older.

The average age was 46 years for all the members of the AESJ. It was 45 years for all the members of the Japan Society of Mechanical Engineers as well as the Institute of Electrical Engineers of Japan. Therefore, the aging membership may be considered to be common to all the traditional fields of engineering.

In the nuclear field, however, it is pointed out that many of the personnel who have played the most important roles in developing the nuclear mandatory retirement age. A report[4] published by the Japan Atomic Industrial Forum, Inc. (JAIF) states as follows: "The employees who entered into companies in the early period of LWR development, experienced in the construction and operation of LWRs as well as with a number of accidents and troubles, and engaged in the improvement of the related equipment and systems will reach their mandatory retirement age in 5 or 6 years. Many companies have concerns about the inheritance of their technologies for designing, operating and repairing nuclear facilities between the generations."

3 Balance of supply and demand for students specializing in atomic energy-related subjects

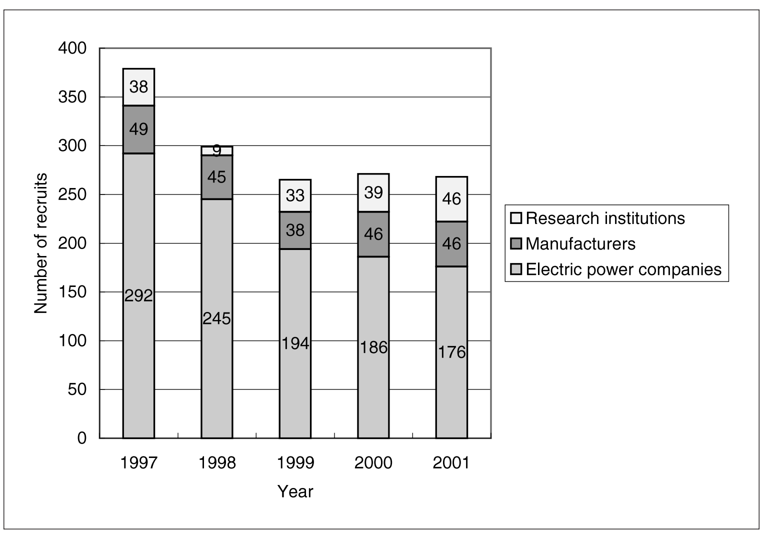
One of the most important factors that determine the number of university and college students who want to specialize in atomic energy-related subjects or the number of young persons engaged in the nuclear field is the number of recruits being sought by atomic energy-related companies, research institutions and other organizations. The decreasing number of recruits being sought by atomic energy-related organizations may decrease the number of young persons working in the nuclear field, and increase the number of students who want to specialize in other disciplines more favorable for employment.

Therefore, this chapter describes the results of investigations made in Japan and the U.S. on the balance between the number of university (and graduate school) students specializing in atomic energy-related subjects (hereinafter referred to as "students specializing in atomic energy-related subjects") and the number of recruits being sought by the nuclear industry.

3.1 Japan

Figures 2 and 3 show the annual numbers of technical employees by types of organization and specialty, respectively, recruited by the nuclear departments of 8 electric power companies,

Figure 2: Annual number of technical employees recruited into the nuclear department by type of organization



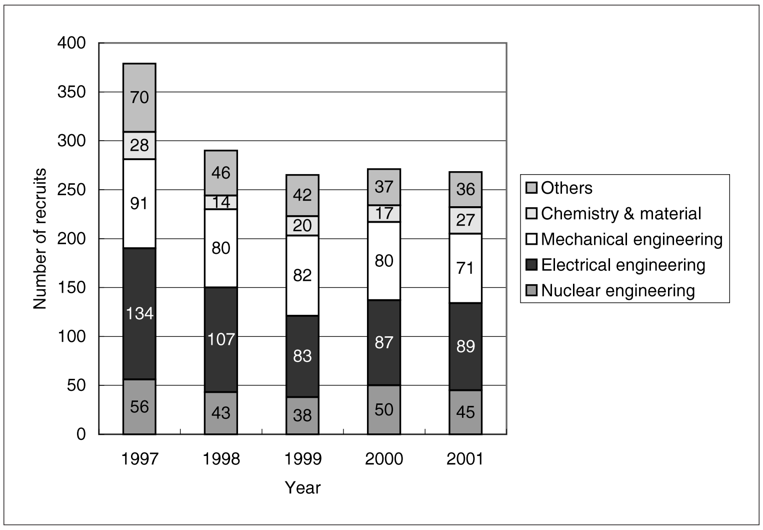
These data are for 8 electric power companies, 3 manufacturing companies, and 2 research institutions[4].

3 manufacturing companies and 2 research institutions [4]. Figure 2 indicates that the annual number of employees recruited by the nuclear departments significantly decreased by 1999, because the annual number of recruits was decreased by all the sectors of the electric power industry including the nuclear one during the same period.

Figure 3 shows that the annual number of students specializing in atomic energy-related subjects and employed by the above-mentioned organizations was 38 to 56, which correspond to about 15% of all the technical employees annually recruited by their nuclear departments (about 10% for the electric power companies and about 1/3 for the manufacturing companies and the research institutions).

On the other hand, Table 1 shows the total number of university and college graduates specializing in atomic energy-related subjects and the number of university and college graduates by career choice in each year[10]. The total number of graduates was around 700 to 800 annually, of which the total number of graduates employed was around 400 annually, except that the numbers of graduates and graduates employed were lower in 2002. The annual number of students employed by the nuclear field including those related to the use of radiation and quantum beams was around 150 or about 40% of all the

Figure 3:Annual number of technical employees recruited into the nuclear sector by type of specialty



These data are for 8 electric power companies, 3 manufacturing companies, and 2 research institutions[4].Data for 1998 do not include 9 employees recruited by the two research institutions.

Table 1: Number of graduates specializing in atomic energy-related subjects and number of graduates by career choice[10]

Year	Total Number of graduates	Number of graduates going on to a higher level of education	Total number of graduates employed (a)	Number of graduates employed by the nuclear sector (b)	b/a (%)
1987	719	278	441	169	38
1990	726	254	472	160	34
1997	689	321	368	175	48
1998	780	362	418	163	39
1999	756	340	416	153	37
2000	812	379	433	159	37
2001	815	385	430	129	30
2002	578	286	292	129	44

These data are for graduates having studied or majored in nuclear engineering-related subjects from Hokkaido University, Tohoku University, the University of Tokyo, Tokyo Institute of Technology, Musashi Institute of Technology, Tokai University, Nagoya University, Kyoto University, Osaka University, Kinki University, Kobe University of Mercantile Marine, and Kyushu University. The data of graduates from Musashi Institute of Technology, Tokai University, Kinki University, and Kobe University of Mercantile Marine were excluded in 2002 and afterwards.

employed students.

In comparisons between the data shown in these charts, the total number of technical employees recruited by the nuclear departments of 8 electric power companies, 3 manufacturing companies and 2 research institutions were annually only 38 to 56 as shown in Figure 3, while the annual number of graduates having studied or majored in nuclear engineering-related subjects was about 700 to 800 with the annual number of graduates employed being about 400 as shown in Table 1. As described earlier, the recruits in the nuclear field in a wide sense accounted for about 40% of all the recruits in all the fields. However, some data indicate that about 75% of all the graduates wanted to enter the atomic energy-related fields[4]. From all the data described above, it can be concluded that the annual number of university and college graduates having specialized in atomic energy-related subjects and employed by the nuclear industry has been strikingly small and decreasing year by year[3, 10, 11]. That is the primary reason for students tending to turn away from atomic energy-related subjects. It seems that this tendency is inevitable under the actual situation where the nuclear industry is diminishing in scale.

3.2 United States of America

In the U.S., there has been no new nuclear power plant constructed in about 20 years. In all the universities and colleges, the number of students specializing in atomic energy-related subjects has decreased by 72% in the related departments and by 46% in the master courses over 10 years, and many atomic energy-related subjects and programs have been closed[3]. Under these circumstances, the annual number of students specializing in atomic energy-related subjects was “decreasingly balanced” with that of graduates employed by the nuclear industry through 1998. In recent years, however, the economy and operating rates of nuclear power plants have been improved, and the federal government has begun to re-appreciate atomic energy as one of the key energy resources for the future. As a result, the nuclear industry has been reactivated. In addition, the increasing number of recruits being sought by the industry has caused emerging concerns about the shortage of students specializing in atomic energy-related subjects since 1998.

Considering these circumstances, a workshop on “Crisis in the Workplace - Manpower Supply and Demand in the Nuclear Industry: Imbalance” was organized mainly by Professor Was (University of Michigan) in the winter assembly of the American Nuclear Society (ANS) held in 1998. In addition, the Nuclear Engineering Department Heads Organization (NEDHO) sent questionnaires on the supply and demand for human resources in the nuclear field to atomic energy-related universities, colleges and companies in the U.S. in 1999. The results were reported in the workshop on “Crisis in the Workplace II - Addressing the Growing Supply/Demand Gap in the Nuclear Industry” in the winter assembly of the ANS held in 1999. The description of these workshops and the results of inquiry by questionnaire were summarized in the NEDHO Report[3].

Table 2 shows the annual supply/demand balance of students specializing in atomic energy-related subjects as the main results of the inquiry by questionnaire as described in the NEDHO Report. This inquiry by questionnaire targeted 32 universities and colleges that had nuclear engineering-related departments and specialty subjects as well as 168 companies related to the nuclear industry.

The students who study mainly the use of nuclear fusion, accelerators and quantum beams account for a considerable percentage of all the students studying or majoring in atomic energy-related subjects (about 30% of all the students in the atomic energy-related departments and about 50% of all the students in the atomic energy-related master courses). Except for these students, Table 2 makes a comparison between the number of students specializing in nuclear engineering subjects (such as reactor engineering, the safety of reactors, nuclear fuels, nuclear fuel cycles, and health physics) in a narrow sense and the number of recruits being sought by the nuclear industry.

In addition, Table 2 indicates that the demand for students specializing in atomic energy-related subjects has significantly exceeded the supply

Table 2: Supply/demand balance of students specializing in atomic energy-related subjects in the U.S. [3]

Year	Supply					Demand f	Gap g (=f–e)
	Number of B. S. (Nuclear engineering in a narrow sense) a	Number of B.S. except those going on to higher education b (=a x 0.75)	Number of M.S. (Nuclear engineering in a narrow sense) c	Number of M.S. except those going on to higher education d (=c x 0.75)	Total e (=b+d)		
1998–99	103	77	96	72	149	512	363
1999–00	124	93	108	81	174	585	411
2000–01	105	79	114	86	165	587	422
2001–02					174*	627	453*
2002–03					174*	642	468*

* Estimated value

in recent years, and it is expected that the supply/demand gap will increase. In contrast with the Japanese situation as described in Section 3-1 above, the NEDHO Report concluded that the shortage of students specializing in atomic energy-related subjects had been caused by the increasing demand for human resources from the nuclear industry in recent years.

4 Government's necessity for training human resources in the nuclear field and the concepts of trained human resources – Is the nuclear industry short of human resources? –

Based on the actual situation in Japan as described in Chapters 2 and 3, this chapter discusses the government's necessity for committing to human resources training, and the concepts in which human resources should be trained.

The factors that determine the demand for human resources from an industry are the industry's scale (such as sales or market) and the labor productivity, unless the short-term factors are regarded. The demand for human resources varies depending on the industrial scale, unless the labor productivity variation with time is taken into consideration. From the other point of view, this means that companies and other organizations employ and reshuffle their personnel under their own management strategies considering the industrial trend.

On the other hand, the nuclear industry in Japan has been diminishing in scale, as described earlier. There are various views on the future outlook of the nuclear industry in Japan. However, it is difficult to predict if the nuclear industry will significantly develop in Japan. Therefore, the demand for human resources from the nuclear industry will probably decrease (remarkably decrease, especially from manufacturing companies that have only a few orders for new plants). For the time being, it is surely difficult to predict if the nuclear industry as a whole will be short of human resources, though it is recognized that the younger generation should take over the inheritance of technologies as soon as possible, especially because the generation that has played the most important role in developing the nuclear industry is aging, as described in Section 2-2.

If the scale of the nuclear industry enlarges in the future, companies will probably recruit the required personnel by increasing the number of new employees and redeploying the existing employees. A report[4] published by the Japan Atomic Industrial Forum, Inc. (JAIF) states that many companies in the electric power, manufacturing and other sectors do not face any serious problem of employment.

In the rapidly advancing disciplines such as life science and information technology (IT), it is predicted that the related industries will be enlarged in scale and that concerns will emerge about the absolute shortage of human resources, and it is considered that the policy challenge is to commit to increasing the quantity of human resources. However, the nuclear industry in Japan is not expected to be in the same situation, as described earlier.

On what grounds is the Japanese government required to cope with the challenge of training human resources in the nuclear field?

For the time being, it is predicted that the nuclear industry will be diminishing in scale and that the number of employees related to the nuclear field will decrease in this industry. Under these circumstances, the challenge in governmental policies is to acquire and train the required human resources, from the viewpoints of controlling and regulating the safety of nuclear plants and radioactive substances (though companies in the electric power and manufacturing sectors, of course, have the primary responsibility of training the safety control personnel), conserving the intellectual properties in the nuclear field (nuclear knowledge), and implementing long-term R&D and other projects.

These viewpoints will be simply described hereinafter.

(1) Controlling and regulating the safety of nuclear plants and radioactive substances

At present, most of the operating nuclear reactors in Japan have a considerably long life expectancy. In the future, it is imperative to satisfy the long-term demand for specialists having a high level of knowledge and engaged in services such as the safety control and regulation of reactors and related plants, the management of radioactive wastes and nuclear substances, and decommissioning.

(2) Inheriting and conserving intellectual properties in the nuclear field

In Japan, the government and companies have allotted a vast amount of budgets and human resources to nuclear R&D activities, since the first Atomic Energy Act was promulgated in 1955. As a result, Japan now has the top level of nuclear technologies in the world as well as an enormous accumulation of nuclear knowledge and technologies. The Japanese government is expected to train the young personnel who will take over these intellectual properties (nuclear knowledge) and transfer them to the next generation.

(3) Implementing long-term R&D projects

In recent years, R&D efforts have been more active internationally to develop an innovative atomic energy system excellent in economy, safety and resistance to nuclear proliferation as well as the diversified utilization of this system such as in the production of hydrogen. It is generally considered that the commercialization of this system has a high potentiality in the future or considerably far future. In Japan, therefore, it is necessary to undertake such R&D efforts with long-term perspectives.

The concrete concepts in which the Japanese government should train human resources from the above-described viewpoints are the researchers and engineers who have high and special knowledge of atomic energy and can fill the most important roles in the nuclear fields of the industrial, governmental and academic circles, respectively. It will take a long time to train the key human resources, and it is difficult for the nuclear industry to replenish them from the other sectors depending on the short- and medium- term trends of the industry.

From the long-term perspectives, therefore, the Japanese government is required to acquire and train the key human resources in the nuclear field by involving the activities of universities and atomic energy research institutions and establishing various systems, in cooperation with the industries concerned. The subsequent chapters will describe the actual situations of nuclear education in universities and colleges; the nuclear education and research assistance by atomic energy research institutions; and the qualification and continuing education systems for technical personnel in the nuclear industry.

5 Actual situation of nuclear education in universities and colleges

This chapter describes the actual situation of nuclear education in universities and colleges. The nuclear departments of industries have employed not only many of the students who specialized in atomic energy-related subjects, but also many of those who specialized in electrical engineering, mechanical engineering and other scientific subjects, as indicated in Figure 3. However, nuclear education in universities and colleges focused on the atomic energy-related subjects and majors.

In recent years, however, subjects having the respective names with the affix of "atomic energy" or "nuclear" have been discarded, especially on the department level. This situation is shown in Table 3. The turning point was the organizational reform of universities and colleges that was inaugurated under the fundamental principles of university and college establishment standards laid down in 1991[10]. As a result, this reform largely changed those organizational structures of many universities and colleges that were vertically divided into departments and graduate schools, and integrated the fractioned subjects for the engineering departments into several major subjects or systems. In many cases, conventional atomic energy-related subjects were integrated as courses into such a system, or otherwise combined with each other in one part of a major subject. In these cases, the keywords such as "energy," "quantum," "system" and "science" were affixed to the names of major subjects and courses as alternatives to the words "atomic energy" and "nuclear."

At the same time when the organizational reform was carried out, more importance was attached in the departmental education to the basic engineering subjects - such as electrical, mechanical, material, information, environmental

Table 3: The actual situation of nuclear education in the departments of universities and colleges

University or college	Department	Initial name of subject (year of establishment)	Current name of subject (year of change)
Hokkaido University	Engineering	Nuclear Engineering (1967)	Nuclear Engineering (not changed)
Tohoku University	Engineering	Nucleonics (1962)	Quantum Science and Engineering (1996)
University of Tsukuba	Engineering Systems	Main transformation engineering major (1977)*1	Main energy engineering major (1998)
The University of Tokyo	Engineering	Nuclear engineering (1960)	System creation science [3 courses of environmental & energy systems, simulation, and bio & information system] *2 (2000)
Tokyo University of Mercantile Marine	Mercantile marine science	Engine science (1962) *3	Mercantile marine system engineering course [nuclear engineering and nuclear system engineering subjects] *2 (1990)
Musashi Institute of Technology	Engineering	Basic energy engineering (1997)	Environmental & energy engineering (2003)
Tokai University	Engineering	Nuclear engineering major in applied science subject (1956)	Applied science [energy engineering major]*2 (2001)
Nagoya University	Engineering	Nucleonics (1966)	Physical engineering [quantum energy engineering course] *2 (1993)
Kyoto University	Engineering	Nucleonics (1958)	Physical engineering [energy science & engineering course and nucleonic sub-course] *2 (1994)
Osaka University	Engineering	Nuclear engineering (1962)	Electronic information & energy engineering [nuclear engineering course] *2 (1996) [Energy & quantum engineering course] (2003)
Kinki University	Science and engineering	Reactor engineering (1961)	Electrical & electronic engineering [energy engineering course] (2002)
Kobe University of Mercantile Marine	Mercantile marine science	Nuclear power science (1972)	Power system engineering course [nuclear system engineering lecture] *2 (1990)
Kyushu University	Engineering	Applied nucleonics (1967)	Energy science (1998)

*1: Basic engineering on establishment.
*2: The words in [ ] indicate the organization in which importance is attached to nuclear engineering in the major subjects.
*3: The nuclear-powered ship engineering research room is established.

and energy engineering - than to the majors, and the number of lectures related to nuclear power generation was largely reduced. These changes occurred in accordance with the engineering education reform strategy wherein the curriculum focused on basic engineering subjects on the department level, while engineering majors were mainly reserved for graduate schools. In some cases, this education reform has been more favorable for students seeking jobs and allowed companies to employ students more freely.

On the other hand, the names of majors were changed in many graduate schools. However, the number of majors with names not changed on the graduate school level are greater than that of subjects with names not changed on the department level, while the number of majors combined with the other(s) are smaller than that of subjects combined with the other(s). Therefore, the educational programs on the graduate school level were not largely changed, compared with those for the departmental education. On the graduate school level, however, there is an increasing tendency to consider nuclear engineering as a wide range of disciplines including quantum and beam science, system engineering, radiation utilization, nuclear fusion and simulation, and it cannot be denied that not enough provision has been made for the education and researches directly related to nuclear power generation.

On the other hand, industries have changed its needs for academic education. The inquiry by questionnaire made by the Japan Atomic Industrial Forum, Inc. (JAIF)[4] indicated that industries required that the students who sought for jobs in the nuclear sector should have surely mastered and developed the basic academic ability, have been well educated in a wide range of disciplines in addition to their major of nuclear engineering, and have a flexible conception, logical thinking ability, challenging spirit, problem-solving ability, and so forth.

Thus, it can be concluded that the conventional education and research programs in which importance was attached to the supply of human resources to the nuclear power generation sector are disappearing in universities and colleges (and their graduate schools). This situation is a response adapting to the general change of the engineering education and research system, or otherwise the diminishing scale of the nuclear industry. Therefore, it is expected that it will be more and more important to improve and develop the nuclear education, qualification and other systems for technical personnel in the nuclear field in order to maintain or improve the nuclear technology level in industries.

6 Nuclear education and research assistance by Atomic Energy Research Institutions and other organizations

6.1 Nuclear training for engineers

Companies and other organizations have provided nuclear education mainly in the form of OJT. To support the OJT, atomic energy research institutions and other organizations have organized training courses for engineers. Table 4 provides a list of key training courses for Japanese engineers. This list includes a wide range of training courses for beginners to high-level professionals. In recent years, the number of trainees has increased in the nuclear disaster prevention training courses for officials responsible for disaster prevention services in local governments.

The Tokai Training Center of the Nuclear Technology and Education Center (NuTEC) installed in the Japan Atomic Energy Research Institute has provided general education and training in nuclear engineering to train engineers in the atomic energy sector [12]. At present, it has opened various training courses for reactor engineering, radiation protection, nuclear fuel engineering, radioactive waste management, nuclear disaster prevention, etc. The training periods range from several days to 21 weeks (for the reactor engineering course). The total number of trainees was 30,410 for the period from 1958 (when the Training Center was established) to 2002. The Tokyo Training Center of the NuTEC has also opened training courses for RI and radiation engineers, and the total number of trainees has reached 21,267.

Table 4: List of key nuclear training courses for Japanese engineers (some radiometry-related and other courses are omitted.)[13]

	Description of main training courses	Number of courses	Number of trainees in 2002
Nuclear Technology and Education Center (NUTEC)/JAERI	Training for atomic energy engineers (Tokai Training Center)	16	871
	Training for RI and Radiation engineers (Tokai Training Center)	13	228
Japan Nuclear Cycle Development Institute	Nuclear disaster prevention	6	1464
National Institute of Radiological Sciences	Radiological nursing & protection, emergency exposure rescue training, etc.	7	347
Radiation Application Development Association	International nuclear safety seminar, Nuclear experience seminar	10	1336
Japan Atomic Industrial Forum, Inc.	Nuclear management seminar for parties interested in the nuclear field, Nuclear power generation quality assurance course, etc.	6	180
Nuclear Safety Technology Center	Nuclear disaster prevention, radiation control & measuring, etc.	23	2641
BWR Operator Training Center.	Training for BWR operators		
Nuclear Power Training Center, Ltd..	Training for PWR operators		588
Japan Nuclear Power Generation Training Center, Ltd.	Basic nuclear technologies, training for radiation controllers, etc.	6	74

6.2 Education and research assistance for graduate school sstudents and postdoctors

The Japan Atomic Energy Research Institute (JAERI) and the Japan Nuclear Cycle Development Institute (JNC) have received graduate school students and postdoctors as special research students and doctors-researchers to conduct researches and receive education by using their facilities.

The special research students are selected from graduate school students as well as graduate school student researchers being jobless for 2 years or less after the completion of the doctoral course, and conduct researches in the general atomic energy discipline for one year. Grants as well as travel and other expenses are paid to them. The JAERI received 60 special research students in the 2003 fiscal year.

The doctors-researchers are selected from postdoctors of 35 years old at most and employed under a one-year contract (that may be renewed up to 2 times depending on the required evaluation of their researches). On voluntary and independent basis, these doctors-researchers conduct their researches in the disciplines appointed by the receiving organizations respectively, by using the experimental and other facilities provided. They may receive advices and supports from the coordinators in the respective receiving research rooms. The JAERI employed 100 doctors-researchers (including those who renewed their contracts) in 2003.

In recent years, atomic energy research institutions have promoted their cooperation with universities and colleges by using the graduate school partnership system. Under this system, researchers in research institutions may be appointed as regular or guest professors and assistant professors to provide research guidance to graduate school students in the respective research institutions with up-to-date equipment until the students obtain their master's degree. The JAERI now has concluded graduate school partnership agreements with 9 universities and colleges.

7 Qualification and continuing education systems for engineers

7.1 Establishment of a "nuclear power and radiation" division in the consultant engineer qualification system

In June 2003, the Advisory Committee on Sciences and Technology in the Ministry of Education, Culture, Sports, Science and Technology submitted its report on reviewing the technical divisions in the examination for qualified consultant engineers[14]. In this report, the council proposed to establish a "nuclear power and radiation" division as a new technical division related to nuclear technologies. This report provided advices and recommendations to the inquiries made by the Education, Culture, Sports, Science and Technology minister in April 2001. The ministry will prepare its draft ordinances and notices based on the council's report, collect public comments, and promulgate its revised ordinances and notices. The examination for qualified consultant engineers will start in the 2004 fiscal year.

The needs for establishing the new "nuclear power and radiation" division include the social importance of nuclear technologies, the inherent nature of nuclear engineering as a multi-technology discipline, the safety of nuclear systems (such as improved skills of engineers, strengthened safety control systems in enterprises, use of engineers in the safety regulation sector, and improved communication with the public on risks), and the international use of engineers.

The qualification of "nuclear power and radiation" consultant engineer certifies the high quality of individual engineers, and it is expected that this qualification may probably contribute to training nuclear engineers into excellent professionals, which may be also considered as the concrete target for these engineers to pursue their self-training.

7.2 Continuing Professional Development (CPD)

In the 2002 fiscal year, the Japan Federation of Engineering Society (JFES) established the Conference for Professional Development of Engineers (PDE) (with a membership of 41 societies and associations) for new engineers graduating from universities and colleges. This conference has started discussions on the preparation of continuing education curriculums for engineers as well as the qualification system.

The Atomic Energy Society of Japan (AESJ), which also is a member of this Conference, established a Working Group for Continuing Professional Development (CPD) within itself. This working group has discussed on the following items regarding the continuing professional development of engineers related to the nuclear power generation and radiation application fields[15].

- The feasibility of studies on the CPD curriculums common to the academic, industrial and governmental circles and required in the nuclear field as well as the possibility of contribution made by the Atomic Energy Society of Japan.
- Inquiries and discussions on the necessity for a new qualification system that is expected by the nuclear industry.
- Inquiries and discussions on the systems and organizations necessary to promote the CPD.
- Discussions on the frameworks of systems for information exchange and cooperation with the other societies and associations.
- Discussions on the framework of the continuing education for those who obtained the national qualifications of managers (for reactors, radiation handling, nuclear fuel handling, etc.).
- Discussions on how the maintenance of the consultant engineer qualification system in the nuclear division should be supported.

8 Conclusion

Considering various factors such as the trend of the nuclear industry, this article has discussed the government's necessity for committing to training human resources in the nuclear field as well as the concrete concepts in which human resources should be trained. In addition, it has described the actual situations of nuclear education in universities and colleges; nuclear education and research assistance given by atomic energy research institutions and other organizations; and education & training and qualification systems for technical personnel in the nuclear industry. This chapter summarizes the important points of what have been discussed and described in the previous chapters, and describes the future challenges to be coped with.

In recent years, the nuclear industry in Japan has been diminishing in scale. The generation that has played the most important role in developing the nuclear industry is now aging. Therefore, it is generally recognized that the younger generation needs to take over the inheritance of nuclear technologies as soon as possible. For the time being, however, it is difficult to predict if the nuclear industry will be short of human resources as a whole.

Under these circumstances, the challenge in the Japanese government's policy is to acquire and train the human resources indispensable for ensuring the safety of the existing plants, take over the inheritance of intellectual properties in the nuclear field, and implement long-term R&D projects, especially the "key human resources" that have a high specialty and can fill the most important roles in the industrial, governmental and academic circles, respectively. It will take a long time to train the key human resources, and it is difficult to replenish the nuclear sector with the necessary human resources from the other sectors depending on the short-term trend of the nuclear industry.

Concerning nuclear education and researches in Japanese universities and colleges, greater importance has been attached on the department level to the basic engineering subjects than to the majors. In graduate schools, there is an increasing tendency to consider nuclear engineering as a wide range of disciplines including the use of radiation and quantum beams. Thus, Japanese universities do not make enough provision for the educational curriculums related to nuclear power generation. This situation is a response adapting to the general change in the engineering education and research systems, or otherwise the diminishing scale of the nuclear industry. Therefore, it is expected that it will be relatively important to improve and develop the nuclear education, qualification and other systems for technical personnel in the nuclear field. On the other hand, the nuclear education and research assistance given by atomic energy research institutions and other organizations to graduate school students as well as technical personnel in the nuclear industry, and the qualification system for technical personnel in the nuclear industry have been gradually improved and developed.

Considering these circumstances, the challenges that the Japanese government should undertake will be discussed hereinafter.

The first challenge is to form a human resources training base by using the human resources and equipment in the two nuclear corporations. An abundance of human resources and equipment exists in the Japan Atomic Energy Research Institute (JAERI) and the Japan Nuclear Cycle Development Institute (JNC). It is essential to make the best use of them not only for the most advanced atomic energy research and development activities, but also for the education and training of the next generation of human resources including the education for students in graduate schools and technical personnel in the nuclear industry. The new corporation to be established by incorporating the two institutes will be required to fill the role of human resources training base in the nuclear field. It is necessary to not only further improve and develop the existing graduate school partnership system as well as the education and training system for technical personnel in the nuclear industry, but also to consider the establishment of graduate schools for professionals*1 using the human resources and equipment in the new corporation. In this human resources training base, it is possible to train a considerable number of human resources having high specialties of key nuclear technologies in a concentrated and effective way. To evaluate researchers in the organizations related to the training of human resources in the nuclear field, it is necessary to build up the framework of an evaluation system wherein not only the results of researches but also the contribution to human resources training are actively evaluated.

Young and good human resources are gathering in potential industries. On the contrary, it is generally considered that the nuclear industry has matured. In medium and long terms, however, the industry is expected to introduce the next-generation atomic energy system excellent in economy, safety, resistance to nuclear proliferation and other features, and to develop new uses for atomic energy such as the production of hydrogen. In recent years, R&D efforts have been more active internationally. To build up the future base of atomic energy technologies in Japan and train human resources in the nuclear field, it is important for the Japanese government to actively support the R&D efforts in developing the new atomic energy system, which is worthy for young researchers to challenge and is expected to be introduced on a large scale into the nuclear industry.

Finally, the birth rate is declining and the population is aging in Japan. In the future, the inheritance of technologies may probably be a challenge common not only to the nuclear field, but also to many engineering fields. To effectively take over technologies in various engineering fields including the nuclear engineering field, it will be important to have the knowledge of their features as well as an approach to the effective inheritance of technologies. Therefore, it is desirable to promote future researches on the inheritance of technologies.

Acknowledgements

In writing this article, the author received valuable advice and the necessary materials from many individuals including Professor Kazuhiko Kudo, Gradutate School of Engineering of Kyushu University, and Mr. Makoto Sobajima, Nuclear Technology and Education Center of the Japan Atomic Energy Institute. Here, the author wishes to express his heartfelt gratitude to all of them.

Note

*1 On July 2, 2003, the prefecture of Ibaraki requested the Japanese government to promote the Initiative “Science Frontier 21” for establishing a general nuclear science research and development base. In its request, it proposed the desired item of promoting the establishment of graduate schools for professionals in the nuclear field.

References

[1] IAEA, Introductory Discussion Paper of the Senior Level Meeting on Managing Nuclear Knowledge, June (2002).

[2] OECD/NEA, Nuclear Education and Training - Cause for Concern? (2000).

[3] Nuclear Engineering Department Heads Organization, Manpower Supply and Demand in the Nuclear Industry (2000).

[4] Report by the Subcommittee on the Problem of Human Resources, Committee for Strengthening the Infrastructure, Japan Atomic Industrial Forum, Inc. (2003) (in Japanese).

[5] Science Council of Japan, Liaison Committee on Nuclear Engineering Researches, and Liaison Committee on Energy and Resources Engineering Researches, Technical Committee on Nuclear Engineering, Re-establishment of Nuclear Science in Harmony with the Society of Human Beings, March 17, 2003 (in Japanese).

[6] Feature Article “Challenges and Perspectives of Nuclear Education and Human Resources Training at a Turning Point,” Atomic Energy eye, Vol. 49, No. 9 (2003) (in Japanese).

[7] “Training for the Next Generation of Engineers Opening Up a New Frontier,” 41st National Symposium of Atomic Energy, Tokyo, Japan, May 22, 2003 (in Japanese).

[8] Toshiro Kitamura, How to Train and Strengthen Human Resources Mainly for the Reparation of Nuclear Power Plants, Atomic Energy eye, Vol. 49, Nos. 9 and 13-16 (2003) (in Japanese).

[9] Japan Atomic Energy Commission, Long-term Program for Researches, Development and Utilization of Atomic Energy, November 24, 2000 (in Japanese).

[10] Kazuhiko Kudo, Actual Situation and Problems of Human Resources Training in the Nuclear Field, lecture meeting in the National Institute of Science and Technology Policy, June 19, 2003 (in Japanese).

[11] Haruhiko Fujii, Nuclear Engineering Education in a Unfavorable Wind - A Few Jobs for Specialists and Concerns about the Availability of Human Resources, Energy Review, March 2002, pp. 46-49 (in

Japanese).
[12] Japan Atomic Energy Research Institute, Nuclear Technology and Education Center, Nuclear Technology and Education Center's Activities (in the 2001 fiscal year), JAERI - Review 2003-003 (2003) (in Japanese).
[13] Provided by the Nuclear Technology and Education Center, Japan Atomic Energy Research Institute (in Japanese).
[14] Advisory Committee on Sciences and Technology, Re Reviewing the Technical Divisions in the Examination for Qualified Consultant Engineers, June 2, 2003 (in Japanese).
[15] Tatsuo Miyazawa, Continuing Professional Development in the Nuclear Sector, 41st National Symposium of Atomic Energy, Tokyo, Japan, May 2003 (in Japanese).

(Original Japanese version: published in September 2003)