

REVIEW OF INTERNATIONAL ACTIVITIES ON NUCLEAR KNOWLEDGE MANAGEMENT AND PROPOSALS FOR FURTHER REFINEMENTS

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Abstract. Concerns are raised world-wide on the sustainability of nuclear societies due to the ageing of nuclear manpower, massive retirements of senior workers within several years, declination of nuclear education and training as well as the shortage of nuclear manpower supply. These concerns were reflected in international activities such as the OECD/NEA report on the nuclear education and training and the IAEA conference on Nuclear Knowledge Management. Many more follow-up activities are currently being formulated and implemented. This paper discusses the nature of the issue, proposes a Four-Season Model of nuclear industry and manpower demand & supply, and raises an issue regarding the possibility of manpower shortage propagation from the advanced countries to the developing countries. The international activities are also reviewed and proposals for further refinements of the nuclear knowledge management activities are made.

1. Introduction

Nuclear educational and training institutes have experienced the reduction in enrollments of young generation showing the sign of declination. The number of universities that provide nuclear engineering program has been in reducing trend and the faculties are ageing without the influx of young faculty members. In the workplaces, the nuclear experts are ageing and are expected to retire massively soon. The nuclear societies world-wide are confronting concerns on the sustainability of nuclear societies not because of lack of knowledge but because of lack of manpower.

These concerns were reflected in international activities such as the OECD/NEA report [1] and the IAEA conference [2]. Currently many follow-up activities are being formulated and implemented actively. However, those activities seem to be expanding hastily in a program based manner lacking the understanding of the nature of the issue and the establishment of proper policy and strategies. Without the clear identification of the nuclear knowledge that should be targeted, those activities might lead inefficient use of the societal resources. This paper reviews the international activities on the issue, discusses the nature of the issue and proposes further refinements of the the current activities.

2. Manpower issue

2.1. Four season model

The nuclear industry has a relatively short history of almost half a century. Rapid growth and massive recruitments in the early stage of nuclear industry development resulted in long employments of the first generation of nuclear experts. Too early saturation of industry caused the suppression of new employments [2]. Also, recent trend of consolidation, privatization, economic competitions accelerated re-organization, out-sourcing, and down-sizing, left limited room for new recruitments. Based upon the history of U.S. nuclear industry, a crude model of manpower demands can be conceived.

Before the 1950's, nuclear engineering was a military program and scientists such as physicist and mathematicians were engaged in the job. Just after the declaration of the "Peaceful use of atomic energy" in UN conference, the domain of the nuclear engineering shifted from military to public. Most of the nuclear power plants and related organizations were set up at this stage. Owing to industrial needs, the workers also shifted from scientists to engineers, most of whom were young.

Since 1980, no new nuclear power plant has been constructed and even the planned ones have been canceled. Nuclear regulations were increased and NPT (Non-Proliferation Treaty) was enforced. More researches were directed to nuclear safety area, where a steady fund could be expected owing to the existing plants. Already the nuclear related organizations were full of still young employers. Without the organizational expansion, new recruitment could be made only in a limited way. The workers grew old hand-in-hand without losing anyone and without adding anyone for 10 years.

Nuclear education and training organizations has reduced and now arrived at a crisis point of low enrollments and rapidly reducing trend. Massive retirements of the first generation of nuclear experts are expected and an idea or expectation of Nuclear Renaissance arises due to the ageing of nuclear facilities.

2.2. Nature of the manpower issue

Regardless of the accuracy of the model, it is evident that there were very large demands for manpower at the early stage of nuclear development. Once the industry was saturated, very few new recruitments were possible and now we are expecting massive manpower demands. Before the industry reaches an equilibrium, massive manpower demand for a short period and exhaustion of manpower demand for a long period are expected repetitively. Massive retirements, if it happens, will incur a second highest peak of manpower demand in nuclear history. Periodically, these manpower demand peaks will appear in any young fields.

Table 1. Four Season Model [3]

	Spring	Summer	Autumn	Winter
Period	1940-1950	1960-1970	1980	1990-
Title	Fetal	Growing	Saturation	?
Activities	Physical exploitation, Military application	Peaceful use, Massive construction of NPPs	NPT, Regulation, Cancellation of new NPPs	Existing facility operation, Lack of vision, Renaissance
Organizations	Manhattan project	Increase due to industrialization	Decrease or stagnation in number and size	Declination of Educational Org. Research oriented
Manpower	Scientists	Engineers, Massive recruitments	Few new recruitment, Less public support, Less enrollment in Science and Engineering	Retirements of 1 st gen. Nuclear experts, Recruit from abroad

When it comes to manpower, the real problem lies in a time lag between demand and supply. These fluctuations in demand will contribute to fill nuclear positions with less qualified staffs, eventually weakening the fundamentals of the society. Thus there is a strong need to achieve equilibrium in manpower demand and supply. A sound policy of manpower development would accelerate the equilibrium of manpower demand and supply and shorten the time period for equilibrium rather than leave the manpower issue to an invisible hand or market.

2.3. Propagation issue

The severity of the problem depends on the country's stage of nuclear development. In most of the OECD countries, the massive retirements are of grave concern. However, in the country where nuclear programs are still expanding, with such programs like the continuation of the new NPP construction, increase of the public and industry R&D funding, the manpower issue poses negligible concerns. Thus, some countries are in their winter period and others are in

other seasons. This difference can be a hope for international cooperation to tackle the temporary manpower shortage.

Vast pool of experts could be constructed by the international collaboration. Depending on the levels of developments in the Four-Season Model of the nuclear technology, while some countries are having difficulty in finding suitable experts, other countries may have some excessive capacity of manpower supply. International collaborations are encouraged such as human resources sharing, international education & training, knowledge networking as well as joint projects.

One important premise for the international collaborations is that the activity should not be extended too much to such a level of devastating a country's manpower demand and supply structure. Otherwise the workforce crisis issue in the advanced countries will simply move and occur in less developed countries.

3. Review of the international activities

3.1. OECD/NEA

Experts from sixteen member countries of the OECD/NEA discussed topics concerning the declination of nuclear education and training organizations. The working group made a comprehensive survey in 1998 and published a report [1].

This report investigated extensively into the problem of world-wide deterioration of nuclear education such as decreasing number and dilution of nuclear programs, decreasing number of students taking nuclear subjects, lack of young faculty members to replace the ageing and retiring faculty members, ageing research facilities, which are being closed and not replaced, significant fraction of nuclear graduates not entering the nuclear industry, in-house training facility and faculty reduction, and low enrollment due to students' negative perceptions.

Also, the report came up with a set of recommendations presented in Table 2 to the responsible bodies of governments, industries, and universities. The strategic role of governments were emphasized such as managing the existing nuclear enterprise, preserving medium and long-term options, sustaining international influence, and pushing the frontiers in the new technologies. Revitalization of nuclear education, vigorous research and maintaining high-quality training and benefits of collaboration and sharing best practices, are the recommendations to the general nuclear societies.

Table 2. Recommendations of the OECD/NEA

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1. We must act now.
 2. Governments should engage in strategic energy planning, including consideration of education, manpower and infrastructure.
 3. Governments should contribute to integrated planning to ensure that human resources are available to meet necessary obligations and address outstanding issues.
 4. Governments should support young students. They should also provide adequate resources for vibrant nuclear R&D programs including modernization of facilities.
 5. Governments should provide support by developing "educational networks or bridges" between universities, industry and research institutes.
 6. Universities should provide basic and attractive educational programs.
 7. Universities should interact early and often with potential students and provide adequate information.
 8. Industry should continue to provide rigorous training programs to meet its specific needs.
 9. Research institutes need to develop exciting research projects to meet industry's needs and attract quality students and employees.
 10. Industry, research institutes and universities need to work together to coordinate efforts better to encourage the younger generation.
 11. The Member countries should ask the OECD/NEA to develop and promote a program of collaboration.
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12. The Member countries should ask the OECD/NEA to provide a mechanism for sharing best practices.
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Regardless of the accuracy of the statistical data cited in the report, it introduced the issue to the international society in a timely manner. An expert group is operating currently to review the influence of the report and to formulate additional recommendations for the nuclear societies. Some countries such as the United Kingdom and Korea have been influenced by the report and the governments have started to take measures to tackle the issue.

However many more countries are either still ignorant of or ignoring the recommendations of the OECD/NEA. The recommendations in Table 2 seem to be just a naïve wish-list requesting more investment of public fund to nuclear society, if it is without active measures such as international policy-making, budget allocation and strong commitment of the agency. It does give a simple warning message to the nuclear society but that seems to be all. Furthermore, in the trend of global electricity market privatization, the roles of governments are reduced to such a level that a strong commitment on the issue is not expected.

The follow-up expert group activities were undertaken. However, without considering the root cause of the issue: lack of vision and job, they simply gathered good practices and again set up a list of recommendations without any enforcement or program to tackle the issue [4]. They should have focused on root causes and proper measures to tackle the issue.

3.2. IAEA

The IAEA also held the Nuclear Knowledge Management Conference with the premise of massive retirements of the first generation nuclear experts [2]. 70 participants from 35 Member States and 4 International organizations congregated to sharpen awareness and understanding of the emerging concerns about the maintenance and preservation of knowledge and expertise in the nuclear field.

Table 3. Top priority activities

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1. Integrate existing nuclear data and information bases (in the IAEA and in Member States) in the form of an easily accessible “Nuclear Knowledge Portal”.
 2. Promote networking of institutions for nuclear education and training in Member States in coordination with existing activities.
 3. Develop guidance documents on the preservation of nuclear knowledge.
 4. Implement targeted preservation of knowledge projects.
 5. Design and implement outreach activities, which improve the general knowledge in society of the benefits of nuclear science and technology.
 6. Facilitate the development of curricula for internationally accepted higher university degrees on “nuclear technology”, e.g. by networking universities.
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An immediate need to preserve existing knowledge in nuclear science and technology was recognized and a unanimous consensus was reached on the IAEA’s obligation to lead activities towards preservation and enhancement of nuclear knowledge. Participants requested an urgent action throughout the nuclear community and beyond to sustain the present level of deployment of nuclear technology and urged the IAEA to bring the conclusions of the meeting to the attention of a wider audience(e.g. the IAEA General Conference).

The conference resolved top priority and additional activities listed in Table 3 and 4. As the participants of the conference were seniors, those lists seem to be biased for the seniors' interests. Most of the activities are actually additional projects for the existing member of nuclear society supporting young generation indirectly instead of giving jobs to next generation. And the priority seems to be given by the easiness of the realization instead of the effectiveness of knowledge transfer to next generation.

Confronting a situation of nuclear workforce crisis and massive retirements of the first generation nuclear experts, the nuclear knowledge transfer is a grave concern. However the nuclear knowledge, which is in danger of not being bequeathed to the next generation, does not seem to be retained by those activities rated with higher priority: knowledge portal, institutional networking and curriculum developments in universities and industries.

Table 4. Additional activities

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1. Provide support for the establishment of an International Nuclear University.
 2. Map existing knowledge preservation activities in member states.
 3. Support for networking retired nuclear experts and young generation nuclear scientists and professionals. Establish a dedicated emeritus programme for preserving the knowledge of nuclear professionals.
 4. Strengthen fellowship and direct support for research and higher education.
 5. Develop a programme focused on attracting a new generation of students into the nuclear area.
 6. Determine the needs and capacity for education, training and research in Member States including advanced technology and distance learning.
 7. Integrate available Agency resources, e.g. INIS, into a knowledge management programme.
 8. Support for closer co-operation between industry, institutions of higher education and research centres.
 9. Support existing and facilitate as appropriate new regional centres for education and training.
 10. Increase the accessibility of meaningful information and knowledge by way of expert and smart systems.
 11. Support of Summer Schools (mentoring programmes).
 12. Strengthen co-operation with other UN organizations
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Those seniors, who are expected to retire in 5 or 10 years, must be densely populated in management, supervising, decision and policy making positions rather than field engineering positions, where relatively juniors are located. If we are seeking sustainability, the nuclear knowledge that should be preserved and handed down to next generation urgently, is not university curricula or OJT (On the Job Training) courses. In fact, the knowledge that should be preserved, is the experience kept in those who will retire soon. As the experience cannot be documented and taught in classrooms, a mentoring program such as widening the participation of young generation to the international society, will be much more effective. It is evident that the nuclear knowledge that can be lost by layoff and that can be lost by retirement should be distinguished and separately planned to preserve. And the priority should be ranked by the urgency.

The needs to preserved knowledge of the suspended projects such as FBR (Fast Breeder Reactor) are acknowledged but it does not mean to pour too much money to breed FBR manpower and revive funding for research. An excessive funding to this kind of job would lead an unjustifiable investment of societal resources.

Need for a new educational institution is very low when the existing institutions are already suffering from low enrollments of students. In fact reduction of young generations entering

nuclear field seems to be caused by the narrow job market, lack of vision, and the nature of the nuclear society driven by the seniors. Furthermore resolutions targeting retirement age extension is a complete non-sense, which can be a short-term solution but can deepen the problem of ageing and thus has potential to devastate nuclear society suddenly after a few years of maintaining the current situation.

More measures tackling the current problems should have been dealt with but unfortunately or intentionally, the priority seemed to have been given to those activities concerned with those who have already got on the boat named 'nuclear society'. The activities which is already or ready to be implemented are those fit the seniors' interests who want to make more programs to nourish them and to extend their job life and retain their controls over the society for the rest of their lives, which they acquired at their 30s. The nuclear society seems to fill responsible positions with those who don't care the society's sustainability after their retirements.

Lastly, the change of the nuclear knowledge activities are to be discussed. The nuclear knowledge activities started by the awareness of the ageing first generation nuclear experts and coming workforce crisis. At first, knowledge transfer to next generation was the ultimate purpose of the program. However as the program was expanded, the title was changed to nuclear knowledge preservation and then nuclear knowledge management covering wider area of nuclear knowledge but forgetting why the activities were started. Now it became a cross-cutting issue covering every aspect of nuclear knowledge and seems to be a battle field of proposals which so far couldn't find funds.

4. Conclusions

International activities regarding the manpower shortage issue and the resulting nuclear knowledge management issue have been summarized and reviewed. The international activities seem to digress due to both the lack of political strategies and unsound interests of the governing seniors. Without proper involvements of the young generation, the declination of nuclear education and eventually of the society would be a "Standing-concern" for the time being.

A crude model based upon the history of the U.S. nuclear industry was proposed. Regardless of the accuracy of the model, it gives the general outlook and nature of the manpower issue. According to the model, periodic occurrence of massive manpower demand in a short period and exhaustion of the demand in a long period, seems to be inevitable and there is a strong need for a manpower policy which can accelerate the equilibrium in manpower demand and supply.

For further refinements of the nuclear knowledge management activities following proposals are suggested:

First, a more precise definition of nuclear knowledge is needed. The nuclear knowledge that can be lost by retirements or lost by layoffs should be differentiated and activities should be devised to tackle the issue directly for the maximum usage of societal resources. Without a precise definition of nuclear knowledge for each specific field, the nuclear knowledge management activities will have to cover every aspect in the nuclear field with limited resources.

Secondly, a comprehensive and frank review of the current international activities should be followed to see if we are a) preparing for massive retirements, b) seeking nuclear knowledge transfer to the next generation, c) seeking accumulation of all the nuclear knowledge in an ample form, d) attaching our programs to an international program, or e) just increasing the international collaboration activities together with the resources available.

Thirdly, if the problem we are discussing is related to a life cycle model or a Four-Season Model of manpower demand and supply, then we have to devise ways to achieve an

equilibrium in manpower demand and supply lest we should discuss the same issue again in 40 years.

Fourthly, in the discussion of the sustainability issue, both experienced seniors and responsible young generation should both be privy to the available information. A good policy is generated from the blending of different voices instead of listing all the voices from just one party. If only the senior officials from organizations have the opportunity to attend these conferences, it will lead to the lack of participation from the young generation who will ultimately be responsible for carrying on the nuclear society.

Finally, if we are to prepare for massive retirements in the future, then the nuclear knowledge that should be preserved and transferred to the next generation such as the experience, management, supervising skills, and international politics. These cannot be simply documented or uploaded to cyber space. A mentoring program or a shadow delegation program is needed to transfer those knowledge to next generations.

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