UNENE: An Update on Nuclear Education and Research

Dr. B.A. Shalaby[1], Dr. V.G. Snell[2] and Dr. B. Rouben[3]
[1]UNENE President, email: basma.shalaby@rogers.com
[2]UNENE Program Director, email: vgssolutions@rogers.com
[3]UNENE Secretary-Treasurer, email: roubenb@alum.mit.edu

Abstract

University Network of Excellence in Nuclear Engineering (known as UNENE) was created in 2002 as a partnership between Industry and universities with the objectives of establishing a nuclear R&D program in universities, train and develop Highly Qualified Personnel (HQP) to address the demographic gap, and to create a sustainable source of expertise for independent industry and public consultation. Seven years into its creation, UNENE is now a well established and fully functional framework with programs mainly focussing on education and research serving the industry at large. The educational component is in the form of an M. Eng. program mainly catering for working professionals by being offered on weekends and using distance-learning tools. It is intended to enhance competencies and build knowledge for students. The R&D programs are led by Industrial Research chairs (IRCs) and other prominent researchers in areas of importance to the industry. This paper examines the above topics and its outcomes as of March 2010.

1. Introduction

UNENE (University Network of Excellence in Nuclear Engineering) was established in 2002 as a partnership between the nuclear industry and universities with the objectives of:

1. Establishing university research in key areas of interest to the nuclear industry
2. Developing a sustainable supply of Highly Qualified Personnel (HQP) to address demographic gaps in the industry
3. Providing an independent university-based source of scientific expertise for public and industry consultation

UNENE members are listed in Figure 1.

UNENE Members

- Atomic Energy of Canada Limited
- Bruce Power
- Ontario Power Generation
- Canadian Nuclear Safety Commission
- CANDU Owners Group
- Nuclear Safety Solution
- CAMECO
- McMaster University
- Queen's University
- University of Ontario Institute of Technology
- University of Saskatchewan
- University of Toronto
- University of Waterloo
- University of Western Ontario
- University of Windsor
- Ecole Polytechnique
- University of New Brunswick
- Royal Military College
- University of Guelph

Figure 1: UNENE Members listed by Government /Industry and Academic

2. UNENE: A Partnership

The industry members, (namely Ontario Power Generation (OPG), Bruce Power (BP) and Atomic Energy of Canada Ltd (AECL)) initiated UNENE research by sponsoring Industrial Research Chairs (IRCs) in many of the UNENE Universities. These chairs are held by world-class scientists with considerable industrial experience and they are well respected in the industry, both nationally and internationally. These IRCs became anchors for establishing research programs and competent research teams within their respective universities. Industry funding of the IRC programs has also served to leverage additional funds from federal and provincial research grants, thus widening the scope and size of these programs – which have allocated $50M (Canadian) to date.

UNENE is a non-profit organization governed by a Board of Directors (BoD) with member representation from the funding industrial partners and universities. Two Advisory Committees, one on Education (EAC) and one on Research (RAC), manage and oversee the respective programs. The EAC and RAC committees consist of both Industry and University members. Both committee chairs report quarterly to the BoD on the status and results of research and educational activities (Figure 2).

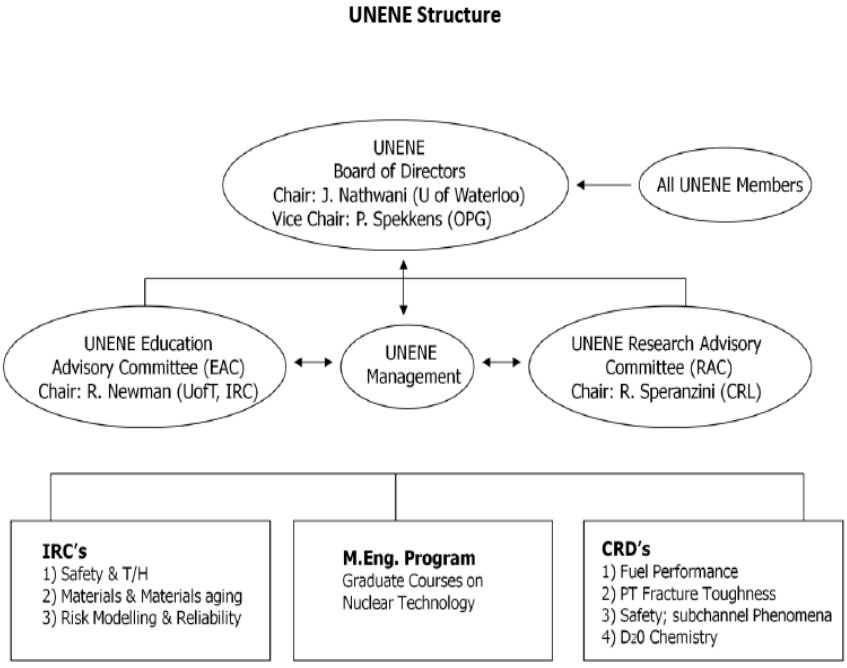

Figure 2: UNENE Structure

3. UNENE and Current Industry Challenges

Canada's nuclear industry is well established as a $6B industry with nearly 60,000 jobs. It started in 1945 with the ZEEP (Zero Energy Experimental Pile), followed by the early nuclear research reactors (NRX and NRU), and continuing to the established CANDU - PHWR (Pressurized Heavy Water Reactor) technology – with a current market share of 8-10% of the world-wide commercial NPP's (Figure 3).

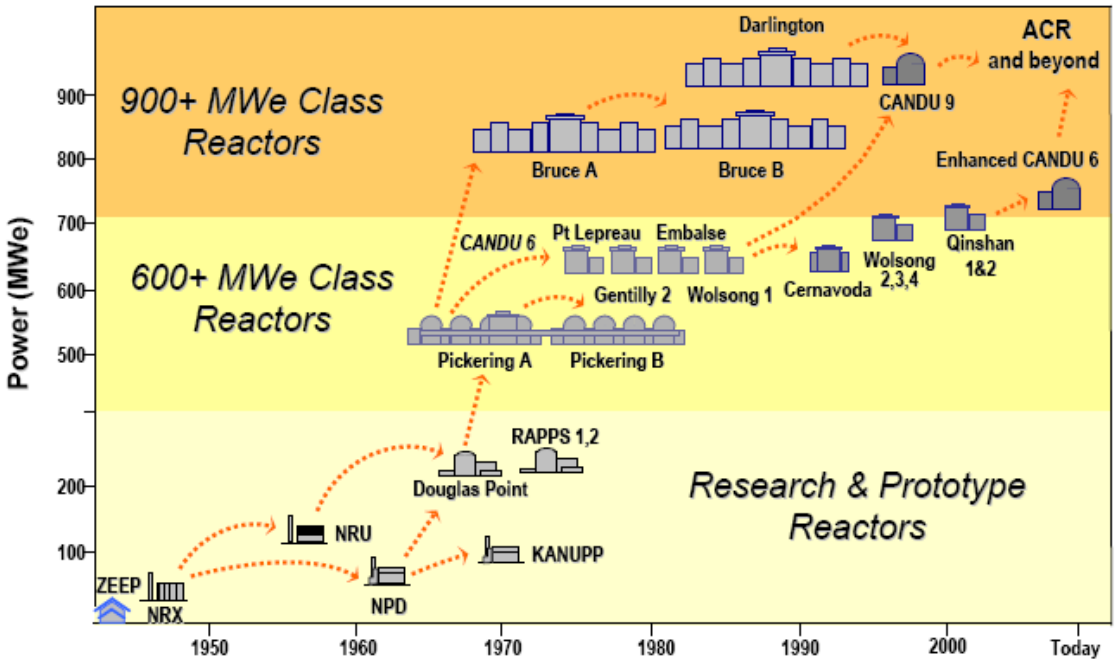

Figure 3: CANDU Genealogy

Nuclear power in Canada now provides 15% of the national electricity supply, and 50% of the electricity supply in the most industrialized province of Ontario.

Most of the plants are Generation II vintage, coming on stream from the mid-1970s (Pickering A Units 1 to 4) to the mid-1990s (Darlington Units 1 to 4). Some of the CANDUs have been life-extended beyond their 25-30-year design life while others are being (or are planned to be) refurbished for a 50 to 60-year life. Future nuclear construction of Generation III and Generation III+ plants are expected to replace retired nuclear capacity and to meet clean energy targets (Figure 4).

As with any industry, an NPP is a complex project with long lead times, and is multifaceted and multidisciplinary in nature, making knowledge one of its key enablers and a vital component over its entire lifecycle: design, licensing, construction, operation, decommissioning and long term waste management. This is even more crucial in view of life extension or life doubling: nuclear competencies and continuity in knowledge need to be maintained for two to three generations.

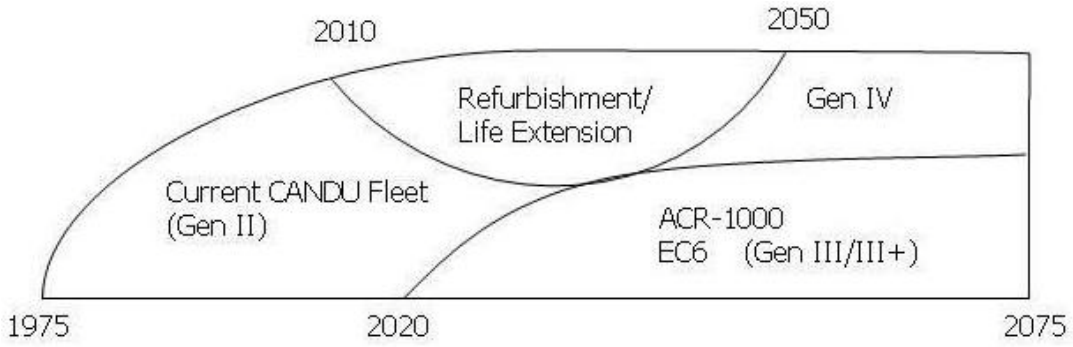

Figure 4: Nuclear R&D and Industry Challenges

So for the industry to secure safe and economic long term operation of the current CANDU fleet, it recognises the role of knowledge preservation and continuous competence-building in order to meet the following strategic priorities:

1. Maintain the safe and economic Long Term Operation of its current nuclear plant fleet.
2. Maintain knowledge of the design and licensing basis of current plants.
3. Advance knowledge and tools towards successful design and licensing of future Gen III+ plants (such as the Enhanced CANDU 6 and the ACR-1000).

With these priorities, the UNENE partnership between Industry and Academia focuses on two key aspects: Education and Research.

4. UNENE Educational Program

A graduate level Master's program was set up by UNENE in collaboration with the member universities. Program courses from member universities, duly accredited in Ontario by the Ontario Council of Graduate Studies, allow UNENE to coordinate a joint course-based Master's of Engineering Program in Nuclear Engineering. The courses cover key areas fundamental to nuclear plant design, safety, operation and other related topics geared to enhance the knowledge and competence of students and other professionals working within the industry. Courses are offered outside working hours; acceptance is according to the normal graduate-level admission prerequisites. The courses currently offered are noted in the Table below.

Table 1: Courses offered towards the UNENE M. Eng. in Nuclear Engineering

Course #	Course Title
UN0801*	Nuclear Plant Systems and Operations
UN0802*	Nuclear Reactor Analysis
UN0803*	Nuclear Reactor Safety Design
UN0804*	Nuclear Reactor Thermalhydraulics
UN0601	Control, Instrumentation an Electrical Systems in CANDU Plants
UN0602	Nuclear Fuel Waste Management
UN0603	Project Management for Nuclear Engineers
UN0701	Engineering Risk and Reliability
UN0702	Power Plant Thermodynamics
UN0805	Radiation Health Risks and Benefits
UN0901	Nuclear Materials
UN0902	Fuel Management
UN1001	Reactor Chemistry and Corrosion
UN0800	Industrial Research Project

*Core M. Eng courses

The M.Eng Program continues to grow both in student enrolment and in the selection of courses offered, as shown below (Figure 5).

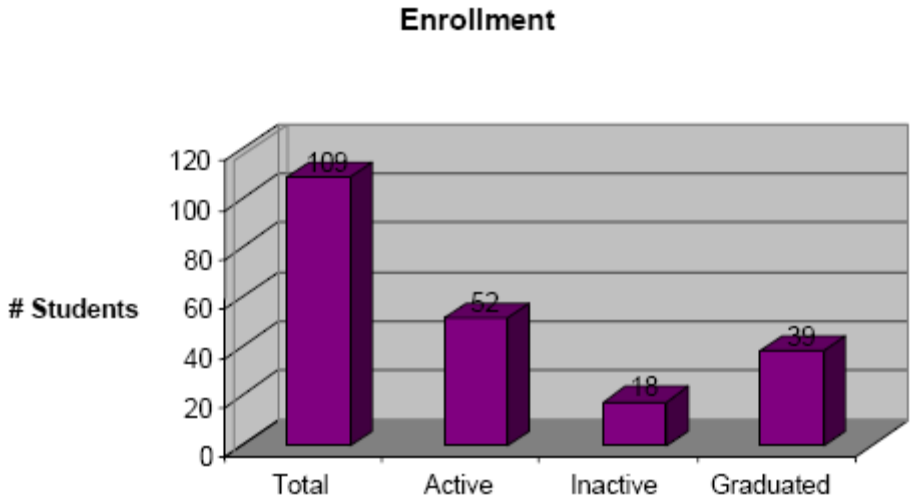

Figure 5: Chart showing Student Enrolment

The UNENE M. Eng. offers many benefits to the industry, such as:

- Development of HQP to meet industry needs.
- Assisting industry in knowledge transfer and preservation.
- Professional/career development of employees towards an effective and highly skilled workforce.
- Lower cost than in-house training (employees take courses outside of working hours on their own time).
- Forum for employee's interaction with industry and university peers.

One utility explicitly recognizes the UNENE M. Eng. as an advantage when an individual applies to become a supervisor. Also, some of the M.Eng course material is now being proposed for high-calibre non-accredited enhanced training to utility professionals.

To accommodate and attract students who work at sites distant from the greater Toronto area, synchronous distance learning over the internet is now routinely applied to all course deliveries through the use of the ELLUMINATE program. As of September 2009, student feedback with distance learning has been positive, and even "live" students appreciate and use the recording feature. New video conferencing systems are currently under assessment; with additional features such as enhanced visual capability, viewing of full screen lecture presentations by all students and ability to see all participants (real time) at different locations.

5. UNENE Research Programs

Since UNENE's inception, Industrial Research Chairs (IRCs) and Collaborative Research and Development (CRD) projects were established as the platforms for nuclear research in Universities. World Class IRCs were endowed in prominent Canadian universities to become anchors for research in key areas of the technology, while developing Highly Qualified Personnel for industry hiring. The IRCs established are:

- McMaster University: Safety and Thermal hydraulics
- Queens University: Material Sciences
- University of Toronto: Nano-engineering of Alloys
- University of Waterloo: Risk and Reliability
- University of Western Ontario (UWO**):** Instrumentation and Control, and Electrical
- Royal Military College (RMC): Fuel Technology
- University of Ontario Institute of Technology (UOIT): Health Physics

Most programs focus on key R&D in areas of interest to the industry such as safety analysis methodologies, phenomena and analytical codes; fuel channel material sciences; corrosion chemistry in nuclear materials; and probabilistic and risk modelling in support of Life Cycle Management in current plants.

To date many outcomes have been achieved.

- Nine (9) CRDs have been funded by UNENE/NRCan on topics closely tied to the IRC programs. The initial CRD projects are nearing completion with five (5) new ones being initiated in 2010 for a three-year duration.

- UNENE program funding leveraged additional provincial and federal funding; making current available funds for UNENE universities in excess of Can $50M.

- The number of HQP developed by member universities has reached 100 HQP (PhDs, PDFs, MASc with most of them successfully recruited within the industry, research institutions, government and universities.

-**National & International collaborations** are forged within the university itself across many engineering disciplines and scientific departments, among different universities, and with industry on specific research programs. Examples of such collaborations are the University of Toronto / University of New Brunswick / University of Waterloo study on corrosion chemistry; the McMaster / CANS (Centre for Advanced Nuclear Systems)work on Thermal hydraulics; Queen's University / Kinetrics on pressure tube deformation; McMaster / Chalk River Laboratories on fuel cycle and physics; and Royal Military College / Chalk River Laboratories on fuel performance.

International collaborations are established with many US universities and the US Department of Energy National Labs, and some European Union universities in areas such as thermal hydraulics (between McMaster / University of Pisa and Trinity College), and development of integrated fuel performance codes between Royal Military College and Oak Ridge National Laboratory.

-Consultation /Interactions with industry: Many technical exchanges, consultations and technical activities take place between industry and universities. IRCs' and Associate IRCs' expertise is sought by industry on resolution or regulatory queries; Life Cycle Management (LCM) decisions for optimal maintenance and risk-based inspections (OPG); NRU leak repair (AECL); ACR-1000 Independent Safety Review (AECL); OPAL Reactor (ANSTO); Pickering Unit 7 Calandria Tube crack (OPG), etc.

-Equipment and Facilities;

- A High Performance Computing Center (HPCC) was set up at McMaster enabling Safety Analysis code coupling and code development. The HPCC is accessible by users University wide.
- A Nuclear Materials Testing Lab is being planned at Queen's with commissioning expected in 2012.

Other notable benefits and successful spinoffs to the industry are:

1. **Integration of research programs** among universities and institutions.

2. **Interaction of Universities with industry** through UNENE Technical Advisory Committee (TAC) (AECL, BP, OPG), resulting in detailed discussion on research directions and opportunities, ensuring industrial–university technical research objectives are met.

3. **Expansion of R&D base** with eleven (11) universities becoming players in research and knowledge building.

4. **Technology Transfer** on topical issues of critical importance to industry on operational, regulatory and new build such as Steam Generators, Fuel Channels, Feeders and MTS components, Regulatory and Operational Safety, Gen IV designs and risk-based inspection and maintenance.

6. Summary

UNENE continues to grow and provide technical and educational support to industry members in key areas of importance to industry. Establishment of research programs in universities has increased the knowledge base and facilitated integration of R&D among Universities and industry, making technology transfer viable and effective in all aspects of the technology. The UNENE M.Eng program has continued to attract students from industry and is expected to grow further now that Distance Learning has been further honed and become easier through the use of Elluminate Software through McMaster University. It is expected that further enhancements in these tools will attract more students from distant sites.

7. References:

[1] G. Bereznai, W. Garland: "New Postgraduate Programs in Nuclear Engineering to meet the needs of the Canadian Nuclear Industry" 16th Pacific Basin Nuclear Conference (16 PBNC), Aomori, Japan, Oct 13-18, 2008, Paper ID P16P1343.