BAE 528
Biomass to Renewable Energy Processes

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Credit: 3 hours
Class Time: Tuesday/Thursday, 11:45 am - 1:00 pm
Classroom: Room 158 Weaver Labs

Prerequisites: Introductory organic chemistry or biochemistry, and microbiology, graduate standing in COE, CALS, PAMS, or CNR, or approval of the instructor.

Course Description:
This course will introduce fundamental principles and practical applications of biomass-to-renewable energy processes, including anaerobic digestion of agricultural and industrial wastes for biogas and hydrogen production, bioethanol production from starch and lignocellulosic materials, biodiesel production from plant oils, and thermoconversion of biomass and waste materials for renewable energy production. A field trip to visit a biogas production facility will be arranged during the course. The topics that will be covered in this course include:

- **Biomass chemistry**
  - Sugars, Starch, Cellulose, Hemicellulose, Lignin, Vegetable oil, etc.
- **Biomass resources**
  - Energy crops, Agricultural residues, Herbaceous biomass, Woody biomass, Vegetable oil
- **Biomass logistics**
  - Harvesting, Transportation, Storage
- **Kinetics and microbiology of biological processes**
- **Anaerobic digestion for biogas production**
  - Anaerobic microorganisms, Anaerobic process for biogas production, Anaerobic process for hydrogen production, Gas purification processes.
- **Bioethanol production process**
  - Pretreatment processes, Saccharification and hydrolysis for fermentable sugar production, Fermentation process, Ethanol purification, By-products
- **Biobutanol production process**
  - Metabolism and pathway, Fermentation technology, Biobutanol recovery
- **Biodiesel production**
  - Materials, Chemical reactions and catalysts, Biodiesel production process
- **Thermochemical conversion processes**
  - Combustion, Gasification, Pyrolysis
Textbook:


Reference Books:


Homework:

Homework will generally be assigned along with the topics and due in a week.

Project:

Each student will complete a project for this course. Students are encouraged to do their projects in groups, but each group should not have more than three students. The project should contain analysis and discussion of an innovative renewable energy production system. A one-page project proposal will be due in the mid of the semester and will be returned with comments within two weeks. Students may choose the topic of their projects or ask for assigned projects. A written report of the project (double spacing, 1” margins, 12 point font, and limit of 40 pages including tables and figures) will be due on Monday of the last lecture week and an oral presentation of the project will be scheduled in that week.

Exam:

Two exams (a mid-term and a final) will be scheduled during the course. They will be open-book exams. Permission for a make-up exam needs to be obtained from the instructor before the exam.

Grading Policy:

Grading will be based on homework assignments, class project, mid-term and final exams, and class participation with the following distribution:

- Homework Assignments (20%)
- Class Project (20%) (written report 10% + oral presentation 10%)
- Mid-Term Exam (20%)
- Final Exam (30%)
- Class Participation (10%)

Academic Integrity:
Students will be expected to adhere to the guidelines for academic integrity as outlined in the NCSU Code of Student Conduct (http://www.ncsu.edu/policies/student_services/student_discipline/POL11.35.1.php).

**Student with Disabilities:**

If you have a disability that may affect your participation in this class, please notify the instructor so that necessary adjustments can be made. You may also contact the NCSU Disability Services for Students (http://www.ncsu.edu/equal_op/dss/).

**Course Schedule (tentative):**

<table>
<thead>
<tr>
<th>Week</th>
<th>Topic</th>
</tr>
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<tbody>
<tr>
<td>Week 1</td>
<td>Introduction</td>
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<tr>
<td>Week 2</td>
<td><strong>Biomass chemistry:</strong> Organic chemistry, Carbohydrate chemistry, Sugar</td>
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</tbody>
</table>
| Week 3 | **Biomass chemistry:** Starch, Cellulose, Hemicellulose, Lignin, Pectin, Vegetable oil  
**Biomass logistics:** Harvesting, Transportation, Storage |
| Week 4 | **Biomass resources:** Energy crops, Agricultural residues, Herbaceous biomass, Woody biomass, Waste materials |
| Week 5 | **Biological process:** Enzymatic reactions  
Bioprocess Microbiology |
| Week 6 | **Anaerobic digestion:** Anaerobic microorganisms  
Methane production process |
| Week 7 | **Anaerobic digestion:** Methane production process |
| Week 8 | Mid-Term Exam                                                        |
| Week 9 | **Anaerobic digestion:** Hydrogen production process, Gas purification  
Field trip – Anaerobic digestion for biogas production |
| Week 10 | **Bioethanol production process:**  
Saccharification and hydrolysis:  
*Starch:* Pre-processing, Saccharification  
*Lignocellulose:* Pretreatment, Hydrolysis |
| Week 11 | **Bioethanol production process:**  
Fermentation process:  
Fermentation microbiology  
Metabolism and pathways |
| Week 12 | **Bioethanol production process:**  
Ethanol purification:  
Fractionation  
Dehydration |
| Week 13 | **Biobutanol production process:**  
Metabolism and pathway  
Fermentation technology  
Biobutanol recovery |
| Week 14 | **Biodiesel production process:**  
Materials  
Biochemical reactions  
Biodiesel production process |
| Week 15 | **Thermochemical conversion processes:**  
Combustion  
Gasification  
Pyrolysis |
| Week 16 | **Project final report – due date**  
Project presentation |
| Week 17 | **Final Exam** |