NOVA SCOTIA AGRICULTURAL COLLEGE
ENGINEERING DEPARTMENT

AGRI 5240: Biomass Conversion & Biofuels 3(3-3) **Term: January 2010**

1.0 Rationale:

Biomass is one of the most important sources of energy in the world, and provides 14% of the world's energy. Recently, Biofuels is considered to be one of the most important sources of energy in transportation sector, and expected to provide energy security. To have a measurable impact on energy security, greenhouse gas emissions, and alleviate the food-fuel competition, biofuel production must use renewable cellulosic biomass as feedstock. This biofuels course will examine state of the art technologies aiming at cost effective biomass conversion along with economics and environmental impact issues. Both biological and thermo-chemical methods for the conversion of biomass to biofuels are considered. The course will be of value to individual engineers and scientists interested in the technologies of the developing field of biofuels.

2.0 Learning Objectives

1. Be familiar with the processes for converting feedstocks to biofuels by biochemical methods.
2. Understand and evaluate ways for converting feedstocks to biofuels by thermo-chemical methods.
3. Recognize how biofuels other than ethanol can be produced.
4. Identify the promising conversion technologies for commercialization in short to medium terms (3–5 years)
5. Understand challenges for commercialization of biomass to energy and liquid fuels
6. Be aware of recent R&D progresses and commercialization activities on thermo-chemical conversion of biomass
7. Understand techno-economic and environmental aspects of biomass processing.

3.0 Lectures, Tutorials and Laboratory

Friday (9 am to 12 pm and 1 pm to 4 pm)

4.0. Responsibilities and Tasks

During this class, the student is considered to be *a scientist in formation.* With this in mind, the student does have the full responsibility to plan and manage his learning. Keep in mind that fundamental scientific knowledge/thinking is acquired by repetition and problem solving. Here are the three main tasks under the responsibility of the student.

The first task is to do the necessary work in order to understand and learn the concepts seen in class. This work consists in reading the suggested material prior to and after class. The lectures purpose is to present, explain and complete the information in relation to the main concepts presented in class. The second task is to actively participate in the activities taking place in the classroom. Discussions and problem solving (alone or in team) are the principal activities in which the participation of the student is demanded and advised specially during tutorial. Finally, the student's third task is to use all the resources at his disposition in order to master the fundamental knowledge and the concepts needed to analyze and model the biomass conversion processes studied.

The instructor's responsibility is to organize and manage the environment in which the student is coming to learn. To this end, he will present the necessary learning resources and

will animate the class activities. He is also available to help students with any kind of problem they could have regarding the content of the class. As usual, he plays a role in the grading process.

5.0 Methodology

Every lecture will be organized in a way that favors a good comprehension of the presented concepts and an active appropriation of knowledge. Generally, the instructor's formal lecture will alternate with a case study of a biomass conversion technology and process. In order for the student to actively participate during the lectures, they would need to have read the class materials before hand.

6.0 Catalog Description:

Introduction to biomass conversion; physical conversion of biomass: drying and dewatering, densification of biomass; thermo-chemical conversion of biomass: torrefaction, pyrolysis, gasification and combustion; Heat and power applications; biogas production: digester design and kinetic considerations; ethanol and bio-diesel conversion technologies: and environmental impacts.

Pre-requisites: Consent of Instructor

Course Outline:

I. Introduction
   1. Biomass Resources: Energy crops and Lignocellulosic materials,
   2. Modes of Biomass Utilization for Energy
   3. Routes of Biomass Conversion Processes and biofuels production technologies

   Characteristics of Biomass Fuels
   1. Composition
   2. Ultimate and Proximate Analyses
   3. Heating Value

II. Physical Conversion
   1. Dewatering and drying: Fundamentals, moisture content and conversion requirements, methods
   2. Size reduction: Fundamentals, Steam explosion
   3. Densification and palletizing: Types of Densification Devices, Properties of Densified Fuels
   4. Separation: Municipal solid waste, Virgin biomass, Extraction

III. Thermo-chemical conversion
   1. Pyrolysis: Torrefaction, Slow and Fast Pyrolysis, Charcoal Production.
   2. Gasification: Fundamentals, Fixed bed Gasifiers, Technical and operations; problems with Fixed bed Gasifiers, Fluidized bed Gasifiers, Entrained Bed Gasifiers, Comparison between Fixed bed and Fluidized bed Gasifiers, Gas Treatment,
   3. Combustion: Fundamentals, Furnaces, Fixed bed systems, Fluidized bed systems, Emission reduction, Steam cycle, Residential and small commercial systems, Solid waste incineration, Electric power production, operating problems

IV. Biogas Production
   1. Types of Substrates, Digester Design, Operational Problems, Kinetic Considerations.

V. Ethanol and Biodiesel conversion Technologies
   1. Properties (Ethanol, gasoline, diesel, gasohol, diesohol)
   2. Ethanol Production from Sugar Biomass, Starch Biomass, lignocellulosic materials
   3. Properties (vegetable oil, biodiesel, diesel)
   4. Biodiesel Production from vegetable oil, and biomass

VI. Environmental Impacts
   1. Life cycle analysis
   2. Environment and social impacts
   3. Improvement options

Laboratory Sessions:

1. Laboratory experiments:
   - 1.1 Proximate analysis
   - 1.2 Torrefaction
   - 1.3 Carbonization
   - 1.4 Densification
   - 1.5 Biomass combustor analysis
   - 1.6 Fluidized bed combustion
   - 1.7 Downdraft gasification
2. Case studies on selected technologies
3. Field visit
4. LCA software

Textbook: Lecture notes

Reference Books:

1. Christopher Higman: Gasification, 2nd Edition, Elsevier, 2008
2. Peter Quaak, Harrie Knoef and Hubert Stassen: Energy from Biomass-A Review of Combustion and Gasification Technologies, World Bank Technical Paper No. 422 Energy Series 1999.
3. H.A.M Knoef: Handbook Biomass Gasification, BTG, 2005.
4. Bhattacharya S.C. and Salam P.A.: A Review of Selected Biomass Energy Technologies, RERIC, 2006
5. Donald L. Klass: Biomass for Renewable Energy, Fuels, and Chemicals, Academic Press, 1998
6. C. Y. WereKo - Brobby and E. B. Hagan: Biomass Conversion and Technology, John Wiley and Sons, 1996.
7. Souza-Santos M.L,: Solid Fuel Combustion and Gasification, Marcel Dekker Inc. 2004.
8. Judy D. Wall, Caroline S. Harwood and Arnold Demain, Bioenergy, ASM, 2008

Journals and Magazines:

1. Energy
2. Energy Sources
3. Energy and Fuels
4. Biomass and Bioenergy

5. Chemical Engineering Science
6. Fuel
7. Fuel processing technologies

7.0 Grading System:

The Final grade will be computed according to the following weight distribution: mid-term exam (30%), semester paper and project (30%), laboratory reports and classroom participations (10%), and final exam (30%). Closed book is used for both mid-sem and final exams.

Instructor:

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