

U N E N E

University Network of
Excellence in Nuclear
Engineering

Status of Nuclear Education in Canada

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Background/History

- Canada has been active in nuclear-science research since the early years of the 20th Century (Ernest Rutherford spent many years at McGill University in Canada)
- This continued with research on multiplying media and nuclear lattices since immediately following the discovery of fission in 1939

Background/History (cont'd)

- The Montreal Lab at the Université de Montréal, in the early 1940s, later led to the establishment of Chalk River Laboratories, and eventually to the founding of Atomic Energy of Canada Limited in 1952
- In the 1950s, Canada, under the leadership of Dr. W. Bennett Lewis, started to plan the application of nuclear technology to electricity generation, and developed the unique CANDU reactor design, based on the high-neutron-economy heavy-water-moderated nuclear lattice, following from Canada's responsibility for research during WWII.

Background/History (cont'd)

- The CANDU design has been very successful, and, starting in the 1960s, various generations of CANDU plants were built in Canada and abroad (see next slide)
- Canada initiated other important applications of nuclear science and technology, e.g.:
 - the cobalt-60 therapy machine of Dr. H. Johns, first developed in 1952.
 - Canada provides the lion's share of medical radionuclides to the world market.

Nuclear Power Plants in Canada



- 17 operating CANDU reactors in Canada & 12 abroad
- Provide 16% of Canada's electricity
- Unique technology – but not so unique science

Needs for Nuclear Engineers

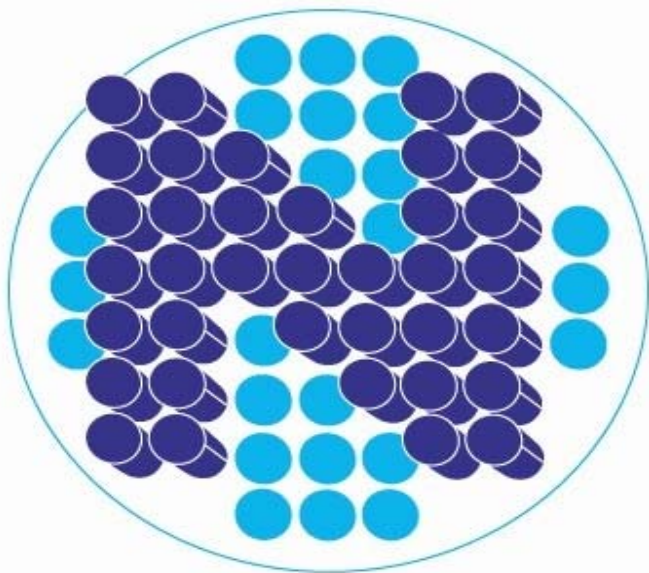
- With the nuclear renaissance looming, current needs in Canada for new engineers and physicists in the nuclear industry are **roughly** as follows, per year:
 - Electric utilities, ~250-300
 - AECL, ~70
 - Mining companies, ~60
 - Total may be in the range of 400-500 per year
 - Note that these numbers cover all disciplines of science and engineering in demand in the nuclear industry

Educational Institutions Involved in Nuclear Education

The following Canadian universities offer programs in nuclear engineering or engineering physics, or closely related disciplines with application in the nuclear industry (e.g., chemical engineering, mechanical engineering, control & instrumentation, nuclear science and radiation). These all offer Bachelor's, Master's, and Ph.D. degrees.

- McMaster University: <http://www.mcmaster.ca>
- Queen's University: <http://www.queensu.ca>
- University of Ontario Institute of Technology: <http://www.uoit.ca>
- University of Saskatchewan: <http://www.usask.ca>
- University of Toronto: <http://www.utoronto.ca>
- University of Waterloo: <http://www.uwaterloo.ca>
- University of Western Ontario: <http://www.uwo.ca>
- Ecole Polytechnique: <http://www.polymtl.ca>
- University of New Brunswick: <http://www.unb.ca>
- Royal Military College: <http://www.rmc.ca>
- University of Guelph: <http://www.uoguelph.ca>

Educational Institutions: UNENE



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- UNENE is an industry-university partnership which offers nuclear courses and supplies highly-qualified graduates (M. Eng.)
- UNENE also supports nuclear research, and creates respected university-based experts

UNENE Industry Partners

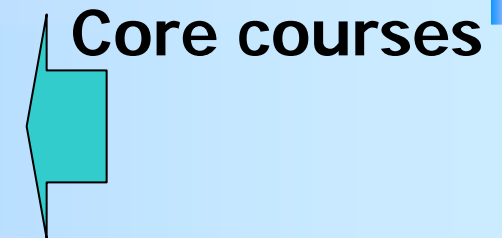
- Ontario Power Generation
- Atomic Energy of Canada Limited
- Bruce Power
- Cameco Corporation
- CANDU Owners' Group
- Canadian Nuclear Safety Commission
- AMEC NSS

The UNENE M.Eng.

- Course-based:
 - 10 courses OR
 - 8 courses plus a project
 - 3 of the 10 courses can be Business Courses from Advanced Design and Manufacturing Institute (ADMI)
- Accredited by Ontario Council of Graduate Studies
 - Courses are graduate level in content & expectations
- Offered by McMaster, Waterloo, Western and Queen's
- Cooperative programme with mutual acceptance
- Geared to the working professional
- Seen as a career enhancer by industry: companies pay the student's course fees and provide strong support

Typical UNENE Courses

- UN0802: Nuclear reactor analysis
- UN0801: Nuclear plant systems and operations
- UN0804: Nuclear reactor heat transport system design
- UN0803: Nuclear reactor safety design
- UN0603: Project management for nuclear engineering
- UN0901: Nuclear materials
- UN0805: Radiation health risks and benefits
- UN0702: Power plant thermodynamics
- UN0701: Engineering risk and reliability
- UN0601: Control, instrumentation and electrical systems in CANDU
- UN1001: Reactor chemistry and corrosion
- UN0902: Fuel management
- UN0602: Nuclear fuel waste management



Note: Much of the UNENE teaching material is fully open on the web.

Enrollment in UNENE

- Active enrollment of 52 as of January 2009
 - Existing + accepted – inactive – graduated
- 29 graduated to date
- New enrollment growing
 - 19 applications as of September 2008
 - Several more since
- Distance Learning is being planned and is expected to bring in more students

Foreign Students

- Foreign students are admitted to Canadian universities.
- In the nuclear programs, foreign students represent a small number – perhaps 5% or at most 10% of all students in the programs.

Research & Experimental Facilities

The following research and experimental facilities exist:

- SLOWPOKE reactor at the Royal Military College
- SLOWPOKE reactor at Ecole Polytechnique
- 5-MW McMaster Nuclear Reactor
- Research reactors at AECL's Chalk River Laboratories:
 - ZED-2 for reactor-physics measurements
 - NRU (celebrated its 50th anniversary in 2008) for irradiation and testing of nuclear fuel and nuclear materials
- Also facilities at Chalk River Laboratories and Whiteshell Laboratories for research in thermalhydraulics, fission-product chemistry and transport, containment, hydrogen, fuel and fuel performance, severe accidents, 3-d fluid flow, etc.
- Other experimental facilities for thermalhydraulics measurements
- The next slide shows some examples of research being conducted at UNENE universities

Research

- McMaster: Nuclear Safety Analysis and Thermalhydraulics
- Queen's: Advanced Nuclear Materials
- U of Toronto: Nano-Engineering of Alloys
- Waterloo: Risk-Based Lifecycle Management
- Western: Control, Instrumentation and Electrical Systems, Nuclear Chemistry
- UOIT: Health Physics and Environmental Safety
- Ecole Polytechnique: Reactor Physics, Thermalhydraulics
- U of New Brunswick: Chemistry and Corrosion
- Royal Military College: Nuclear Fuel Performance

Co-Operation/Collaborations with Industry and Government

There is strong co-operation and collaboration with Canadian industry and government:

- UNENE has established 7 Industry Research Chairs (IRCs) and 2 Associate Chairs at Canadian universities.
- Research performed by IRCs and their students is supported by funds from industry (largest amounts from Ontario Power Generation, AECL, Bruce Power) and matching funds from NSERC (National Science and Engineering Research Council)
- Funds from industry members in UNENE have allowed the support of additional, smaller research projects, again with matching funds from NSERC.

Research-Based UNENE Graduates

- University Professors, supported by UNENE, supervise research-based Master's and Doctoral students.
- ~ 90 Masters, 30 Doctoral and 15 Post Doctoral people planned in short term
- Currently 10 doctoral, 16 masters and 10 postdoctoral candidates are registered

National and International Co-Operation

In addition to the UNENE Educational Network, other collaborations exist between universities and other institutions:

- **CANTEACH**
 - Open electronic library of teaching material
- **Canadian Nuclear Society**
 - Scientific society of individuals
 - Courses to working professionals
 - Contacts with sister nuclear societies worldwide
- **Canadian Nuclear Association** – association of companies in the Canadian nuclear industry
- **CANDU Owners' Group**
 - International association of utilities, owners of CANDU plants + AECL. COG also administers research for the nuclear industry, supported by industry funds.

References

University web addresses have already been given.

Other web addresses:

- UNENE: <http://www.unene.ca>
- CANTEACH: <http://www.candu.canteach.ca>
- Canadian Nuclear Society: <http://www.cns-snc.ca>
- Canadian Nuclear Association: <http://www.cna.ca>
- CANDU Owners' Group: <http://www.candu.org>

Conclusions

- As the nuclear renaissance begins, we already see a significant increase in enrolment for nuclear education and increased hiring in the industry
- Need to ensure no barriers to mobility & to make most use of scarce teaching resources
- Canadian universities and UNENE will to ensure a supply of human resources to the Canadian nuclear industry
- Reliable industry support is key