MEC 3040: Bioenergy Fall 2019

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Meeting times:
Lecture: T,Th, 1:00 – 1:50 pm in GRE 124; Lab Th 2:00 – 3:50

Canvas: Note that Canvas links to my own course web site where most materials are posted:
richmond-hall.weebly.com/mec-3040.html

Office hours: See my schedule at http://richmond-hall.weebly.com/contact--schedule.html.

Mailbox: in the Green Hall Faculty Lounge

Course objectives:
This course provides an overview of bioenergy technologies that can be used to replaced current fossil fuel-based heating systems while contributing to the production of renewable electricity and transportation fuels. Solid, liquid and gaseous biofuels are introduced, though the course focuses on wood and grass biomass and anaerobic digestion of organic wastes. A variety of feedstock resources, processing and characterization methods are covered along with various systems use for energy conversion by combustion/oxidation. Policy, permitting, transportation, economics, nutrient recovery, carbon cycling and life cycle analysis are compared and contrasted. Case studies focus on systems installed in Vermont.
3 credits; 2 hours of lecture; 2 hours of lab

Course outcomes:
- Identify and quantify the natural resources and processes used to produce biomass and biofuel (ABET2,4; EPO3,8)
- Identify the transfer and storage systems used for biomass and biofuels
- Demonstrate knowledge of the scientific principles of bioenergy conversion to heat and power. (ABET1; EPO2,8,9)
- Apply knowledge of bioenergy systems to understand and evaluate plans for installation, operation, and maintenance of a system. (ABET2; EPO3,8)
- Apply knowledge of bioenergy systems to identify the basic factors that affect system performance and efficiency. (ABET2; EPO3,8)
- Apply knowledge of bioenergy systems Identify and employ methods for operating, monitoring, and controlling the system. (ABET2; EPO3,8)
- Demonstrate familiarity with the standards, policies, and economics of bioenergy production, processing, and bioenergy systems construction and operation (ABET3,4; EPO1,7)
- Evaluate the EREOI and life cycle costs of bioenergy and its impact on carbon balance.

Required texts:
None. I'll assign readings from a variety of sources.

Supplemental texts on reserve at Hartness Library:
Boyle, G., Everett, B., Ramage, J. (2003) Energy systems and sustainability: power for a sustainable future, The Open Univesity, UK
ISBN: 978-0-19-926179-6

Boyle, G. (2004) Renewable energy: power for a sustainable future, Oxford University Press, UK
ISBN: 0-19-926178-4

Dahiya, A (ed) (2015) Bioenergy: Biomass to biofuels, Academic Press, Waltham, MA
ISBN: 978-0-12-407909-0

Rosillo-Calle, F, Johnson, F.X. (2010) Food versus fuel: an informed introduction to biofuels. Zod Books, London & New York

Available on-line
BIOEN 1 - 4: Bioenergy & sustainability course series (March 2012)
fyi.uwex.edu/biotrainingcenter

Study and work expectations:
Students enrolled in college courses should expect to spend 2 hours working on the course for every hour of course meeting. This course is reading and writing intensive. I expect you to spend time on required readings. We will be discussing them in class and reading will also help you with assignments. In terms of writing, I am looking for quality and will consider spelling, grammar, structure and persuasive argument. I expect you to have written a research paper and to be familiar with developing theses, outlines, and arguments and with citing references.

Assignments, work, due dates and policies:
- **Homework** problems and **lab exercises** are due at the next class meeting unless otherwise specified. ***No*** late work will be accepted. However, acknowledging that we can all have a bad day, I will drop one zero for the semester. In addition to sets of homework questions, homework will include reading articles and watching videos. Short and simple **'reading quizzes'** can be completed as you read or watch are designed to help you keep up with assignments.
- **Labs** involve field trips, visiting speakers, or laboratory work. Assignments involve reading related to trips and speakers, preparation of questions for speakers, short reports on field trips and results from lab exercises.
- **Quizzes** are **take-home** and are designed to help you review material. Make up quizzes are not given but you'll generally have at least 2-3 days to complete each quiz. I'll drop the lowest quiz grade of the semester only if it is not a zero.
- **Exams** will allow you more than one hour and you will be allowed notes on one side of a 3"x5" notecard and a calculator.
  - **Make-up exams** will be provided if you have a valid reason and if you contact me before the exam or immediately after the exam.
  - You may replace you hourly exam grades with your grade for the corresponding section of the **cumulative final exam**, if the latter grade is higher. However, zeros are not replaced so you should plan to take each hourly exam.
- **Citing references:** Some assignments will ask you to do some research and find sources. When using sources cite them using a recognized citation system such as APA or MLA.

Grading scheme:
I post grades on Canvas' 'grade book'. All assignments will be announced in class and posted on my Weebly site and Canvas. I give partial credit on all assignments. Students are responsible for keeping all graded material until final grades are in so that we can resolve any grading disputes.

Exams (10% each) Cumulative final exam	30% 10%
Take-home quizzes	15%
Reading quizzes and homework	20%
Lab exercises	15%

* I will drop your lowest reading quiz grade of the semester and the lowest grade from your short writing assignments, provided you completed all of them.

A+	A	A-	B+	B	B-	C+	C	C-	D+	D	D-	F
97-100	93 - 96.9	90 – 92.9	87 – 89.9	83 – 86.9	80 – 82.9	77 – 79.9	73 – 76.9	70 – 72.9	67 – 69.9	63 – 66.9	60 – 62.9	< 60

Attendance:
On-time attendance is expected. I report excessive absences through the college's academic alert system and as part of academic warnings. Students missing class are responsible for material covered; get handouts from a classmate or the course website. **Please notify me if and when you must be absent and explain why you were unable to attend.**

Communication:
My official course-related communication will be via your official college email address. You are responsible for regularly reviewing email as important course information may be delivered this way. If you use your own e-mail system, arrange to have your college email forwarded.
See IT or http://support.vtc.edu for assistance.

Cell phones:
Students must surrender their phones during class. I will make exceptions if there is a need.

Focus on learning:
During class our focus must be learning. Please respect this focus. If I find that your behavior is preventing others from focusing on learning, I may ask you to leave.

Academic integrity:
Students are expected to practice academic honesty, understand and abide by Vermont Technical College's Policy on Cheating and Plagiarism (T107). I expect students to prepare and submit their own work for all assignments. I strongly encourage you to read widely and discuss this course with others but expect you to cite work that you refer to or use as a source. You are welcome to work in groups or with tutors, but all work you submit must be demonstrably your own. ***Be aware that I will be using software to check your work against other sources.*** If there is any question regarding the appropriateness of collaborating on homework or projects, check with me before the assignment is due.
https://www.vtc.edu/my-vermont-tech/my-vtc-home/policies-procedures

If you need help with this course:
Students having problems with course material should feel free to talk with me. In addition, if anything regarding the classroom environment interferes with a student's learning experience, it should be brought to the attention of the instructor. Students experiencing any special difficulties should take advantage of recitation hours and my office hours and should feel free to schedule extra hours with me or with tutors available at the Center for Academic Success. Please let me know how I can help you focus and succeed in the course.
https://www.vtc.edu/my-vermont-tech/my-vtc-home/center-academic-success

Disabilities and accommodations:
Anyone who feels they may be eligible for an accommodation based on the impact of a disability should contact me to arrange an appointment to discuss the course format and the sort of supports that may be needed. I rely on the Learning Specialist's office for assistance in verifying the need for accommodations and developing accommodation strategies. If you have not contacted the Learning Specialist, I encourage you to do so. Robin Goodall is available in the Center for Academic Success (Conant 224), ext. 7-1278, or by email at rgoodall@vtc.edu.
https://www.vtc.edu/my-vermont-tech/my-vtc-home/center-academic-success

Week	Topic
1	**Introduction to bioenergy** • What is bioenergy? Forms and current use • Feedstock, co- and byproducts • The debate: bioenergy drivers vs. bioenergy ethics and sustainability ▪ Primary vs waste biomass: a clear difference ***29 Sep lab: Marsh-Billings – first in the nation managed, sustainable forestry***
2	**Biomass: introduction to wood & grass** • Woody biomass resources and traditional use • Current use and future forecasts • Harvesting energy wood (or perennial crops) ***5 Sep lab: Walk of a conserved but working woods with forester John McLean***
3	**Processing and forms of biomass feedstock** • Cord wood vs. chips vs. pellets • EROEI concepts and comparisons • Combustion systems, scales of use and emissions *12 Sep Lab: Tour of campus for bioenergy facilities equipment*
4	**Biomass combustion and heat vs. CHP** • Controversy: heat vs. electricity vs. CHP • Local use vs. global movement: greenwashing? • Is co-generation a bridge to a greener future? ***19 Sep lab: Norwich University's wood chip-fired heating plant (Chris Sanden)***
5	**Carbon accounting, LCA, carbon capture and the future of biomass** • Carbon flows and accounting are a critical part of biomass lifecycle analysis (LCA) • Temporal factors in carbon neutrality: lag times for regrowth • Carbon capture and storage (or capture and reuse) could be a gamechanger *26 Sep lab: Exploration of biomass's carbon balance, CCS, CCU [Adam Sherman]*
6	**Introduction to bio-oil & biodiesel** • Used or waste oil collection and use • Feedstock: cultivation and harvesting • Forms of use: bio-oil vs. biodiesel *3 Oct lab: talk - John Williamson or Greg Pahl*
7	**Biodiesel processing and fuel standards** • Chemical and physical transesterification • Biodiesel use: heating, engines and EROEI • Testing and fuel standards • Future? Algal bio-oils? ***10 Oct: REV conference***
8	**Biodiesel vs. bioethanol economics, use and enviro impacts** • Use and economics of biodiesel vs. bioethanol • Comparative economics: the effects of subsidy • Comparing use of biodiesel and bioethanol in the US and Europe ***24 Oct lab: Biodiesel transesterification***

9 **Basics of anaerobic digestion**
- The biochemical process of AD
- Products, co-products, by-products
- Differential use of AD in the US vs. Europe and the rest of the globe

31 Oct lab: Tour of VTCAD; Vanguard speaker re Middlebury project

10 **Factors affecting AD & types of system design**
- Microbes and feedstock
- System design and environmental factors
- Operational parameters

7 Nov lab speaker: Alex Depillis: Insights into AD in on farms in Vermont

11 **AD feedstock: energy values, C:N ratios, & prediction of biogas production**
- Feedstock materials and sources: waste vs. intentional crops
- Energy content depends on biochemistry: fats vs. carbs vs. proteins
- Ratios of carbon to nitrogen optimize AD
- AD can be inhibited by a variety of factors

14 Nov lab: Ball jar AD of a variety of feedstock materials +/- inhibitors

12 **AD implementation: regulations, finance, opportunities and challenges**
- Capital and operational costs vs. potential revenues
- Models of ownership: private vs. public-private partnership vs. public
- Environmental services are still seen as externalities: fines vs. credits

24 Nov lab exercise: Predicting energy output of AD diets with databases & spreadsheets

13 **The integrated biorefinery model**
- A quick look at systems thinking
- What is the biorefinery model?
- What can bioenergy learn from fossil fuel's use of the refinery model?

6 Dec lab: Hands-on experience with LCA

14 **Bio-energy opportunities**
Entrepreneurial opportunities in bioenergy in Vermont and the US
- Case studies

12 Dec lab: Presentation of case studies of growing companies and organizations

15 ***Cumulative FINAL EXAM***