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**INDUSTRY, UNIVERSITY AND GOVERNMENT PARTNERSHIP TO ADDRESS RESEARCH, EDUCATION AND HUMAN RESOURCE CHALLENGES FOR NUCLEAR INDUSTRY IN CANADA**

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**Abstract.** This paper describes the outcome of an important recent initiative of the Canadian nuclear industry to reinvigorate interest in education and collaborative research in prominent Canadian universities. This initiative has led to the formation of the University Network of Excellence in Nuclear Engineering (UNENE), incorporated in 2002.

### 1. Introduction

Like most industries that built nuclear power plants in 60s and 70s, the Canadian nuclear industry employees' average age is hovering around mid-forties and with a very small younger cohort to back up, nuclear industry faces the risk of knowledge loss. Canadian nuclear industry observes [1] that 25-30% of senior research scientists are due to retire in the next five years. The problem is compounded by a significant difficulty in recruiting new employees to replenish its depleting workforce. It is, therefore, justifiably concerned.

In order to strengthen research and education and consequently enhance the supply of bright, highly qualified and skilled nuclear engineers and scientists, a unique partnership among university, industry and Government of Canada has emerged. This partnership is the fundamental basis for establishing University Network of Excellence in Nuclear Engineering (UNENE). UNENE is an alliance of nuclear industry and prominent universities in Canada. UNENE was formed and incorporated as a not-for-profit Corporation by Government of Canada with Letters Patent issued July 22, 2002.

Canadian nuclear utilities, designers and suppliers of equipment and services, confronted with the need to replace rapidly retiring nuclear engineers and scientists, are realizing that there is an inadequate supply of qualified university graduates. During the recent past, the slowdown in nuclear power development in Canada had curtailed the demand for new nuclear professionals down to a trickle. Without exciting job opportunities in sight and unfounded fear of nuclear technology, the interest of prospective high school graduates in university level nuclear education and research plunged. Consequently, with declining enrolments in nuclear studies and higher demand from competing disciplines, most universities found it difficult to sustain nuclear programs. The result is that in most universities retiring nuclear engineering faculty members have not being replaced by like qualified faculty members. As such, nuclear education and research have suffered and the available pool of graduating students is small and insufficient to meet emerging industry demand. In fact, the nuclear human resource challenge in Canada is not unlike USA [2] and [3] and Europe.

On the industry side, as a consequence of electricity markets opening for competition, larger utilities have been breaking up into smaller companies. Smaller companies have limited resources plus, in order to compete successfully, they are concentrating primarily on electricity production and, where possible, outsourcing research, design, construction, engineering, waste management, outage work and services including generic training, to preferred suppliers. It appears that the whole industry is now made up of smaller companies, critically dependent of one another. Smaller companies, endowed with limited resources, are unable to undertake educational components in-house and are therefore receptive to

partnerships. Setting up reliable and meaningful partnerships has, indeed, become the strategic norm for most companies.

Confronted with these challenges, in early 2001, Ontario Power Generation (OPG), a successor company of Ontario Hydro undertook an initiative to set up strategic partnerships with universities. The vision was readily shared by Bruce Power (BP), Atomic Energy of Canada Limited (AECL), CANDU Owners Group (COG) and Canadian Nuclear Safety Commission (CNSC). In an overall scheme of nuclear knowledge management, it became obvious to all of them that, in order to retain the wealth of knowledge its retiring staff had acquired during design, construction, commissioning and operation of nuclear power plants, a significant part of which may not have been fully documented, they urgently needed a significant number of bright, highly qualified and skilled new employees who would be capable receptors for this knowledge transfer, which otherwise may be lost. In addition, new staff will be required to address new challenges of returning laid up plants to service, taking steps for plant life extensions, devising optimal maintenance strategies and making finer estimates of safe operating limits and ensuring efficient operation to enable nuclear generators to compete successfully in an open electricity market.

The initiative was to establish an alliance of the nuclear industry with a select number of those Canadian universities that are willing to work together with one another and are agreeable to assign a higher priority to mutually agreed-upon and complementary aspects of nuclear engineering which match their existing strategic initiatives. In return, the nuclear industry would contribute in cash and kind and enable universities to acquire additional resources by applying for grants matching industry contributions from the Natural Science and Engineering Research Council (NSERC), Government of Canada. It is possible because NSERC grants are awarded to create research excellence in universities to benefit the Canadian economy and for training highly qualified personnel. Thus an alignment of university, industry and government objectives laid the foundation for establishing the University Network of Excellence in Nuclear Engineering (UNENE).

## 2. Objectives

UNENE established three principal objectives:

- Reinvigorate university-based nuclear engineering research by creating new, high profile, industry supported research professorships and supporting research of existing professors.
- Promote enrolment of bright students in nuclear engineering graduate programs and financially support them.
- Create a pool of respected nuclear expertise in universities that can be accessed by the public and governments for impartial and trustworthy advice on nuclear issues.

## 3. Strategy

### 3.1. *Build on partner strengths and interests*

Prior to the formation of UNENE, extensive consultations, presentations and site visits took place to identify interests and strengths of participating nuclear industry and universities. Once UNENE was in place, NSERC programs were studied and through meetings and presentations the senior executives of NSERC were made aware of the UNENE initiative and its forthcoming requests for funding.

### 3.2. *Strengthen university resources*

Leveraging industry investment in nuclear research and graduate studies and enabling university members to secure equivalent Government funds through NSERC is a key UNENE strategy to augment university resources.

Since most nuclear engineering programs have weakened and there is hesitation on the part of universities in rebuilding their faculty strengths to offer fully accredited programs, UNENE

has fostered an active collaboration among member universities in sharing expertise and resources. By mutual consent an area of expertise is assigned to each member university. The selected area for a university meets the strategic objectives of that university and also complements areas selected for other universities. UNENE provided industry investment to strengthen the selected areas by appointing new NSERC-UNENE Industry Research Chairs (professors) on the understanding that the remaining 50% of the required funding will be sought by each university from NSERC. Applications for grants from NSERC show industry investment and include budgets for the salaries and benefits for a senior and a junior Chair, research equipment and operations, and support for post-doctoral fellows and graduate students. In some cases, in support of research, industry provides additional equipment and software.

The NSERC and UNENE funding temporarily relieves a host university from financial costs for the first five years but binds the university to adding new tenured positions for faculty and for providing needed space and infrastructure support. At the end of five years from the start date, upon satisfactory delivery of the proposed research output and upon willingness of continuing financial support from the nuclear industry, NSERC may renew funding for the NSERC-UNENE Chairs for up to two more five-year terms for the Chairs.

In addition to funding new NSERC-UNENE Industry Research Chairs, UNENE has set aside funds to support relevant research of existing professors by awarding several 3-year grants that are eligible to receive equally matching NSERC Collaborative Research and Development Grants. These grants are not restricted only to member universities and will largely be used to support graduate students.

Industry investment is thus multiplied by universities to support research and graduate studies in nuclear engineering.

### *3.3 Concentrate on graduate programs*

It was concluded that in the absence of any nuclear engineering undergraduate programs and weakening nuclear engineering options in programs such as Engineering Physics, Engineering Science, Mechanical Engineering, Materials Engineering and Chemical Engineering, one of the best options is to promote graduate programs in the nuclear discipline to which the brightest graduates from engineering programs such as Chemical, Mechanical, Materials, Electrical, Civil and Honours Science are attracted by newly appointed high profile research Chairs and faculty receiving research support from UNENE. Fortunately, subsequent to the formation of UNENE, a new university, the University of Ontario Institute of Technology (UOIT) has been established in Canada. UOIT is offering an undergraduate program in Nuclear Engineering and another in Radiation Science. These additions will increase the supply of candidates for graduate work.

Preparing the future nuclear workforce through graduate programs in nuclear engineering is favoured because it allows recruitment of bright students from other disciplines, provides a technologically advanced and mature workforce and at the same time allows these employees to, if needed, seek future employment in their undergraduate disciplines.

### *3.4 Ensure active university-industry collaboration*

In order to derive full benefit of research as well as keeping it focussed and relevant each NSERC-UNENE Industry Research Chair works with an advisory committee comprising similar experts from sponsoring industries. Similar contacts are established for other funded researchers. The researchers are required to submit satisfactory annual research reports for the release of the following year's funding.

Opportunities are provided by the industry members of UNENE to professors and graduate students to spend time at industry sites, use research infrastructure and gather operational data

for research. In many cases graduate students are co-supervised by industry experts who may also become members of the advisory and examination committees.

### 3.5 *Make university expertise accessible to graduate students, industry and public*

Graduate students registered for the Master of Engineering program, described later in this paper, have access to expertise at all member universities, since these faculty members make their speciality courses available to students irrespective of the university where they are registered. The member universities are encouraged to appoint UNENE supported professors as adjunct professors from other universities.

UNENE member industries acquire the first right on the intellectual property generated by research it funds. Also, in special cases, the member industries have access to research professors to set up exclusive research contracts of interest to them.

The augmented university expertise is accessible to the regulator as well as the public for impartial advice on nuclear technology issues.

## 4. Progress

### 4.1 *UNENE Membership*

UNENE is currently comprised of the following members:

Industry:

Atomic Energy of Canada Limited

Bruce Power

Ontario Power Generation

CANDU Owners Group

Canadian Nuclear Safety Commission

Nuclear Safety Solutions

Universities:

McMaster University

Queen's University

University of Toronto

University of Waterloo

The University of Western Ontario

University of Ontario Institute of Technology

Ecole Polytechnique

University of New Brunswick

### 4.2 *Organization and operation of UNENE*

The members of UNENE appoint a Board of Directors for setting strategic directions, policies and procedure, and approving programs and expenditures. The Board operates through two standing committees. These are: Research Advisory Committee (RAC) and Education Advisory Committee (EAC). These committees draw additional specialist representatives from the UNENE member organizations. Day to day management of UNENE is performed by President and CEO, Secretary/Treasurer and a Course Coordinator.

### 4.3 *Research roles and NSERC-UNENE Industry Research Chairs at universities*

The following list provides areas of specialization set up through the establishment of NSERC-UNENE Industry Research Chairs, names of Chair-holders, their start dates and a brief overview of their proposed research topics. Each university is funded at \$2M for five years equally split between UNENE and NSERC. A search is on to fill the remaining available faculty positions.

McMaster University

Nuclear Safety Analysis, Dr. John Luxat, May 1, 2004, + a junior faculty

Best estimate and uncertainty based nuclear safety analysis; vapour generation and boiling heat transfer; modeling dryout, post-dryout and quench processes; thermal-mechanical

behaviour of reactor components at high temperature accident conditions; computational fluid dynamics models for two-phase flow.

Queen's University

Nuclear Materials, Dr. Rick Holt February 1, 2002, and Dr. M. Daymond, July 1, 2004

Control of microstructure/texture of zirconium alloys; experimental study of anisotropy and deformation of zirconium alloys; modeling anisotropy and deformation of zirconium alloys; effects of deformation on plastic instability and failure; improvements in measurement of crystallographic texture; micro-structural characterization and qualification; experimental study and modeling of macro- and microscopic stress and strain development during manufacture and evolution during service; theory of radiation damage and in-reactor deformation.

University of Toronto

Nano-Engineering of Alloys for Nuclear Power Systems, Dr. Roger Newman, June 1, 2004.

Mechanisms of oxidation and cracking in hot water under reducing conditions; alloy design for corrosion resistance; building on atomistic understanding to promote favourable interface structures; exploiting alloy corrosion processes for the fabrication of useful nano-structured materials; corrosion and stress corrosion research for nuclear industry.

University of Waterloo

Risk-Based Life Cycle Management of Engineering Systems, Dr. Mahesh Pandey, September 1, 2004, + a junior faculty. Assessment methods: probabilistic models of load and resistance models; mechanics-based failure models; digital image analysis for condition assessment; reliability estimation models and computation methods. Management models: in-service inspection models; maintenance plans and repair technologies; decision analysis. Maintenance optimization strategies.

The University of Western Ontario

Control, Instrumentation and Electrical Systems for Nuclear Power Plants, Dr. jin Jiang, September 1, 2003 + a junior faculty. Fault detection/isolation and control loop stability monitoring/enhancement; probabilistic based maintenance optimization for control and instrumentation systems; application of distributed control systems in CANDU power plants; load-following control of CANDU power plants; enhancement of training simulators for engineering applications.

University of Ontario Institute of Technology

Nuclear Knowledge Management. The topic and details of research are currently under active discussion.

In addition to all of the above, UNENE benefits from NSERC Industry research Chairs held by Dr. Daniele Rozon (Hydro Quebec), Michel Pettigrew (AECL and Babcock and Wilcox) at Ecole Polytechnique, and Dr. Derek Lister (New Brunswick Power and COG Owners Group) at University of New Brunswick.

Other Research Projects

In addition to the above research areas UNENE is currently processing a number of research proposals for funding starting in 2004. In total, during the first phase of UNENE operation (5 years), 11 projects will be funded; each for three years at an average of \$180,000. The total funding will be equally split between UNENE and NSERC.

#### *4.4 Graduate studies programs*

Two distinct approaches have been taken to support graduate programs in Nuclear Engineering:

- A course-based Master of Engineering in Nuclear Engineering. This is a total cost recovery program jointly offered by UNENE member universities. The program is designed for part-time studies enabling employers to sponsor newly recruited employees as well as

those hired in the recent past. To successfully complete the degree a student must complete 10 term-courses. Students are encouraged to complete a major project in lieu of two term-courses. A student may register at any one of the universities participating in the program. The courses are offered in flexible modules to suit distant students and faculty. Faculty members are drawn from different universities. The program has been submitted for accreditation. At present nearly 25 students are registered in the program. In 2003-04 the following courses were delivered:

- Reactor Physics
- Nuclear Plant Systems and Operations
- Nuclear Reactor Safety Design
- Thermal Hydraulics

In addition to the above, courses to be offered in the near future include: Engineering Risk Analysis; Reactor Chemistry and Corrosion; Nuclear Materials; Control, Instrumentation and Electrical Power Systems; Nuclear Waste Management; Fuel Management; Health Physics/Radiation Protection; Power Plant Thermodynamics; Codes, Standards and Jurisdictions; Project Management.

It is expected that on a part-time basis the students will typically take 2-3 years to complete the program. Once stabilized and fully subscribed, on an average the program is expected to graduate 15-20 students annually.

- Research-based graduate degrees

Students will work full time for these degrees at member and other UNENE funded universities and programs. In steady-state we expect 3 Post Doctoral Fellows, 6 Ph.D. and 18 M.Sc. graduating each year.

#### 5. External Relations

UNENE expects to play an important role in World Nuclear University and establish an active liaison with Asian Network of Education in Nuclear Technology (ANENT), European Nuclear Education Network (ENEN) and a similar organization in the USA.

Where possible UNENE instructors will include material from CANTEACH, a separate Canadian initiative to develop nuclear educational material [[www.canteach.ca](http://www.canteach.ca)]

#### 6. Acknowledgement

The author is grateful to UNENE for its support and this opportunity to present this paper. The opinions and interpretations included in this paper are those of the author and do not individually or collectively represent the positions of UNENE member organizations.

#### 7. Conclusions

This paper describes a successful UNENE the initiative arising from the partnership of Canadian nuclear industry, 8 universities and Government of Canada through NSERC's Industrial Research Chair (IRC) and Collaborative Research and Development (CRD) grant programs. UNENE is accelerating production of highly qualified nuclear engineers and scientists to fill the vacancies created by retiring experts. The initiative is important and needs further expansion in order to meet current demand and that of the future should Canada start building new power plants.

### REFERENCES

- [1] REPORT OF THE RESEARCH REVIEW GROUP to the Canadian Nuclear Safety Commission, RSP-0176, March 2004
- [2] R. SHANE JOHNSON, "University Programs", Nuclear Energy Research Advisory Committee, Department of Energy, USA, April 15, 2002

- [3] ANGELINA S. Howard, Keynote Address, Conference on Nuclear Training and Education, Orlando, Florida, August 20, 2002