Development of a Multi-Disciplinary Graduate Program: Master of Engineering in Environmental Studies at the University of New Brunswick

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Abstract

To meet increasing demands from industry, governments and the public for highly qualified personnel in the growing environmental industry, the Faculty of Engineering at the University of New Brunswick has developed a multi-disciplinary Master of Engineering in environmental studies program. This program provides students a broad exposure in environmental studies, yet allows them to concentrate in specialized engineering disciplines. A student will complete the degree requirement by taking 30 credit hours of approved courses consisted of mandatory Common Courses and Technical Electives. Guest lectures by industry and real-life projects are among the salient features of this program.

1. Introduction

Extended and accelerated industrial activities of the mankind have resulted in significant improvement of human life and, at same time, caused serious social and environmental problems including the depletion of natural resources, deterioration of the environment, and over population. The demands of the public, governments and businesses for environmental protection and sustainable development have brought about the creation and subsequently rapid expansion of the environmental industry in prevention and remediation of pollution, improvement of ecological systems, and conservation of natural resources. Environmental industry has become one of the major industrial sectors in developed countries and has been experiencing a much faster growth than the GDP of many countries.

Today, the environmental industry has grown into a complex social, technical and economic entity including diversified areas, as shown in Figure 1. Such a complex

industry sector now requires highly qualified technical personnel to work in broad areas of technical disciplines. It is the responsibility of the institutions of higher education to meet the demand for the technical human resources.

Figure 1. Overview of the environmental industry.

Environmental technologies nowadays have branched into multi-disciplines. To help universities meet the growing demand for environmental design engineering talent, and to help universities create and develop new and innovative designs, design concepts and design tools, NSERC has established the program of Chairs in Environmental Design Engineering. According to NSERC [1], environmental design engineering includes the creation and development of:

- innovative tools, approaches, methodologies and standards to improve the environmental aspects of

product and process designs;

- state-of-the-art environmentally friendly and efficient designs of products, processes and process technologies;
- creative approaches for using energy, water and natural resources more efficiently, for reducing waste and for preventing pollution.

The University of New Brunswick (UNB) established an NSERC Chair in Environmental Design Engineering in 2001, under the strong support from other Atlantic universities, Atlantic companies and governmental departments. One of the mandates of this NSERC chair is to develop a Master of Engineering (M.Eng.) in environmental studies for all engineering departments at the Faculty of Engineering of UNB. This paper reports the objective, overview and detailed curriculum of such an M. Eng. program.

2. Objectives

The objectives of this M.Eng. in environmental studies are:

- To provide a quality M.Eng. degree with concentration in environmental studies to potential graduate students;
- To offer a degree that provides students a broad exposure in environmental studies, yet allows them to concentrate in specialized engineering disciplines;
- To meet the increasing demands from industry, governments and the public.

This M.Eng. degree program with concentration in environmental studies is available for potential graduate students in Civil Engineering, Chemical Engineering, Electrical and Computer Engineering, Forestry Engineering and Mechanical Engineering in the Faculty of Engineering at University of New Brunswick. The rationale for such a program includes strong interests from the student community; increasing demands from industry, governments and the public for highly qualified personnel in environmental engineering; the need to attract students without a substantial increase in faculty resources; and strong support and contributions from Atlantic-based environmental companies.

3. Overview

The overall structure and features of the M.Eng. in environmental studies program are given in the

following:

- The degree program is open to qualified B.Sc.E and B.Sc. degree holders.
- Academic responsibility for each M.Eng. student remains with individual Graduate Academic Unit (GAU).
- A Program Coordinator will coordinate the courses and the degree program.
- Common Courses of 12 credit hours (ch) are mandatory, allowing a broad exposure in environmental studies, and development of independent skills through projects, reports, and presentations.
- Technical Electives of 18 ch, of which at least 14 ch must be from Engineering Faculty, are selected for an emphasis on engineering specializations.
- Project/Report of 6 ch is available as a Technical Elective for certain GAUs but may be mandatory for other GAUs.
- Optional CO-OP program is available for qualified students to have term employment with companies specializing in environmental engineering business.

The overall curriculum is presented in Table 1.

Table 1. Curriculum structure of the M.Eng. in environmental studies

Total number of credit hours: 30 ch		
Common Courses: 12 ch (4 out of 6 courses)		
CE 6483	3ch	Environmental Engineering
ChE 5313	3ch	Energy and Environment
(ChE 5314	3ch	Chemical Process Industry)
EE 6693	3ch	Advanced Topics in Environ. Design Engineering
FOR 6452	3ch	Ecological Modeling
GGE 5533	3ch	Environmental Policy, Law and Information Management
ME 5933	3ch	Industrial Ecology
Technical Electives: 18 ch (available in each GAU) (at least 14 ch must be from Eng. Faculty)		
CE/ChE/EE/GGE/ME 6996	6ch	M.Eng. Report
ECON 6755	3ch	Environmental Economics
plus		
A list of sample courses in Section 6		

4. Common Courses

The Common Courses of this M.Eng. program represent the minimum common requirements of the degree and are intended to provide a broad exposure to the students in environmental studies. The Common Courses, together with Technical Electives, provide students with training of independent skills through projects, reports and presentations. The choices of Common Courses include CE 6483 Environmental Engineering, ChE 5313 Energy and Environment, ChE 5314 Chemical Process Industries: Overview and Environmental Impact, EE 6693 Advanced Topics in Environmental Design Engineering, FOR 6452 Ecological Modeling, GGE 5533 Environmental Policy, Law and Information Management, and ME 5933 Industrial Ecology. Among these common courses, several are new courses developed by individual GAUs for this M.Eng. program, including ChE 5313 Energy and Environment, EE 6693 Advanced Topics in Environmental Design Engineering, FOR 6452 Ecological Modeling, GGE 5533 Environmental Policy, Law and Information Management, and ME 5933 Industrial Ecology. Some of these courses are taught in course modules by experts from industry, universities and governments, giving students an exposure to the real world cases and leading edge technologies.

5. Advanced Topics in Environmental Design Engineering

EE 6693 Advanced Topics in Environmental Design Engineering is a new course specially developed for this M.Eng. in environmental studies program. The objectives of this course are to provide students with broad exposure of topics in environmental design engineering through industrial and academic guest lectures, case studies and practical projects. This new course is intended for graduate students in the M.Eng. in environmental studies program, and also for professional engineers who are interested in this field.

This course covers multi-disciplinary, industrial and broad-based topics in environmental design engineering, and includes the following major topics:

- **Pollution and Pollution Control:** sources, impacts, control and treatment for water pollution, air pollution, soil pollution, solid waste and chemicals, noise and electromagnetic pollution.
- **Advanced Energy Systems:** introduction to energy sources, energy demand, fuels and their consumption pattern, need for environment friendly

energy conversion technologies, introduction and discussion of advanced energy systems, introduction to combined cycle power generation, basic analysis of combined cycles, combined cycle power generation configurations and advances, biomass utilization, energy efficiency measures.

- **Renewable Energy:** principles and applications of energy conversion using renewable sources and their environmental, economical and social benefits, renewable energy sources including wind energy, solar energy, biomass, geothermal energy, and wave energy.
- **Product Life Cycle Assessment:** product life cycle, principles of life cycle assessment, environmental labeling, cleaner production and green products.
- **Environmental Impact Assessment and Environmental Management:** regulations, methodologies and processes of environmental impact assessment, principles of environmental management, environmental quality management, environmental monitoring technologies.
- **Sustainable Development:** principles and objectives of sustainable development.

This course has a strong environmental design component. In addition to lectures, design projects form a major part of the course in which students receive practical experience through real-life design practice and case studies. A substantial part of the projects is suggested by companies. Each project is reported and presented at the end of the course. Substantial work is needed to complete the project. The topics are generally covered in the lectures of the course. However, much more additional reading is needed to tackle the problems. Students are free to choose one topic from a list of projects, considering that they have various engineering background in various engineering disciplines. Typical projects are given in the following:

- **Options of Energy Supplies for a Remote Community:** The small community needs energy supplies for electricity generation, space and hot water heating, transportation (local vehicles), cooking etc. All energy resources (Diesel, gas, heating oil) are now imported from big community centres far away. The shipment is once a year. In order to provide energy supply needs of a Northern remote community economically and environmental friendly, various renewable and non-renewable energy resources are studied. The focuses are cost-effective and environmental-friendly options of

energy supplies. Thus, in the project, economic calculations and greenhouse gas emissions may be the key factors in comparing various options. Advanced power generation such as co-gen, may be considered.

The available information about Remote Community (Holman, Northwest Territories) is listed below:

Diesel use: 575,119 liters/year
Electricity use: 2,026 MWh/year
Diesel price: 87 ¢/liter
Fuel cost per kWh: 24.6 ¢/kWh (diesel fuel only)
Annual average wind speed: 5 m/sec
Other energy resources: solar, wind; others will have to be brought in
Existing diesel generators: 480kW, 300kW, 360 kW
Peak load=430kW, min load=150kW
Transmission line: 3-phase 600V (line-to-line)
Village: about 480 people, 160 houses.

Tools that may be useful for this project:
RETScreen Renewable Energy Project Analysis Software, <http://retscreen.gc.ca>;
HOMER, Hybrid Optimization Model for Electric Renewables, <http://www.nrel.gov/homer>.

- **Treatment Options for a Contaminated Site:** Treatments are required for a contaminated site for redevelopment. This project will investigate the various types of treatment options for metal-contaminated soils. These would be soils originating from contaminated sites that cannot be managed on site due to lack of space or levels exceeding the risk-based levels safe for human health. It is interested to know the types of treatments available, types of by-products produced, relative costs of remediation, relative efficiency in metals removal and examples of where this has been done. USEPA, the Canadian Council of Ministers of the Environment (CCME) and Environment Canada websites may be the places to start.
- **Life Cycle Greenhouse Gas Emissions of Various Power Generation Options:** Mixed fuels (energy resources) are used for electricity generation in New Brunswick. The fuels included nuclear, coal, oil, large hydro, small hydro and wind. Electricity generation industry is the largest greenhouse gas emitter in New Brunswick. This project will examine the greenhouse gas emissions of various power generation fuel options (nuclear, coal, oil, large hydro, small hydro and wind) based on a life cycle approach (i.e. from "cradle" to "grave" of

generation facilities). The results of the study will be presented in a similar way as in a report presented by Hydro Quebec (see below for reference).

References of this project are:

Hydro Quebec, Greenhouse Gas (GHG) Emissions for Power Generation Options, 2003.
www.hydroquebec.com/environnement/comparaison_energie/index.html;

NB Power, 2002 Environmental Performance Report, 2003.

- **Permits and Environmental Impact Assessment of a Small Hydro Plant:** A small hydro (100 kW) unit is planned at an old abandoned dam across the Kouchibouguac River in New Brunswick. The site was used by NB Power for electricity generation and abandoned many years ago. This project will look into the potential development site and will answer the question: "What permits/assessments are required to develop a small hydro station?". Environmental considerations and regulative considerations will be the major focus.
- **Effects of Energy Conversion Efficiency Improvement on Power Output, Pollutant Reductions and on Plant Economy:** There is a growing energy demand around the world. It is projected that the energy demand for the world will increase by 35% in 2020 compared to the energy consumption level in 1999. The increase in demand has to be met from various sources. There is a need to develop advanced energy technologies to utilize the fuel sources in a more efficient manner with reduced pollutants and greenhouse gases (Kyoto agreement). Also, there is a scope to improve the efficiency for the existing power plants through various measures, including retrofitting of the old combustion units with advanced ones. The project has two parts:

Part I: The first objective is to investigate the effect of various operating conditions (such as steam cycle conditions, gas turbine operating conditions) on the performance of a combined cycle power plant unit (coal or natural gas fired). The investigations will focus on the detailed investigations on fuel savings obtained, reduction pollutant gases and greenhouse gases. The investigations will contribute to understand the influence of plant operating conditions, which will help to better design these units.

Part II: The second objective of the project to

develop a correlation involving efficiency of the plant with fuel savings, pollutant reductions (NO_x, SO_x; responsible for acid rain) and greenhouse gases (responsible for global warming). For a specific plant and capacity case, the savings obtained through improved plant efficiency should be calculated.

6. Technical Electives

Since the majority of students enrolling in the M.Eng. in environmental studies have their own academic backgrounds and interests, Technical Electives allow them to concentrate in specialized engineering disciplines. Each engineering department provides a list of technical electives for the students focusing on the disciplines.

A sample list of Technical Electives is presented in the following:

ChE 5313	3ch Energy and Environment
CHE 5314	3ch Chemical Process Industries: Overview and Environmental Impacts
CHE 5344	3ch Combustion
CHE 5414	3ch Adsorption and Membrane Processes for Pollution Control
CHE 6314	3ch Air Pollution Control
CE 5402	3ch Environmental Planning for Capital Works
CE 5421	3ch Water and Wastewater Analysis
CE 5702	4ch Open Channel Hydraulics
CE 5753	4ch Engineering Hydrogeology
CE 6153	3ch Waste Geotechnics
CE 6413	3ch Physical and Chemical Processes in Environmental Engineering
CE 6423	3ch Biological Processes in Environmental Engineering
CE 6443	3ch Water Quality Management
CE 6463	3ch Solid Waste Management
CE 6763	3ch Numerical Modeling of Groundwater Flow and Solute Transport
EE 6513	3ch Introduction to Random Variables and Stochastic Processes

EE 6523	3ch Detection and Estimation Theory
EE 6653	3ch Power Electronics
EE 6913	3ch Biomedical Instrumentation
EE 6923	3ch Biological Signal Processes
GGE 6022	3ch Advanced Topics in Ocean Mapping
GGE 6093	3ch Advanced Topics in Industrial Metrology
GE 6341	3ch Special Studies in Remote Sensing
GGE 6501	3ch Land Information Management
GGE 5013	3ch Water Levels and Tides
ME 5283	4ch Issues in Occupational Health and Safety
ME 5163	4ch Machinery Vibration and Noise
ME 5293	4ch Manufacturing Systems and Design
ME 5363	4ch Systems Engineering
ME 5653	4ch Predictive Control and Intelligent Sensors
ME 5713	4ch Nondestructive Testing
ECON 6755	3ch Environmental Economics

7. Conclusion

The M.Eng. in environmental studies program is in full operation at the Faculty of Engineering at the University of New Brunswick. This program has provided a mechanism to provide quality training of technical personnel for environmental industry, to attract professional engineers for continuing education, to enhance the collaborations among different departments in the faculty, and to strengthen the ties between the university and industry.

We are now in process of developing collaborative M.Eng. in environmental studies programs with other universities, to foster cooperation in graduate education and training and to fully utilize the resources available in partner universities.

8. References

- [1] NSERC, *Chair in Environmental Design Engineering*, <http://www.nserc.gc.ca>, 2003.