Prospect for Nuclear Engineering Education in Malaysia

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Abstract—**The use of nuclear power for electricity generation using nuclear power reactors are well-known. Malaysia is considering the use of nuclear power in her energy mix. Engineers with nuclear engineering background will be needed alongside other engineering disciplines. The planning window for a national nuclear power program is long, but the need to graduate nuclear engineers from Malaysian universities should be thought about earlier. There are courses in Malaysian universities that are related to nuclear science and technology. These courses are far from typical nuclear engineering curriculum, but can be the basis for setting-up such program. The nuclear program is not expected to be very big as to require multiple universities offering nuclear engineering degree program. Furthermore suitable faculties are dispersed among several universities. Consortium of universities could be an approach to start the human capital aspect of the nuclear power program.**

Keywords-nuclear engineering; energy; power generation; electricity

I. INTRODUCTION

NUCLEAR energy is supplying more than fifteen percent of global electricity demand with more than 400 nuclear reactors operating in more than thirty countries [1]. The percentage contribution has been around that figure since over a decade ago. As global electricity demand is increasing, that constant percentage indicates that nuclear energy contribution to electricity requirement is increasing in real term.

Realization of climate change, greenhouse gaseous emission, and dwindling supplies of fossil resources against continuously increasing electricity needs trigger what is called a 'nuclear renaissance.' Slow progress in the use of renewable resources as significant bulk energy source and the improved safety of nuclear power plants are additional factors that make nuclear to be a viable source in fulfilling that ever increasing electricity need.

Countries in the Asian region appear to be the growth centers. Malaysia is also on the same path and has decided to positively consider nuclear energy in her energy mix. Estimates put the first nuclear electricity in Malaysia would be generated by the year 2025 [2]. One of the implications of such decision is that it makes preparation of suitable and sufficient human resources imperative. It is possible to introduce nuclear power reactors by relying totally on foreign expertise, for example through Built-Operate-Transfer (BOT) and similar arrangements. However, even in such arrangement, the requirement for trained manpower can only be reduced and postponed, not eliminated, if the program is to be sustainable. Over-dependence on such approach can potentially negate the viability of nuclear energy as a reliable energy source.

II. NUCLEAR TECHNOLOGY APPLICATIONS IN MALAYSIA

A. *Profile of Nuclear Technology*

The applications of nuclear technology can be divided into two large groups: peaceful and non-peaceful. The peaceful applications can further be divided into power and non-power applications. Power applications refer to the use of nuclear technology for the generation of electricity using nuclear reactors. Non-power applications refer to its use in other socio-economic development sectors: medical and health, agriculture, industry, manufacturing, and environment.

The non-power applications of nuclear technology in Malaysia are fairly well-developed [3]. As examples, in medical and health sector more than seventeen health care centers are now equipped with nuclear medicine facilities. In agriculture, new strains of plants are being produced using radiation induced mutation method. In industry, radiography, scanning, and radioactive tracer methods are used in troubleshooting and optimizing industrial plant performances. In manufacturing, disposable medical gloves and devices are routinely sterilized using gamma radiations. The uses of local natural resources are expanded through radiation processing methods. Nuclear technology also has applications in preserving national heritage via the use of techniques such as luminescence dating [4], computed tomography [5], and methods involving ionizing radiation [6]. It is also used in an area that is not generally known to have any applications such as dam management.

The use of nuclear power for electricity generation is now being considered seriously.

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B. Nuclear Infrastructure

The establishment of a national nuclear research institute in 1972, now known as the Malaysian Nuclear Agency, catalyzed the development of nuclear science and technology in Malaysia. The institute was set-up as a research and training facility to develop the manpower and technical capability for the introduction of nuclear power program in Malaysia. A 1 megawatt thermal nuclear research reactor was built and commissioned in 1984. However the discovery of oil fields and subsequent development of petroleum industry in Malaysia in the middle of 1980s set the program back. The diversity of nuclear science and technology enables the institute to instead focus in its non-power applications.

The administrative infrastructure for further growth of the technology in Malaysia was completed with the setting-up of the Atomic Energy Licensing Board (AELB) in 1985. The board is the regulatory agency that implements the Atomic Energy Licensing Act which was enacted in late 1984.

The progresses on non-power applications give rise to the teaching of the subject in local universities.

C. Nuclear Education in Malaysia

A study by the Malaysian Nuclear Agency showed that there are nuclear-related subjects being taught at local universities [7]. Table 1 show that eight universities conduct programmes related to non-power applications of nuclear science and technology; four of them offer such programmes at postgraduate level. These are results of progress and development in the non-power sector of the application of nuclear science and technology in the country. As can be seen, the courses are largely concentrated in the medical applications, which is consistent with the growing number of nuclear medicine centers in the country.

III. NUCLEAR ENGINEERING

A. Manpower Requirements

Typically, the operating organization responsible for a nuclear power plant has a staff of 200–1000 persons, who jointly/collectively have a variety of scientific, engineering and other technical backgrounds in fields needed to effectively and safely operate and maintain the plant. These include: nuclear engineering, instrumentation and control, electrical engineering, mechanical engineering, radiation protection, chemistry, emergency preparedness, and safety analysis and assessment. Scientific areas such as neutronics, physics and thermohydraulics and technical areas such as radiation protection, radioactive waste management, quality management, maintenance and spare parts management are also required to support not only the operating organization but also the regulatory body.

In addition to the required scientific, engineering and other technical education, normally the relevant staffs are also required to undergo another three or more years of specialized training to gain experience prior to initial fuel loading of a nuclear power reactor. For the first project, much of this specialized training and experience, and other nuclear-specific needs are initially provided by suppliers of the technology, and complemented by the International Atomic Energy Agency (IAEA) and other international organizations. However, it is advisable and preferable to set up a plan to gradually develop local suppliers and expertise, for example through a technology transfer agreement as part of the contract with the supplier.

The development of a national academic programme for the education of the necessary scientists, engineers and other technicians to support technical research would also be expected to be in place as part of the commitment to the development of the required national capabilities.

B. Nuclear Engineering Curriculum

The existence of some kind of subjects in nuclear technology in the country, the ability to realize the various safety methods and management of nuclear-related laboratories with their concomitant safety rules, regulations, and procedures provide valuable exposure and footing to the expansion of the capability to nuclear engineering education.

Nuclear engineering relates to the nuclear aspect of nuclear power plant. A nuclear engineering curriculum would include subjects such as:

- Nuclear reactor theory
- Nuclear reaction and radiation
- Nuclear chemistry
- Nuclear thermal engineering
- Nuclear fuels and materials
- Fuel cycle engineering
- Nuclear reactor design
- Nuclear safety engineering

However, to adequately handle nuclear power plants other areas of specialization are needed. Most of these areas such as mechanical engineering, electrical and electronics engineering, modeling and simulation, instrumentation and control, thermo-hydraulics and fluid mechanics, and mechatronics are already offered in Malaysian universities. What is lacking is the nuclear power content per se as mentioned above.

The growth and progress in the teaching of non-power related courses in Malaysian universities could be used as model and foundation to introduce gradually the nuclear power content.

C. Nuclear Education and Training

The decision by government to introduce NPP has positive effect on the enrollment and re-invigoration of declining nuclear engineering departments in many universities elsewhere.

With the nuclear power program materializing, the same trend could be seen in Malaysia. A concern, however, is whether there is enough capacity and resources to set-up a full-fledged department in a university. Networking and collaboration could be a way forward.

Another concern is the level of up-take of the graduates from such program. Matching supply and demand can be a tricky problem in this specialized area of nuclear engineering. However, provided that the excess number is not large, they could be employed in non-nuclear related technical/ engineering area. Other than nuclear power industries such as nuclear utility company and nuclear manufacturing company, nuclear engineering graduates in Japan also get employment in non-nuclear companies such as in manufacturing, transportation, and electronics industry [8].

D. Networking in Education and Training

Nuclear education and training resources are available in some countries with differing levels of advancement depending on the stage of development and of nuclear technology and the general issue of declining interest on science and technology courses among students. Even in country like Japan, the need to educate human resources for the operation of existing facilities with high safety standards is becoming a concern in the face of declining student enrollment. In India, some of the trained nuclear human resources in certain specializations prefer to leave abroad. Preservation and further development of nuclear knowledge and expertise to ensure an adequate number of suitably qualified workforce for the nuclear industry is a challenge not only for countries that are planning to introduce nuclear power programmes but also to some extent those having the programmes in place.

National and international networking and collaboration of universities, research institutions, regulatory bodies, and industry and government agencies is recognized as a key strategy for capacity building, for making better use of available educational resources, and for creating a functional framework to support education and training.

There exist several initiatives to preserve and develop nuclear knowledge through networking. In Europe the European Nuclear Education Network (ENEN) was established several years ahead of a similar arrangement, Asian Network for Nuclear Education and Training (ANENT) in Asia. ANENT was launched by the IAEA in 2004 with the support of its Technical Cooperation programme since 2007. The ENEN has collaborated with the IAEA since its establishment in 2003 for nuclear education and training as well as knowledge management. In terms of education, the ENEN and the IAEA are collaborating with the World Nuclear University (WNU) in organizing regular summer schools. ANENT is also collaborating closely with Asian Nuclear Training and Education Program (ANTEP), a network system established under the Forum for Nuclear Cooperation in Asia (FNCA) that is lead by Japan. The collaboration is for creating synergistic effects in regional cooperation on nuclear education and training among countries in the region.

In nuclear safety, the Asian Nuclear Safety Network (ANSN) was developed in 2002 under the IAEA Safety Program for sharing of nuclear knowledge in safety. To date several e-training courses on the energy planning have been successfully conducted for the East Asia Region using the ANENT Cyber Platform.

IV. Collaboration Among Universities

The window of sixteen years from today to the year 2025 is just adequate to fulfill the manpower demand. Assuming additional three years training to adequately prepare graduates for nuclear power program, current secondary school students would be the future human resources for the programme. However, initial planning works also require expertise and trained personnel. Based on the Malaysia Educational Pathway map shown in Fig. 1, it means that the batch of students about to enter institutions of higher learning would be the target.

A comparison study of the education and training systems used for developing technical manpower in NPP countries such as Brazil, France, Germany, India, Spain and the USA, identifies several possible ways to develop the manpower for a nuclear power programme, starting from existing level of education and training infrastructure [9]. The possible path, shown in Fig.2, indicates that if the level of existing basic educational and training infrastructure is adequate, then only specialized trainings in nuclear power technology need to be developed and added. On the other hand, if the existing level is inadequate, then it must be upgraded before the specialized training stage. Alternatively, a newly established or existing nuclear training center could also be considered to provide both the upgraded basic and specialized training stages. However, ‘crash’ programmes should not and cannot represent a standard and permanent manpower development method.

For Malaysia, where sufficiently experienced personnel for nuclear power programme is not available, a large number of fresh graduates must be recruited and undergo additional training. The scope and nature of the additional training and specialized programmes required depend on the quality of the universities and resources available.

Courses and training in nuclear subjects could be introduced into the university curricula for the scientific and theoretical aspects of nuclear training. However, nuclear power technology and engineering need a more specialized training and specialized facilities.

Collaboration among Malaysian universities, in consortium-like manner, could be an approach to start a nuclear engineering curriculum in Malaysia.

Another approach could be for the Malaysian Nuclear Agency to upgrade its facilities and capability to manage and coordinate specialized education and training in nuclear power technology and engineering program using both local and foreign universities resources. Networking and international collaborations with established entities such as ENEN and ANENT could also be pursued. However, this set-up would require special arrangement with respect to accreditation and should a degree-granting academic programme be set-up outside the ambit of universities.

A more short term approach would be introduction of short courses or even elective subjects in appropriate discipline.

Malaysia could also collaborate regionally to address regional problems on manpower training and development for nuclear energy.

V. CONCLUSION

There are several choices for developing local capabilities to support the impending nuclear power programme in the country. Suitable ones could be adopted based on short term, medium term, and long-term bases needs. The potential demand for such offerings from countries in the region could also be factored-in in considering the design of the programme.

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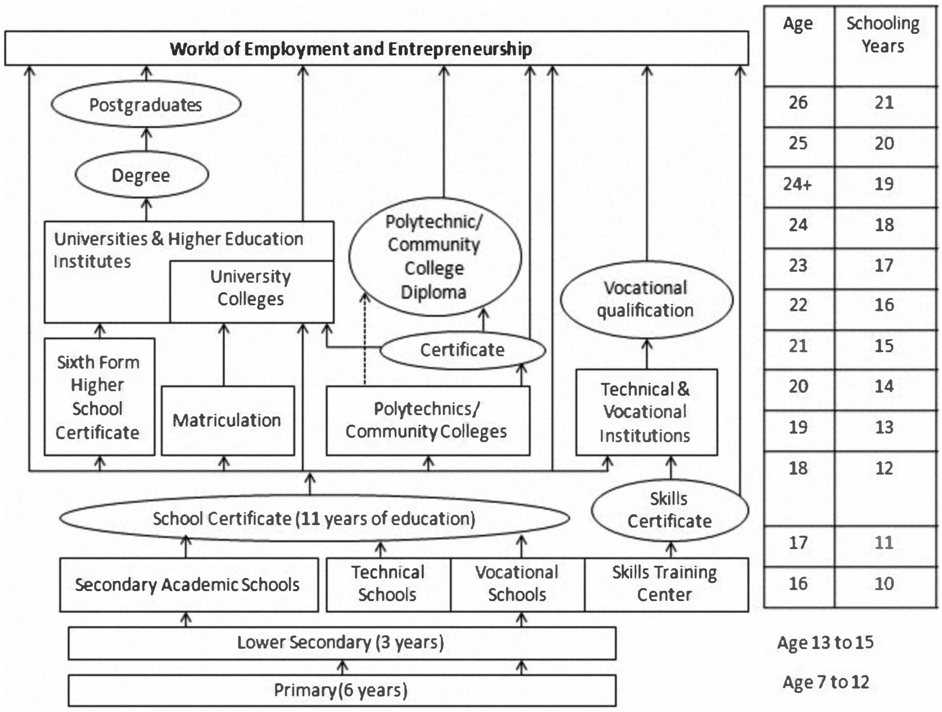

Fig.1. Malaysia Educational Pathway

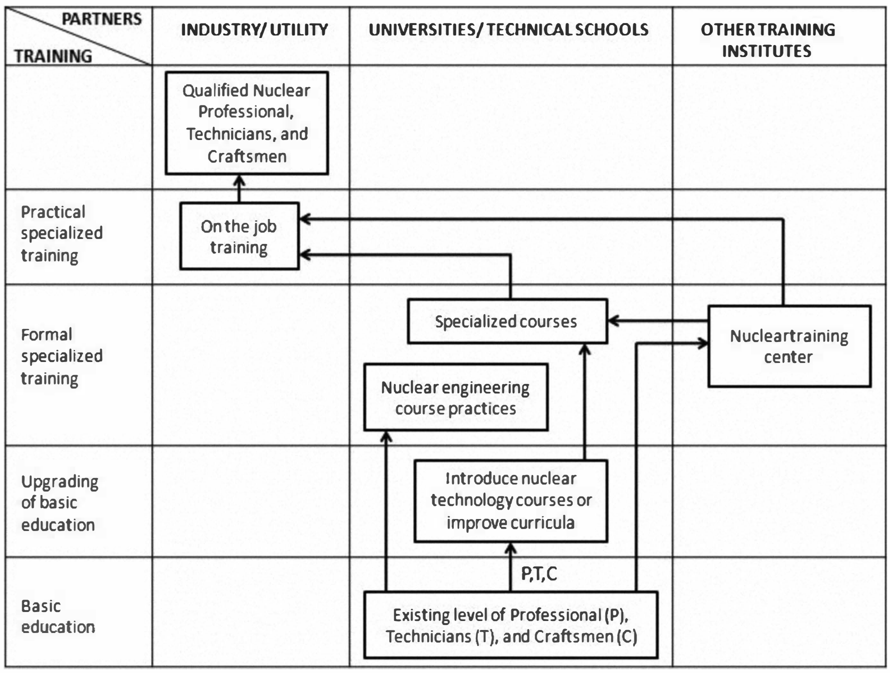

Fig.2. Possible paths for education and training for nuclear power programme.

TABLE 1. NUCLEAR-RELATED SUBJECTS AT MALAYSIAN UNIVERSITIES

University	Level of Study	Scope
Universiti Kebangsaan Malaysia (UKM)	Undergraduate Postgraduate	Nuclear science programmes – B.Sc., M.Sc., Ph.D Radiotherapy and Diagnostic Imaging Programmes – B.Sc. Master of medicine (Radiology) Master of Science in Radiation Safety
Universiti Malaya (UM)	Undergraduate Postgraduate	Bachelor of Biomedical (BBMedSc) – course module includes Nuclear Medicine Technology Medical Physics (Master)
University Sains Malaysia (USM)	Undergraduate Postgraduate	Medical Physics – Bachelor of Applied Science Medical Physics – M.Sc. Medical Radiation Programme Master of Medical (Radiology) Postgraduate Education Certificate (PGEC) in Radiation Protection and Safety
Universiti Putra Malaysia (UPM)	Postgraduate	Research areas – Applied Radiation (radiation synthesis, medical physics)
Universiti Teknologi Malaysia (UTM)	Undergraduate	Basic nuclear science and technology as core subject in year 3 Health Physics – B.Sc. Application of radioisotope and radiation in industry
Universiti Teknologi MARA (UiTM)	Undergraduate	Basic nuclear science and technology as elective subject in year 4 Diploma in Medical Imaging
Universiti Malaysia Sarawak (UNIMAS)	Undergraduate	Medical Physics – Bachelor of Applied Science
Universiti Darul Iman Malaysia (UDM)	Undergraduate	Diploma in Radiography