The status and patterns of nuclear education in an anti-nuclear environment, Austria

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Abstract: This paper describes the current status and basic patterns of nuclear education in Austria and highlights the Nuclear Knowledge Management (NKM) activities of Atominstitute (ATI) through national and international networks. This institute hosts a TRIGA Mark II research reactor for research, training and education purposes. Austria has no nuclear power plant in operation because of the legislation prohibiting nuclear power production within its boundaries. Therefore, its nuclear education focuses on safety issues, i.e. environmental, health and engineering. This paper presents the increasing trend of students in nuclear subjects since 1995. The atomic institute is playing an active role in NKM through the European Nuclear Education Network (ENEN) association. Being the closest facility to the International Atomic Energy Agency (IAEA) headquarter, it also facilitates the international training and educational activities regarding nuclear science and technology.

Keywords: NKM; nuclear knowledge management; Atominstitute; TRIGA Mark II; ENEN; European Nuclear Education Network; IAEA; International Atomic Energy Agency.

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Biographical notes: Rustam Khan, having MSc Nuclear Engineering from Pakistan Institute of Engineering and Applied Sciences (PIEAS) in 2002, did his PhD on 'Neutronics Analysis of TRIGA Mark II Research Reactor and its Facilities' from the Atominstitut of Vienna University of Technology. During his doctoral study, he has been involved in Nuclear Knowledge Management (NKM) activities in Europe and IAEA through different Technical Meetings (TM) on NKM. He has 20 publications in international journals and conferences.

Helmuth Böck got his PhD in 1969 in Nuclear Engineering. He remained a reactor manager of the 250 kW TRIGA Mark II reactor at the Atominstitut Vienna until his retirement in 2008. During his active period, he was frequently hired by the IAEA as a technical expert in the field of research reactor operation and safety. He made more than 50 expert missions to research reactors in Africa, Asia and South America. He is doing his research in NKM

for last 6 years. He has supervised about 90 Masters and PhD students and published more than 250 papers in international journals or international conferences.

Mario Villa has been working as an Assistant Professor since 1999 at the Atominstitut of the Austrian Universities. He obtained his Masters in Physics and PhD in Technical Sciences. During the last 11 years, he has delivered lectures in the field of theoretical reactor physics and practical courses in the field of reactor physics and reactor instrumentation. During this time, he published more than 37 papers in international journals and conference proceedings. Since July 2008, he has been working as a reactor manager of the 250 kW TRIGA Mark II reactor.

1 Introduction

Austria does not operate any nuclear power plants and the use and development of nuclear energy for peaceful purposes have been significantly influenced by the passing, on 15 December 1978, of an Act prohibiting the use of nuclear fission for energy purposes in Austria (OECD publication, 2003). The events in Chernobyl in 1986 encouraged this parliamentary decision and further strengthened public opposition against nuclear power. Confirming this policy, on 13 August 1999 the Parliament adopted the Federal Constitutional Act for a 'Nuclear-Free' Austria. Therefore, the country's main interest of keeping its nuclear education in the safety aspects of nuclear facilities relating primarily to environmental, health and safety concerns arises from nuclear power plants in neighbouring countries. Due to ever-growing concerns regarding climate change and the need to reduce dependence on fossil fuels, Austrian nuclear educational and training activities support the European efforts to address the emerging issue of nuclear workforce.

There are world-wide serious concerns on sustainability of nuclear technology benefiting the mankind in areas like medicine, health, electricity production, etc. The sustainability of all peaceful activities regarding utilisation of nuclear technology needs nuclear human resources. The most crucial is the demand for graduates and highly qualified personnel as these are required for safe and reliable operation of existing facilities, capacity building and innovative R&D. This demand is mostly fulfilled by the higher educational institutions; such as the universities and associated institutes. Maintaining qualified, well-trained and competent workforce is a critical element in the safe and efficient operation of nuclear power plants and other nuclear R&D organisations.

The need to preserve, enhance and strengthen nuclear knowledge is globally recognised. Many efforts are being made on national, regional and international levels. For example, at Organisation of Economic Co-operation and Development (OECD) level, a study report carried on '*Nuclear Education and Training: Cause for Concern?*' in 1999 showed that nuclear education and training is decreasing, perhaps to problematic levels in OECD member states (OECD publication, 2000). The facilities and faculties for nuclear education are ageing, and the number of nuclear programmes is declining. This trend was observed in most OECD/NEA member states (OECD publication, 2000). To address these problems, many steps have been taken on national and regional level in Europe.

One of the steps, as a best practice, to improve the situation is networking. The networking is being used as tool to exchange experts, information and facilities. Networking of educational institutions has been recognised widely as a key strategy for

capacity building and better use of available educational resources. By practice, its benefits have been acknowledged, and networks are being established on all levels, i.e. national, regional and international levels. The World Nuclear University (WNU) is good example at a global level while the European Nuclear Education Network (ENEN) network at regional level (Europe) is in practice. Many national nuclear networks exist in Europe i.e. BNEN in Belgium, CIRTEN in Italy and Nuclear Technological Education Consortium (NTEC) in UK etc.

The ENEN, a non-profit-making association pursuing a pedagogic and scientific aim, was formed in 2003 (ENEN Association, 2003). Its objectives are the preservation and development of nuclear higher education and expertise. The ENEN association has established the delivery of the European Master of Science in Nuclear Engineering (EMSNE) certificate. Education and training courses have been developed and delivered to materialise the core curricula and optional fields of study in a European exchange structure (ENEN Association, 2003). Austria, as a member of OECD, is actively contributing in nuclear educational and training activities in Europe. The ATI is an energetic member of ENEN, therefore contributing its activities for preserving, enhancing and managing nuclear knowledge. The ENEN activities have been extended to new project named as Nuclear European Platform of Training and University Organisations (NEPTUNO). The NEPTUNO integrates European education and training in nuclear engineering, nuclear safety and other nuclear disciplines with the major objectives to secure qualified curricula in nuclear education at European universities according to the Bologna declaration and to harmonise professional training and accreditation schemes (ENEN Association, 2003).

This European master programme in nuclear engineering EMSNE is supported by experimental facilities like TRIGA Mark II research reactor at ATI. The Eugene Wigner Course is carried out in cooperation with central European universities. ATI offers the 'Practical course on reactor physics and kinetics' and a 'Practical course on reactor instrumentation' as a part of EMSNE (ENEN Association, 2003).

Beyond the regional level, ATI cooperates with the nearby located International Atomic Energy Agency (IAEA) in international research projects, Coordinated Research Programmes (CRP) and providing expert services. In support to the IAEA, regular training courses are carried out for safeguard trainees. The fellowships are also offered to researchers and staff members from developing countries to carry out expert missions to research centres in Africa, Asia and South America. In the past 20 years, more than 120 IAEA fellows from all over the world have been trained at ATI (Böck and Villa, 2007). The fellows, after getting training, have been integrated in the respective work programmes. Experience showed that out of this fellowship a long-term relation between the institutes continues.

1.1 Nuclear education in Austria

The Federal Ministry for Education, Science and Culture is the responsible body for higher education in Austria. It supports and regulates the educational institutions (i.e. universities, R&D organisations, etc.) in the country. Universities through their faculties and institutes precede the objective-oriented education. As this work is devoted to the status and pattern of nuclear education in the country, the educational institutions involved in nuclear education will be addressed in this paper. Austria has a strong anti-

nuclear policy; therefore, nuclear knowledge needs to be preserved because of many reasons. First, the neighbouring countries operate nuclear power plants and discussions on international or bilateral level demand educated experts in this field. Secondly, the future of Austria's power supply may require a revision of its anti-nuclear policy and therefore also long-term knowledge management is necessary. Thirdly, nuclear knowledge has many other applications beyond power production, i.e. in industry, medicine, agriculture, etc. Currently, the ATI is major contributor in preservation of nuclear knowledge in Austria.

There is no university or institute offering a nuclear engineering degree or 100% nuclear degree. But there are some pure nuclear subjects; for example, nuclear engineering, reactor physics, reactor experiments, dosimetry and radiation protection, etc. are offered to physics and diploma engineering (equivalent to master degree) students. Following are the main institutions who are involved in nuclear education.

1.1.1 Demonstration BWR facility

The act of prohibiting the use of nuclear fission for energy purposes in Austria was passed on 15 December 1978 (OECD publication, 2003). This Act was adopted as a result of the referendum rejecting the start-up of the almost 80% completely installed first Austrian nuclear power plant at Zwentendorf in 1978. This facility is now being utilised for demonstration purposes for students in this field. This is unique facility of its type.

1.1.2 Austrian Research Centre, Seibersdorf

Although the 10 MW MTR type ASTRA research reactor was shut down in July 1999, the nuclear competence in the fields of nuclear technology in the centre are nuclear engineering, radiation safety and application, health physics, radiopharmaceuticals and energy sources. This waste storage facility, together with related waste treatment facilities, is operated by the Austrian Research Centre, Seibersdorf, to meet the radioactive waste management needs of Austrian industry, hospitals, other medical institutions and research institutes. The storage facility has a design capacity of 15,000 barrels containing 200 litres each.

1.1.3 University of Salzburg

The division of physics and biophysics has five research groups. Two groups i.e. environmental radioactivity, radioecology, risk assessment and dosimetry and modelling group are focussing their research on environmental radioactivity, neutron activation analysis, radioecology risk assessment, dosimetry and modelling aerosol research cell biology and tumour research experimental physics.

1.1.4 University of Vienna

The Institute of Risk Research (*Institut für Risikoforschung*) of the University of Vienna was founded in 1995 with the aim of supporting an interdisciplinary, independent and critical scientific discussion of risks to society and to manage relevant interdisciplinary projects. The institute consists of a small international team of scientists from different

disciplines. Originally, research focused on topics concerning nuclear safety, but has lately evolved towards more fundamental questions of risk research and more general aspects of risk.

1.1.5 University of Technology, Vienna

The Vienna University of Technology manages five faculties. The faculty of Science and Informatics administrates physics, chemistry, informatics, geophysics department and Atomic institute of Austrian Universities (ATI). Because of the scope of this paper and role of ATI in regional and international efforts of nuclear knowledge management activities, the ATI will be addressed in detail along with its academic and training programmes.

2 Atominstitut (ATI)

The ATI operates a TRIGA Mark II research reactor since 1962 at the rather low power of 250 kW and with a completely mixed cylindrical core. It is equipped with a thermal column, radiographic collimator, four beam tubes and three in-core pneumatic transfer systems. The core has a cylindrical grid plate with 96 positions in six rings for fuel elements, three control rods and various other core installations with the same outer diameter of a standard TRIGA fuel element.

The ATI plays an active role in the performance of ENEN and NTEC. ATI participates in ENEN training programmes like Eugene Wigner courses, NEPTUNO and MTR+3I programmes. In cooperation with NTEC (2005), one week training course on reactor physics and kinetics, radiation protection and reactor I&C systems is carried out since 2007. Each group consists of six students. This course of two weeks per year is a part of the NTEC MSc programme in Nuclear Science and Technology.

There are following seven different research groups working in this institute.

1 Electron and X-ray Physics

2 Nuclear and Nuclear Astrophysics

3 Nuclear Technology, EDV and Electronics

4 Neutron and Solid State Physics

5 Radiochemistry

6 Radiation Protection and Dosimetry

7 Low Temperature Physics and Superconductivity.

2.1 ATI activities

ATI keeps three types of main activities which are national, regional and international activities. National activities mainly cover the academic programmes (like Master and PhD programmes) and training programmes. The main nuclear relevant subjects covered in academic programmes are nuclear engineering, reactor physics, experiments on the TRIGA reactor, radiation protection, radiochemistry, neutron activation analysis,

dosimetry, etc. The institute's educational and training programmes to promote the nuclear education in Europe cover the regional activities. These activities involve ENEN Master of Nuclear Engineering and NEPTUNO project. The ATI is also member of global organisations like IAEA, WNU, etc. and contribute to the international activities. Following are the main programmes through which ATI is contributing at all three levels.

2.2 Academic programmes

The atomic institute graduates about 20 Masters and five PhD students per year in the following subjects:

- Neutron and Solid State Physics,
- Nuclear Technology,
- Radiochemistry,
- Low Temperature Physics,
- Radiation Protection,
- Nuclear and Astrophysics and
- X-ray Physics

2.3 Training programmes

Being the closest nuclear research facility to IAEA headquarter, the ATI organises following activities in cooperation with the IAEA:

- Development of safeguards instrumentation;
- Development of instruments for prevention of illicit trafficking;
- Calibration of nuclear instrumentation;
- Irradiation and test of safeguards instrumentation;
- Storage of special nuclear material;
- Training courses for junior safeguard inspectors;
- Since 1992, more than 100 IAEA fellows from developing countries.

2.3.1 Practical courses offered by ATI

ATI offers practical courses mainly for reactor physics and kinetics, reactor instrumentation and control (I&C) and radiation protection. Following experiments are regularly performed within the reactor physics and kinetics course:

1 Measurement of the thermal neutron flux density in the reactor core,

2 Measurement of the epithermal and fast neutron flux density in the reactor core,

3 Determination of the importance function and the void-coefficient,

4 Determination of the neutron absorption cross section according to the danger coefficient method,

5 Measurement of the reactor period,

6 Radiation protection around a research reactor,

7 Critical experiment,

8 Control rod calibration and determination of the core excess reactivity,

9 Sub-critical safety rod calibration,

10 Determination of the reactivity value of uranium fuel and graphite elements in different core positions,

11 Reactor power calibration and determination of the temperature coefficient of the reactivity and

12 Demonstration of a reactor pulse with different reactivity insertion.

Following experiments on reactor instrumentation and control are performed within the reactor instrumentation and control course:

1 TRIGA Mark II instrumentation:

- Instrumentation and control system,
- Characteristics in continuous operation,
- Characteristics in transient operation;

2 Calibration of the nuclear channels:

- Nuclear channels (channels 1,2,3) linearity check;
- Reactor scram settings test;
- Fuel temperature channels;
- Water temperature channels;

3 Rod drop time of the control rods;

4 Neutron flux density measurement using Compensated Ionisation Chambers (CIC);

5 Neutron flux density measurement with fission chambers (FC);

6 Neutron flux density measurement with Self-Powered Neutron Detectors (SPND):

- Slow or delayed SPND,
- Prompt SPND,
- Other influences on the SPND signal;

7 Pressurised water reactor simulator.

Since March 2002, ATI has been arranging following courses of nuclear technology:

- Three eight-day courses for staff of NPP Bohunice (six persons);
- Three eight-day courses for staff of NPP Mochovce (six persons);
- One ten-day course for the German Reactor Safety (GRS) institute (eight persons);
- Each year, one two-weeks course for about 20 ENEN students since 2004;
- One one-week course for UK nuclear submarine staff (two engineers);
- Every two years, a one-month training course for the IAEA (six to eight junior; safeguards trainees selected by the IAEA);
- Two times a year, a one week course for nuclear engineering students of NTEC programme, UK.

The commercial training courses for the NPP staff are carried out on routine basis as follow:

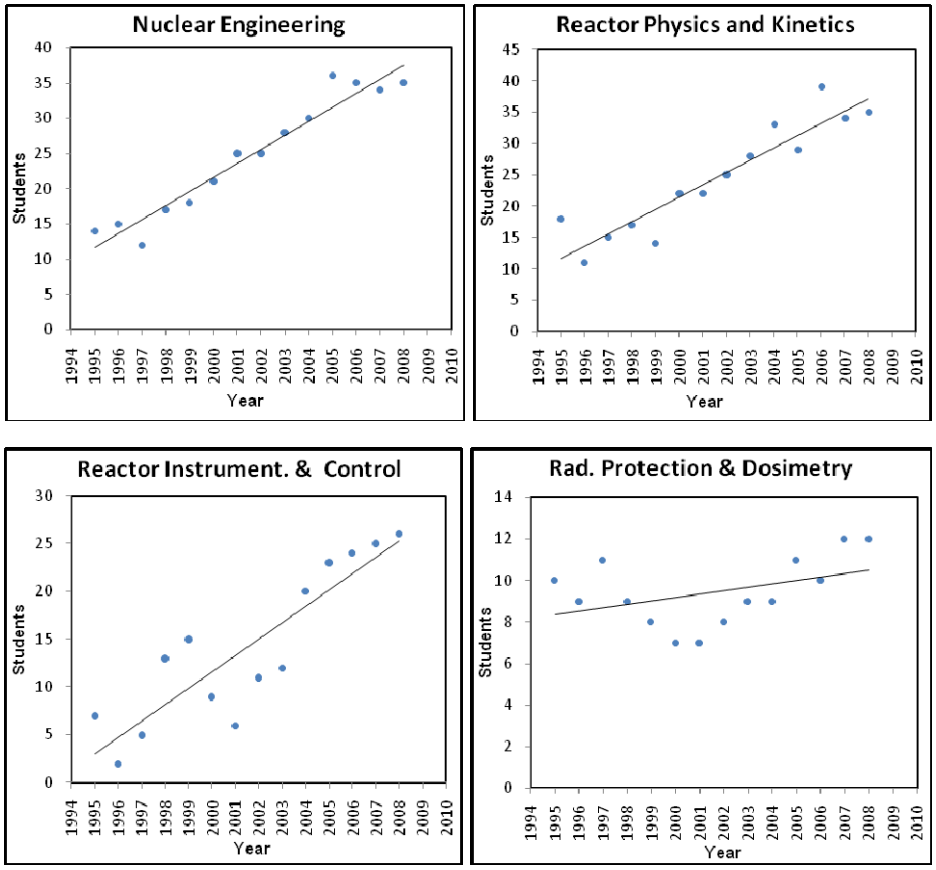
- Courses organised through university cooperation Vienna–Bratislava;
- Groups of four to six junior NPP engineers;
- Duration of course is one full week, six hours per day;
- Course content selected from 20 proposed exercises according to interest and needs;
- Theory behind each exercise is introduced before;
- Complete English manual available.

2.4 Development of nuclear education since 1995

Figure 1 reflects the trend of students in nuclear subjects offered at ATI. These graphs show that enrolment trend of students in favour of nuclear technology is increasing. The ostensible reason for this growing trend may be the awareness level of public in general and students in particular about the potential of safe usage of nuclear energy in the coming future.

European efforts like ENEN, NETUNO, etc. to promote nuclear education and training attract the students towards nuclear subject. Being a member of ENEN association, Austrian students also participate the ENEN activities like the Eugene Wigner Course for Reactor Physics Experiments. It is a three-week course with a high involvement of practical exercises organised by four European universities for Master and Postgraduate students from European as well as non-European countries (Miglierini, 2007). It is expected that Austrian students participate ENEN activities like EMSNE in future. Also, Public Information Materials Exchange (PIME, 2008), an international conference organised by European Nuclear Society (ENS) to convince the public through print and electronic media of safe and efficient use of nuclear technology, is helping to raise the nuclear student enrolment rates in universities. Nuclear industry incentives of offering attractive jobs in Europe are also affecting anti-nuclear climate in the country.

Figure 1 Historical view of nuclear education at ATI since 1995 (see online version for colours)



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