RC 323

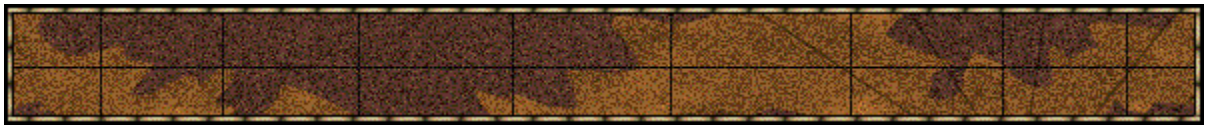
Bio-Energy and Biogas

3 Credits

Instructor: David Dubois
Original Developer: Robert Baron
Current Developer: Robert Baron
Reviewer: James Woodhouse
Created: 07/02/2008
Revised: 02/12/2020
Approval: 02/12/2020

The Implementation Date for this Outline is 25/10/2021

RC 323 Version: 2



Bio-Energy and Biogas

Calendar Description

RC 323 is an introductory course which gives a broad overview of the conversion of biomass directly to energy (heat or electricity) or other forms of stored energy (biogas/liquid/solid fuels). The focus is on commercial scale applications of bioenergy.

Rationale

This is a required course for the Sustainable Energy Technology program. Bioenergy is a renewable energy extracted or produced from biological sources, with an end result as heat, electrical energy or a gas/liquid/solid fuel. With increasing public concerns for climate change and diminishing supply and rising prices of fossil fuel, bioenergy, as one of the most important renewable energy sources of the future, is experiencing rapid growth.

This 45-hour course aims to deliver outcomes as listed in the outline. Particularly, by the end of this mutual learning experience, participants in RC 323 will be able to participate in general discussions regarding bioenergy. RC 323 also provides in-depth information for those looking to develop and implement bioenergy and biogas projects. RC 323 also prepares people to debate the carbon footprint and sustainability of bioenergy and biogas projects.

Prerequisites

RC 200

Co-Requisites

None

Course Learning Outcomes

Upon successful completion of this course, students will be able to

1. recognize the importance of bioenergy within the context of energy in Canada and the world.
2. chart the advantages and challenges associated with direct combustion and gasification in relation to each other.

3. explain how heat can be converted into electricity using the Rankine Cycle (steam), the Organic Rankine Cycle (ORC), or other technologies that are emerging.
4. practise using the key parameters in determining order of magnitude estimates of bioenergy system size and biomass consumption.
5. discuss the impact of an appropriate fuel source for a bioenergy system, including air emission treatment system options.
6. review certification and stakeholder engagement when developing bioenergy systems.
7. give examples of the different conversion processes to produce either gas, liquid and solid biofuels from different biomass feed stocks via a discussion of the difference between aerobic and anaerobic digestion, and a comparison of pyrolysis to gasification and combustion.
8. evaluate critical issues related to design, construction, and operation/maintenance of a biogas system.
9. calculate the input energy, carbon emission, methane emissions, nitrous oxide emissions, and total greenhouse gas emissions based on the energy consumption of a propane/fuel oil heating system converted to biomass.
10. defend whether "debt-then-dividend" or "dividend-then-benefit", as defined by Maomet a FutureMetrics, is correct.

Resource Materials

***Required Text(s)*:**

Gerardi M. 2003.The Microbiology of Anaerobic Digestesters. Wastewater Microbiology

Series. John Wiley & Sons, Inc., Hoboken, New Jersey.

In addition to the above text, RC 323 uses a variety of online sources. These sources provide learners with a diverse knowledge base that can be used beyond this course. Examples include:

Biomass Energy Centre. Retrieved December 5, 2014, from https://www.forestresearch.gov.uk/tools-and-resources/biomass-energy-resources/

Biomass Energy Resource Center. Retrieved May 27, 2021, from http://www.rerc-vt.org/

Carbon Trust. Retrieved December 5, 2014, from www.carbontrust.com

A comprehensive bibliography with current links is provided for the learners in the individual learning assignments.

***Reference Text(s)*:**

None

Conduct of Course

This course consists of the equivalent of 45 hours of lecture delivered on-line using a learning management system (lms). Course content modules and links to assigned readings are available on-line. A course facilitator is available to guide the learner through the course, answer any questions and grade assignments. Learners are expected to participate in on-line discussion forums and asynchronous conference discussions with other classmates and the course facilitator. Assignments are submitted electronically using the lms. In addition to learning activities and assignments, students are required to do either a final project or term paper.

The final exam is open book and taken using the lms. In order to complete the course on time, deadlines for assignments, the exam and the project or term paper are enforced.

Evaluation Procedures

The final grade is an aggregate of the following components:

Activity		Weight
Assignments	Assignment 1.1	3%
	Assignment 2.1	2.5%
	Assignment 2.2	2.5%
	Assignment 3.1	9%
	Assignment 3.2	5%
	Assignment 4.1	2.5%
	Assignment 4.2	2.5%
	Assignment 5.1	7%
	Assignment 5.2	7%
	Assignment 6.1	4%
	Assignment 6.2	5%
Class Discussions		5%
Final Exam	Term Paper/Final Project	20%
	Final Exam	25%
Total		100%

Grade Equivalents and Course Pass Requirements

A minimum grade of D (50%) (1.00) is required to pass this course.

Letter	F	D	D+	C-	C	C+	B-	B	B+	A-	A	A+
Percent Range	0-49	50-52	53-56	57-59	60-64	65-69	70-74	75-79	80-84	85-89	90-94	95-100
Points	0.00	1.00	1.30	1.70	2.00	2.30	2.70	3.00	3.30	3.70	4.00	4.00

Students must maintain a cumulative grade of C (GPA - Grade Point Average of 2.00) in order to qualify to graduate.

Attendance

Active participation is required in all courses within the Sustainable Energy Technology certificate and diploma programs. Each facilitator designates these requirements through the use of tools within the management system and personal contact with learners.

These expectations can be given marks as part of the assessment process. Each course outlines these expectations within the course structure.

For example, learners can be asked to demonstrate their participation/attendance through discussion forums, sharing research results, contributing relevant information, submitting assignments, communicating with colleagues and the facilitator, and participating in synchronous meetings or asynchronous activities.

Attendance is considered vital to the learning process. Absenteeism is recorded. For example, if a discussion forum is organized; the learner is expected to attend as per the guidelines set by the facilitator.

Students can request for an excused absence. An excused absence is one that is verified with your facilitator.

NOTE: Any exceptions to the above attendance policy (e.g. family or work-related issues) **must** be approved in writing by the Department Chair **prior** to the beginning of the course.

It is the student's responsibility to know their own absentee record.

Course Units/Topics

Module 1. Introduction to Bioenergy (4 hours)

1. Current Impacts of Bioenergy
2. Review of Terminology and Important Definitions
3. Feedstock Review
4. Supply Chain Logistics

Module 2. Conversion of Biomass Direct to Bioenergy (10 hours)

1. Biomass Combustion
2. Gasification
3. Combined Heat and Power
4. Organic Rankin Cycle and Other Technologies to Produce Electricity from Biomass
5. District Heating

Module 3. Design Aspects of Biomass to Energy Systems (8 hours)

1. Basic Estimating for Commercial Scale Heat and CHP Bioenergy Systems
2. Fuel Handling and Boiler Operation
3. Emissions (Air/Ash)
4. Permitting, Certification, and Stakeholder Engagement

Module 4. Conversion of Biomass to Biogas and Other Fuels (5 hours)

1. Biogas
2. Pyrolysis
3. Densified Biomass

Module 5. Anaerobic Systems (15 hours)

1. Overview of Anaerobic Digestion
2. Operational Factors
3. Process Operation

Module 6. Carbon Footprint and Sustainability of Bioenergy (3 hours)

1. Sustainability of Biomass
2. Carbon Footprint
3. Comparing and Contrasting Viewpoints on Bioenergy

2602 - 59 Avenue, Lloydminster, Alberta, Canada T9V 3N7. Ph: 780 871 5700
5707 College Drive, Vermilion, Alberta, Canada T9X 1K5. Ph: 780 853 8400
Toll-free in Canada: 1 800 661 6490 E-mail: admissions@lakelandcollege.ca