Advanced Topics in Environmental Design Engineering
- A Multi-disciplinary Graduate Course for Faculty of Engineering at UNB

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Abstract

The Faculty of Engineering at University of New Brunswick has developed a Master of Engineering (M.Eng.) degree program with concentration in environmental studies for graduate students in Civil Engineering, Chemical Engineering, Electrical and Computer Engineering, Forestry Engineering, Geology and Geomatics Engineering and Mechanical Engineering. One of the common courses of this graduate program is a newly-developed multi-disciplinary course of Advanced Topics in Environmental Design Engineering.

The objective of this course is to provide students with broad exposure of topics in environmental design engineering through lectures, case studies, field trips and projects. The lectures consist of 10 in-class modules delivered by industrial and academic guest lecturers in various technical fields of environmental engineering. This course covers multi-disciplinary topics including: Pollution and Pollution Control, Advanced Energy Systems, Renewable Energy, Life Cycle Assessment, Environmental Impact Assessment and Environmental Management, Sustainable Development. This course has been available to graduate students since 2003.

1. Introduction

During Years 2001-2003, the University of New Brunswick (UNB) developed a Master of Engineering (M.Eng.) in environmental studies for all engineering departments at the Faculty of Engineering, with broad-based consultation with its faculty members and local companies.

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. in environmental studies program is available to potential graduate students in Civil Engineering, Chemical Engineering, Electrical and Computer Engineering, Forestry Engineering and Mechanical Engineering in the Faculty of Engineering at UNB.

A multi-disciplinary course of Advanced Topics in Environmental Design Engineering was developed for the M.Eng. program. Along with other three common courses, this new course provides the students in the M.Eng. in environmental studies program with a broad exposure in environmental studies, and allows them the development of independent skills through projects, reports, and presentations. This paper presents the detailed contents, projects and experience with the delivery of this course.

2. Objectives and Contents

The objectives of this course are to provide students with a 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.

Environmental design engineering covers broad topics and 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 contents of this course were developed following the above guidelines to include multi-disciplinary topics in environmental design engineering:

• **Pollution and Pollution Control**: sources, impacts, control and treatment for water pollution, air pollution, soil pollution, solid waste and chemicals, remediation of contaminated sites.

• **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.

• **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, objectives and indicators of sustainable development, climate changes and impacts, case studies.

### 3. Delivery

Lectures are one of the major parts of this course. The lectures consist of 10 in-class modules delivered by experts in industry, government and universities as guest lecturers in various technical fields of environmental engineering.

Some of the guest lectures are listed in the following:

• **Wind Energy Systems**: fundamental physics of wind and wind energy; wind turbine characteristics, applications in grid-connected systems, wind-diesel systems and standalone systems, state of the art technologies and design options, project development including pre-construction planning and monitoring stage and construction stage (civil work, electrical work and erection), operational issues (operation and maintenance, cold climate operation), issues of concerns (bird kills, public safety, noise, aesthetics and lightening), economics of wind energy systems.

• **Waste Water Treatment**: wastewater treatment processes (preliminary, primary, secondary, tertiary, thickening, dewatering) with a focus on biological treatments, fundamental wastewater microbiology (microorganisms in wastewater treatment, their growth conditions, sampling and monitoring), fundamentals of aerobic and anaerobic treatment (terminology, aerobic treatment fundamentals, aeration equipment, anaerobic treatment fundamentals, bio-gas equipment, aerobic vs. anaerobic), typical wastewater characteristics, waste water treatment case studies.

• **Potable Water Treatment**: objectives of water treatment, basic treatment process for surface water and ground water with an emphasis on chlorination and minimum treatment standards, Fredericton Water Treatment Plant, water quality tests, costs of water treatment, introduction to MEDIA G2® Iron-Based Adsorption Technology - from idea to products.

• **Life Cycle Assessment**: definition and objectives of life cycle assessment, process of assessment, goal definition and scoping, life cycle inventory (data, calculation procedures, allocation, treatment of energy), impact assessment (classification, characterization, valuation), improvement assessment, environmental performance indicators.
• **Environmental Impact Assessment:** introduction to EIA, stages of EIA, EIA report, benefits and costs of EIA, EIA framework in Canada, Clean Environment Act and EIA regulations, Canadian Environmental Assessment Agency and federal EIA (screening, comprehensive study, panel review or mediation), case studies of federal EIA, steps and methodologies for EIA (scoping, assessing environmental effects, mitigating environmental impacts, determining significance of adverse environmental effects); provincial EIA process: project description, screening review, full EIA, case studies.

• **Environmental Management:** environment related acts and regulations, NB Drinking Water Protection Program - multi-safeguard approach: source protection, appropriate treatment, proper operations and maintenance, secure distribution system, monitoring and alarms, verification of water quality by analysis, emergency response; contaminated sites management, policies/protocols governing contaminated sites management, risk assessment, technical management tools in New Brunswick, contaminated sites management process.

• **Climate Change and Sustainable Development:** climate change and its impacts, national and international policies, education and implication, case studies of New Brunswick, Kyoto Protocols, introduction to sustainable development, sustainable development indicators, case studies, Efficiency Vermont - a story of success, coastal communities and sustainable development in NB.

Projects related to the lectures and contents of this course are mandatory for students to conduct, as described in the next section. Individual presentations by students are done at the last week of the term. A site visit is organized for students to tour an environmental facility. The tours give students a fundamental understanding of real-life operation of certain environmental facilities such as waste water treatment plants, potable water treatment facilities, energy control centers etc.

4. **Projects**

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 local companies and government departments. 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 environmentally 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 c/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.

• **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 high risk levels for human health. It is interested to know the types of treatments available, types of by-products, 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 contain useful information for the project.

• **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.

• **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 Protocol). In addition, 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.

• **Renewable Energy Systems.** The students are free to select a specific renewable energy systems to work on introduction, basic design and worked examples. The renewable energy system may be one of the following: wind energy, small hydro electric, solar energy, fuel cells, bio-mass etc. Substantial review of a renewable energy technology is necessary to write an introductory level report, which can be subsequently used as reference materials for undergraduate students and general public.

5. **Conclusion**

EE 6693 Advanced Topics in Environmental Design Engineering is a new course specially developed for the M.Eng. in environmental studies program at the Faculty of Engineering of UNB. This course provides students with a broad exposure to environmental design engineering. Guest lectures in a modular form are the major form of delivery of the technical materials of this course. Individual projects and presentations are designed to allow the students to develop independent skills. This course has been available for the graduate students in the Faculty of Engineering at UNB since 2003, and has been well received by the students.

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