Department of Chemical and Biochemical Engineering
Rutgers University, New Brunswick

16:155:571

Sustainable, Renewable and Clean Energy Science and Engineering

Fall 2015

Meeting Day/Time: Thursday, 5:00-8:00 PM. (This may change at the first lecture time if there is better time that is more convenient and agreeable to all).

Class-Room: Room: BME-116 (in Biomedical Engineering Building), Busch Campus, Rutgers University at New Brunswick

Instructor: Professor Teddy (Tewodros) Asefa

Office: Room CBE-138 (in Chemical Engineering Building or Engineering C-Wing)

Contact Info: E-mail: tasefa@rci.rutgers.edu (preferable to phone); Tel.: 848-445-2970

Office hours: Wednesdays 1:00 - 2:00 pm or by appointment

Course Lectures: Check at Sakai (see info below)

Course Content This course is intended to give mainly but not exclusively an engineering and scientific perspective about conventional energy resources, energy challenges and our endeavors on the development of future, sustainable, clean and renewable energy sources. This course will start by offering an introduction and basic fundamental knowledge and science about available energy resources and fossil fuels. It will follow with the challenges we face related to energy; the current state-of-the-art in energy production; various energy resources and how they work; sustainable methods being developed for generation of various clean and renewable energy sources; and the design and optimization of materials, biomass, chemical products and processes that enable energy conservations. The course will also provide information on new materials/nanomaterials, engineering concepts, and thermochemical, photochemical and electrochemical devices for energy applications. The course will examine the relationship between materials, material designs, energy systems and energy resources to address sustainability and clean energy challenges, by providing special emphasis on fundamental roles played by chemical engineering and basic scientific principles.

Specific Learning Objectives:

- To understand topics related to energy resources, methods for conversions from one form of energy to another, and future prospects on energy.
- To understand our energy challenges, traditional energy resources and the advantages and disadvantages of various energy resources, including renewable energy sources.
- To understand the principles of operation of various electric power plants, energy conversion systems, *e.g*., fossil, biomass, nuclear powered plants, hydroelectric, etc.
- To cover basic science and engineering concepts and principles (*e.g*., mass transport, thermodynamics, catalysis, bioengineering, modeling, etc.) pertinent to energy and renewable energy applications for sustainable future (*e.g*., conversion of renewable resources to synthetic fuels; energy conversion techniques; solar, wind, biomass, geothermal, hydro-electric, wave and tidal energy technologies; bioenergy technologies for conversion of biomass into fuels; etc.).
- To highlight thermodynamics concepts and chemistries that can lead to improved power densities, efficiencies and emissions in power generating systems and green energy resources; chemical reactor designs that can lead to better energy resources; processes as related to combustion and combustion thermodynamics, reaction kinetics and combustion transport, chain reactions, ignition, quenching, etc.
- Topics related to energy supply options and/or that can affect decision making: solar, biomass, and geothermal resources, nonconventional fuels from heavy oils, tar sands, natural gas hydrates, and shale-oil, etc.
- Topics on catalysts and biocatalysts, catalyst improvement, and reactor engineering that can decrease energy consumptions or produce energy sources.
- Energy engineering topics related to chemical reaction networks, nonconventional fuel upgrading, carbon dioxide capture and conversion, design of novel energy conversion processes, energy supply chains, and combustion technologies (methane conversion, gasification, pyrolysis technology, etc.).
- Topics addressing chemical aspects of interfaces in materials for solar cells, efficient energy storage technologies, etc.
- Topics covering bio-derived energy and biochemical engineering of enzymes/microbes for the production of fuels from biomass; biomass conversion technologies and bioenergy (collection, transport methods, preprocessing and treatment methods; hydrolysis and fermentation of biomass into ethanol, bioenergy technology, trans-esterification or bio-oil and biodiesel technology, etc.).
- Understanding scalable device structures for low cost energy using chemical principles; process design, energy analysis, engineering economics and environmental assessment of renewable energy systems; and their advantages and disadvantages.
- Developing technologies for transporting and storing thermal and electrical energy and chemical synthesis and device fabrications involving some chemical concepts.

Lecture Notes: Although there is no single ideal text-book for the course, a few are recommended below and will also be used to cover many of the topics. Some of these books may be available in the Rutgers Book-Store. Lecture materials and information from literature and other sources will also be used in many of the lectures. The lecture notes and other reference materials will be posted on Sakai or the class web-site. Access to these sites will be provided to all students enrolled in the course. The materials covered in lecture will be illustrative rather than exhaustive.

Text-Books:

Sustainable Energy, (SI) Edition, 2015, by Richard A. Dunlap, Cengage Learning.

Renewable energy: Power for a Sustainable Future, by Godfrey Boyle, 2004, Oxford University press, Oxford, UK.

Other Suggested and Supplemental Books:

Sustainable Energy, Second edition By Jefferson W. Tester, Elisabeth M. Drake, Michael J. Driscoll, Michael W. Golay and William A. Peters

Solar Engineering of Thermal Processes, 3rd Edition, by John A. Duffie, and William A. Beckman. 2006, John Wiley & Sons, Inc.

Sustainable Energy: Without the hot air, February 20, 2009 by David JC MacKay (http://www.withouthotair.com/Contents.html)

Biorefineries for Biomass Upgrading Facilities, by Ayhan Demirbas, 2010, Springer publishers.

The Brilliance of Bioenergy, by Ralph Sims, 2002. James and James Publications, London, UK.

Exams: There will be two exams. Both exams will be given during the time of regular lecture hours (see below).

Grading and Grading Policy:

There will be no make-up exams.

The overall grade of the course depends on a combined score of the following:

Mid-term Exam	30%
Final Exam	30%
Written Report (one)	20%
Oral Presentation	20%

The written report will have to have no more than 2,000 words, without references and it has to be on an area of drug development, drug manufacturing and materials engineering as relevant to drug development. This has to be from a recently published article on some reputable international journals such as *Energy and Environmental Science, Biotechnology for Biofuels, International Journal of Hydrogen Energy, Progress in Energy and Combustion Science, Nano Energy, Applied Energy, Solar Energy Materials and Solar Cells, Journal of Power Sources, Energy Policy, Renewable Energy, Journal of Physical Chemistry C, Biofuels, ChemSusChem, Bioproducts and Biorefining, Energy Economics, Renewable Energy, Journal of Power Sources, IEEE Transactions on Power Systems, Renewable and Sustainable Energy Reviews, Biomass and Bioenergy*, *International Journal of Renewable Energy Engineering*, *International Journal of Renewable Energy Technology, Bioresource Technology*, *Catalysis Science and Technology*, *Bioresources*, *BioProducts, Biofuels, Bioproducts & Biorefining (Biofpr)*, *Renewable and Sustainable Energy Reviews*, *Energy Conversion Management*, *Solar Energy*, *etc.* Students need to choose a topic by October 29th, 2015 and should submit a short abstract (less than 100 words) and send it to Dr. Asefa about it via e-mail also by October 29th, 2015. Students that fail to do this and submit the report will get 0 for this part. No make-up writing assignments will be given to improve their grades. The format of the report will be as follows:

- Page numbers: 5-10 pages without references
- Font: 12 Times New Roman or Arial
- Line Spacing 1.5
- Paper Margins: No less than 1”
- Due on December 3, 2015

Student Oral Presentation. The student presentation will be held in the middle of the lecture and at lecture break. The presentation will consist of (a) a 10 min student oral presentation on a topic of choice, relevant to the course and pharmaceutical materials, and (2) it will be followed by a 5 min question and answers session. The student can do this with his/her own laptop computer or/and alternatively using white boards. The students’ alphabetical list will be used for the schedule (details on the first class). The student can choose a recent article from a reputable international journal or news article on energy.. Students who do not present in their assigned time will receive zero point for this part.

The written report has to be submitted by its due date of December 3, 2015. Any late submission will be accompanied by deduction of points (3% a day) from whatever the student receives for that part (20%).

The students have to use their own laptop computers to do the presentations (or alternatively, they can send their presentation to Prof. Asefa, at least one hour before the class time, means 4:pm at the day of the class at the latest) so that Prof. Asefa can upload the presentation on his computer for them. No memory stick allowed on Prof. Asefa's computer for computer virus issue.

There is absolutely No make-up exam no matter the circumstances are. If a student fails to take any of the exams for a valid *documented in writing medical/emergency reason*, the remaining exam will be converted to make up for the missed one to calculate the final grade. Because an e-mail sent is not always an e-mail received, advance notice for absences can not ever be accepted by e-mail and you will need to get a confirmation from Prof Asefa.

E-mail

The professor may receive, read and answer only e-mails that have a Rutgers e-mail address. E-mails from other e-mail accounts may actually get filtered out by the instructirs' e-mail server without the instructor's knowledge, for e-spam and computer virus reasons.

Cheating, plagiarism and academic dishonesty: Cheating will not be tolerated. You may be required to show your Rutgers ID when you turn in your exam to compare your picture and signature. Students caught cheating will fail the assignment (gets 0 point on the specific assignment. University policy on academic dishonesty will be followed and the student(s) will be referred to the appropriate university office for disciplinary action. A letter will be sent explaining the punishment to the Associate Deans. If you have further complaints regarding the failed assignment and the letter, you must contact the Associate Deans directly.

Each student has to turn in his or her own exams. Copying is considered cheating and will be treated as stated above, with 0 points given for the exam and a letter to the Dean's offices. If you let someone copy your quiz from you, you will have 50% deduction from your grade and a letter sent to the Associate Deans and persons in charge in your college describing these.

For more details on **Academic Integrity**, please also refer to:
http://ctaar.rutgers.edu/integrity/policy.html

Course Schedule/Calendar

(Subject to change depending on availability of guest lecturers or the pace of covering some lectures that may need more explanations in classes)

15 Lecture Weeks

Date	Topics
Sept. 3 (Thurs.)	**Energy Basics and Technical Performance** - Forms of Energy - Reviews of Engineering Concepts Pertinent to Energy - Some Basic Thermodynamics and Thermodynamic Analysis - Rate Processes in Energy Conversions - Sustainability Metrics and Measure of Sustainability - Systems Analysis Approaches - Energy Efficiency, Production Rates, Estimation and Evaluation
Sept. 10	**Introduction: Past, Present and Future Energy Use** - Global Energy Reserves - World Energy Consumption and Demand and Challenges - Renewable versus Non-Renewable Energy Sources - Clean and Sustainable Energy - Estimation and Evaluation of Energy Resources - Future outlook
Sept 17	**Fossil Fuels / Energy** - Introduction - Fossil Fuel Energy Base - Harvesting and Energy Products - Principles for Evaluating Fossil Energy Technology
Sept. 24	**Environmental, Geopolitical, Sociological and Economical Impacts of Fossil Fuel Use** - Thermal Pollution - Chemical Pollution - Particulate Pollution - Greenhouse Effect - Climate Change - Carbon Sequestration and Carbon Cycle - Geopolitical, Social and Economical Impacts
Oct. 1	**Bioenergy** - Biomass Sources - Advantages and Benefits - Available technologies and Challenges - Feedstock Collection and Transport Methods - Feedstock Pre-Processing and Treatment Methods - Biomass conversion technologies (Thermo-chemical, Combustion Gasification, Pyrolysis technology, Trans-Esterification, etc.)

	- Biochemical Conversion (Enzymatic Hydrolysis, Fermentation) - Recent Advances and Applications of Bioenergy technology
Oct. 8	**Geothermal Energy and Nuclear Energy** - Physics and Chemistry on Geothermal and Nuclear Energy Sources - Reactor Technology - Future prospects - Fuel Sources and Fuel Cycle
Oct. 15	***Mid-Term Exam***
Oct. 22	**Solar Energy and Solar Photovoltaics** - Solar-Thermal Energy - Materials for Solar Energy Conversions - Solar Photovolatics or Solar Cells - PV Integration, Resources and Future Prospects - Grid-Connected PV systems - Environmental Impacts and Safety
Oct. 29	**Hydroelectric Energy** - Principles of Hydropower Technology - Turbine Design - Types of Plants - Utilization and Economics - Environmental Impacts and Other Challenges
Nov. 5	**Wind, Ocean Wave, Tide, Current, and Thermal Energy Conversion** - Wind Resources - Wind Turbines and Power Generating Systems - Energy from Tides and Waves and Economic Prospects - Current Status and Prospects
Nov. 12	**Energy Carriers and Fuel Cells** - Electric Power, Hydrogen Fuel, and Others - Fuel Cells - Hydrogen as Energy Carrier
Nov. 19	**Energy Management** - Storage (Batteries, Capacitors and Supercapacitors, etc.) - Transportation - Energy Distribution
Nov. 26	***Thanksgiving Week – No Class***
Dec. 3	**Energy Economics and Industrial and Commercial Energy Usage**

	- Technical and Economical assessment of Renewable Energy Technology - Energy Associated with Reactors and Catalysis - Environmental Impact Assessments and Sustainability Issues - Energy Efficient Building systems - Future Prospects, Research and Design Projects
Dec. 10	***Final Exam***

** Guest lecturers may appear and give some lectures or research presentations (typically 1 hour) related to biomass conversions, energy materials synthesis, characterization and modeling. This will be held preferably at the beginning or in the middle of the lectures as a break. Also, as mentioned above, students may be assigned to present a 10 min long presentation related to energy materials, energy policy, energy economics, etc. from the literature in the middle of the lecture and during a lecture break (one or two students per class may be assigned).