UNENE and Nuclear Human Resource Development in Canada

Dr. V.G. Snell
Programme Director, University Network of Excellence in Nuclear Engineering

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Background

There are currently 17 operating nuclear power plants in Canada, which provide 16% of Canada's electricity, and more than 50% of the electricity of the province of Ontario. With the phase-out of coal plants in Ontario, electricity forecasts show a significant supply gap opening up around 2015[1], and as a result Ontario has decided to include new nuclear power plants, as well as life-extension of 10 existing nuclear plants. As a result Ontario Power Generation (OPG) expects to hire hundreds of new nuclear engineers; over the next few years 40-50% of their experienced nuclear engineers will retire[2]. Timely supply of the new graduates and their mentors is clearly a significant challenge.

UNENE

UNENE (University Network of Excellence in Nuclear Engineering) is uniquely placed to contribute to Human Resource Development (HRD) needs. UNENE is an alliance of universities, nuclear power utilities, design and research organizations and regulatory agencies for the support and development of nuclear education and R&D in Canadian universities. UNENE was established as a not-for-profit corporation by the Government of Canada on July 22, 2002. The main HRD purpose of UNENE is to assure a sustainable supply of qualified nuclear engineers and scientists to meet the current and future needs of the nuclear industry through university education. It does this through programmes that:

- Upgrade the education of staff working in the nuclear industry
- Develop and supply highly-qualified graduates
- Support nuclear research, and
- Create respected university-based experts for consultation by industry and the public.

UNENE members include AECL (the designer of CANDU); the two nuclear utilities in Ontario (OPG and Bruce Power); three additional nuclear companies; the Canadian regulator (Canadian Nuclear Safety Commission); and 12 Canadian universities – the detail is shown below:

[1] Atomic Energy of Canada Limited, "Maintaining Flexibility: Ontario's Electricity Supply Gap and Implications for the Supply Mix" report for Ontario Power Authority's Call for Submissions in Response to the Minister's Request for Advice on the Electricity Supply Mix; August 25, 2005.
[2] Talk by Pierre Charlebois, Chief Operating Officer, OPG Hosted Dinner for World Nuclear University Summer Institute, Toronto, Ontario; July 21, 2008.

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

UNENE Activities

In line with the four programme objectives, UNENE undertakes three major activities:

1. UNENE funds **Industrial Research Chairs** (IRC)[3] in nuclear-related subjects at 7 universities (McMaster, Queen's, Toronto, Waterloo, Western Ontario, University of Ontario Institute of Technology, Royal Military College). These chairs are held by world-class scientists who have considerable industrial experience and are well respected in the industry. The IRCs become anchors for establishing research programs and competent research teams within the respective universities. Industry funding of the IRC programs has also served to leverage additional funds from federal (Natural Resources Canada) and provincial research grants, thus widening the scope and size of these programmes – which have allocated $50M (Canadian) to date. Over a hundr Highly Qualified Personnel (HQP) – Ph.D., Post-Doctoral Fellow, M.Sc. – have been produced, with most of them successfully recruited within the industry, research institutions, government and universities.

   The IRCs and their disciplines to date are:

   - McMaster University: Safety and Thermalhydraulics
   - Queen's University: Material Sciences
   - University of Toronto: Corrosion Control and Materials Performance
   - University of Waterloo: Risk and Reliability
   - University of Western Ontario (UWO)**:** Instrumentation, Control, and Electrical
   - Royal Military College (RMC): Fuel Technology
   - University of Ontario Institute of Technology (UOIT): Health Physics and Environmental Safety

   Most of these programs focus on R&D in areas of key 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.

[3] B.A. Shalaby, V.G. Snell and B. Rouben, "UNENE: An Update on Nuclear Education and Research", CNS 31st Annual Conference; May 24-27, 2010; Montréal.

2. UNENE funds **collaborative nuclear R&D** (CRD) projects at universities. To date, eleven CRDs have been funded by UNENE/ Natural Resources Canada on topics closely tied to the IRC programs. The initial CRD projects are nearing completion with five new ones started in 2010 for a three-year duration.

   Both IRCs and the CRDs are sources of both highly qualified graduate students and independent experts (the professors).

3. UNENE runs a course-based **Master's of Engineering programme** aimed at improving the fundamental knowledge of professionals already working in the nuclear industry. This is discussed in more detail below.

UNENE Master's of Engineering

The UNENE M.Eng. is a joint programme, course-based, consisting of 10 courses, or 8 courses plus a project. Three of the ten courses can be Business Courses from Advanced Design and Manufacturing Institute (ADMI). The Programme is accredited by the Ontario Council of Graduate Studies. The courses are graduate-level in content and expectations. The courses are offered by McMaster, Waterloo, Western and Queen's and (shortly) UOIT.

The whole programme is geared to the working professional. Each course requires a time commitment of about 40 hours in-classroom plus 100 hours homework. Students are formally evaluated via assignments, tests and exams and their marks become part of their university academic record. The M.Eng. is *not* like industry training – it is university education for academic credit at the graduate level. However some of the M.Eng courses have been adapted for high-calibre non-accredited enhanced professional development of utility professionals.

The M.Eng. courses span the *specific* science and engineering used in nuclear power:

UNENE Courses	
UN 0601 / Control, Instrumentation and Electrical Systems in CANDU based Nuclear Power Plants	**UN 0803 / Nuclear Reactor Safety Design**
UN 0602 / Nuclear Fuel Waste Management	**UN 0804 / Nuclear Reactor Heat Transport System Design**
UN 0603 / Project Management for Nuclear Engineers	UN 0805 / Introduction to Operational Health Physics
UN 0701 / Engineering Risk and Reliability	UN 08xx / Nuclear Fuel Engineering
UN 0702 / Power Plant Thermodynamics	UN 0901 / Nuclear Materials
UN 0801 / Nuclear Plant Systems and Operations	UN 0902 / Fuel Management of the Reactor Core
UN 0802 / Nuclear Reactor Analysis	UN 1001 / Reactor Chemistry and Corrosion

The courses in **bold** are compulsory for all students.

The UNENE educational material is posted on the UNENE web site and is available to the public at http://www.unene.ca/courses/coursedescriptions.htm. It is supplemented by the CANTEACH project, a public nuclear-knowledge repository (at http://canteach.candu.org/) that provides high-quality technical documentation relating to the CANDU nuclear energy system. Collectively this material represents a valuable source for nuclear educators.

The courses are given at a central location (Whitby, Ontario), near the OPG nuclear power plants. However it is quite far to travel for people from some of the other nuclear sites. To date the optimum trade-off between effective learning and travel time has been to run each course over four alternate weekends. Recently, distance learning has been implemented for *all* the UNENE courses, to enable students from sites remote from the Greater Toronto Area, such as Bruce Power, Chalk River and the Canadian Nuclear Safety Commission (CNSC), to participate without the hazards of frequent long-distance winter travel. The remote students participate synchronously in the live course through any high-speed Internet connection – most prefer to do it from their homes. Two-way audio over the Internet allows them to hear the professor in real time, and to ask questions. There is also two-way video, which is normally used initially to show the remote students what the professor looks like, and vice versa, and then turned off to focus on the audio and overheads. Remote students can also show their own work to the local class through a shared electronic desktop. Sessions are fully recorded and students can review them via the Internet at other times. So far the feedback from students has been positive.

A further challenge was that a few of the more mature students have become rusty in some of their senior undergraduate science and mathematics skills. A series of optional not-for-credit refresher courses has therefore been implemented to ensure students enter the formal UNENE courses with the appropriate level of knowledge.

Figure 1 shows the cumulative enrollment as of January 2011. Many of the graduates have gone on to key positions in the industry – for example, at one utility, while a UNENE M.Eng. is not a formal requirement to become a shift-supervisor, it is known to be a major advantage to have it on one's application.

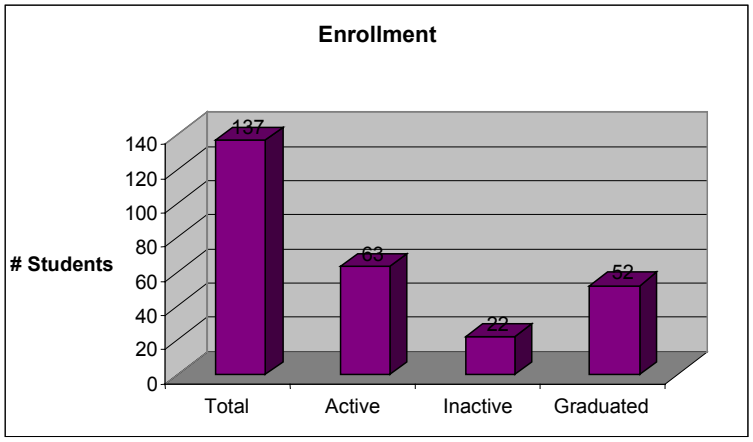

Figure 1 - Cumulative enrollment as of January 2011

Financially, the M.Eng. programme is more or less break-even as far as UNENE is concerned (student fees cover the costs). The employer typically reimburses the student's fees, and in most cases the student contributes his/her own time. The employer therefore gets the benefit of 1400 hours of donated time for each M.Eng., equivalent to about ten months' salary.

Conclusion

In conclusion, to help meet the upcoming surge in human resource demand as the nuclear renaissance begins and as boomers retire, we need to ensure there are no barriers to student mobility, and that learned institutions cooperate to make the best use of scarce teaching resources. Reliable sustained industry support is key. The Canadian model of cooperation among universities, and mutual recognition of courses and degrees, may be also useful internationally. Finally the use of distance education technology, now in effect for all UNENE courses, opens the door to organizations outside of Canada to develop cooperation with UNENE in terms of course delivery and student exchange.