



Spring 2014

CHBE/ENST 281: Engineering Solutions for Sustainable Communities

Instructors: Dr. Kyriacos Zygiourakis, Prof. Richard Johnson

Course Overview

Our Houston and Rice communities face many challenges as they try to develop and implement sustainable solutions to their energy and environmental problems. They need the help of engineers who not only have strong technical backgrounds, but are also effective communicators. Students will work in teams to analyze and solve specific problems affecting our campus or our city (or both). Emphasis will be placed on the integration of engineering fundamentals with societal issues, environmental and safety considerations, sustainability and professional communications.

In the spring of 2007, students in CHBE/ENST 281 conducted the university's first greenhouse gas inventory since 1999. This data primed the discussion about Rice's impact on global warming. In October 2007, Rice University President David Leebron signed the American College and University Presidents Climate Commitment, thus agreeing that Rice will develop a plan to become "carbon neutral" by a soon-to-be-determined future date. In the spring of 2008, CHBE/ENST 281 students updated the greenhouse gas inventory, began quantifying the effect of university-owned "carbon sinks," and provided an initial overview of steps that the university can take to reduce its greenhouse gas emissions. In the following years, CHBE/ENST 281 students built upon the work of previous classes with a particular focus on energy and water sustainability and carbon footprinting. For the past three years, CHBE 281/ENST 281 students explored the energy, climate, and other related environmental impacts of Rice's food purchasing and of Rice's new building construction, while also building upon the work from past classes on energy and water sustainability and greenhouse gas reduction strategies. This year's class will continue and expand these efforts, quantifying both impact and the potential benefit of proposed solutions.

Non-engineering students with technical backgrounds are welcome to enroll in the course, and those who have enrolled in the past have typically done well.

Learning Outcomes

Students will be introduced to a general framework for assessing the impact of humans on the environment. They will develop a broad understanding of the current and future availability of various primary energy sources, along with the environmental consequences of consuming these resources. In particular, students will be introduced to the topic of global warming, and over the course of the semester will be exposed to linkages between global warming and energy scarcity discussions. Students will learn about several technologies and approaches that are touted as "green" solutions, and will be challenged to think critically about these solutions. Through a series of assignments, readings, and in-class exercises, students will learn how to assess environmental performance by using Rice as an example, and how to evaluate potential solutions for improving environmental performance.

Overview of Assignments

Students will be expected to complete the following work:

Individual Assignments

- Assignment 1 is an exercise intended to introduce students to **calculating carbon footprints** and approximating how changes in behavior and technology are reflected in both personal and global impact. **Due Date: January 15**
- Blog responses will be required for several of the course readings as a way to track student understanding of the course material and also to enable the instructors to gauge student opinion about particular topics. The course blog can be found at: <http://2014chbe281.blogs.rice.edu/>
- Additional assignments may be introduced to further engage students in the course material.

Group Assignments

- The Group Lecture will enable students to use concepts and tools learned in the class to assess the potential of various alternative energy sources in meeting our energy needs. Student teams will present their findings to the class in the form of a lecture on April 14th and 16th.
- The Group Project topics will focus on energy, food, water, and CO₂ emissions, drawing upon data provided by Richard Johnson and other members of the Rice administration. Student teams will present their projects to the class on April 21st and 23rd, and submit a final paper on or before April 25th.

Quizzes

- To assess understanding of course lectures and reading materials, students will take approximately three quizzes during the semester.

Final Exam

- The final is intended to test each student's ability to **synthesize** the key lessons, readings, and findings from the class.

Required Texts

- Margonelli, Lisa. *Oil on the Brain*. Broadway Books. New York. 2008.
- In addition, students may need to purchase a book as part of the Group Lecture, and will certainly need to consult numerous sources in developing the lecture.

Schedule

Note that we may ask for students to attend events outside of regularly scheduled class meeting times. Students with existing class conflicts will be excused.

Section 1: An Introduction to Global Warming and Sustainability

The course begins with a primer on one of the world's most significant challenges – global warming – and an extended discussion of our capacity to endure, as captured in the concept of sustainability.

Monday, January 13th: History and Science of Global Warming, Part 1

We will trace the history of scientific research related to climate change in order to provide a basic understanding of the natural and man-made forces that influence the Earth's climate.

Wednesday, January 15th: History and Science of Global Warming, Part 2

Today will be a continuation and conclusion of the lecture on global warming.

Required reading:

- U.S. National Research Council, *Climate Change: Evidence, Impacts, and Choices*. Washington, D.C.: National Academies Press, 2012. http://nas-sites.org/americasclimatechoices/files/2012/06/19014_cvtx_R1.pdf

Assignment 1 due:

- Go to the Assignments section of OWL-Space for Assignment 1: Introductory Exercise – Calculating Carbon Footprints. This exercise is intended to give you a chance to think about global warming from the perspective of your own impact.

Blog Response, due at noon on 1/15:

- Please provide your brief feedback on today's reading, including any questions that you might have about the topic of climate change.

Monday, January 20th: MLK Holiday – No Class

Wednesday, January 22nd: An Introduction to Sustainability

Today's lecture will provide an overview of the concept of sustainability.

Required reading:

- Brown, Lester R. "On the Edge." In *World on the Edge: How to Prevent Environmental and Economic Collapse*, 3-18. New York: W.W. Norton & Company, 2011. http://www.earth-policy.org/images/uploads/book_files/wotebook.pdf
- Johnson, Richard R. and Andrea Larson. "An Overview of the Historical Context for Sustainable Business in the United States, 1960-2000." Charlottesville, VA: University of Virginia Darden School Foundation, 1999.

Required viewing:

- Dr. Albert A. Bartlett. “Arithmetic, Population, and Energy.” View all 8 parts of his lecture at http://www.youtube.com/view_play_list?p=6A1FD147A45EF50D
- William McDonough. “A Celebration of Abundance: Something Lived, Something Dreamed.” Stanford University, October 15, 2008. View the entire 1:11:56 lecture at: <http://www.youtube.com/watch?v=L0c-QUxVJcM>

Blog Response, due at noon on 1/22:

- How would Dr. Bartlett respond to McDonough, and vice versa? Also, please provide your general feedback and questions related to the entire set of assigned material. We encourage you to continue to reflect on your personal carbon footprint calculations in your response as you consider the arguments of other experts, such as those in today’s materials.

Monday, January 27th: Sustainability at Rice

We will discuss the history of Rice’s sustainability efforts and set the context for the class’s upcoming project work. Time permitting, we will also review the results of the carbon footprint exercise.

Required reading:

- Johnson, Richard R. and Elizabeth Long, “A Decade of Lessons from Connecting Campus Sustainability with the Classroom at Rice University.” *Teaching Sustainability: Perspectives from the Humanities and Social Sciences*, Stephen F. Austin University Press, 2014.
- Orr, David. “What is Education for?” *In Context* #27 (Winter 1991): 52-55. <http://www.context.org/ICLIB/IC27/Orr.htm>

Blog Response, due by noon on 1/27:

- What is your reaction to Dr. Orr’s essay? In your response, consider how some experts from previous assignments – Bartlett, Brown, McDonough – would respond to Orr, and vice versa. Finally, given that the readings suggest/promote a view of hands-on (experiential) learning about sustainability that is campus-focused, feel free to share any past experiences or observations that you might have about this approach to education.

Optional Resource:

- Consider “liking” the Sustainability at Rice University Facebook page, which is a source for news, event announcements, and general information about Rice’s sustainability efforts.

Wednesday, January 29th: Quiz 1 + Project Introduction

Today’s class will start with a brief quiz to assess your understanding of global warming and sustainability. Please be on time – the quiz will start promptly at the beginning of class. Following the quiz, we will introduce the class group project and will assign project teams.

Monday, February 3rd: Green: The New Red, White, and Blue

We will view in class Thomas Friedman’s documentary “Green: The New Red, White, and Blue” about energy and climate change solutions. This DVD provides a glimpse of many of the subjects that

we will explore in this class, to which we will add a level of analysis and rigor that is at times lacking in Friedman's film.

Section 2: Non-Renewable Energy

Over the coming weeks, we will explore the primary fossil fuels that are used to provide energy in the United States: oil, coal, and natural gas. In these discussions we will cover such topics as the history of the resource's development, current extraction technologies, past and present resource production data, outlooks for future resource capacity, environmental impacts, and more.

Wednesday, February 5th: Energy and Sustainability

To set the stage for the upcoming series of lectures about our primary energy sources, students will be introduced to concepts and tools to help them to critically evaluate discussions about energy without necessarily being subject experts, including a general framework for understanding the impact of humans on the environment: the IPAT equation.

Required reading:

- *What You Need to Know About Energy*. Washington, D.C. National Academies Press, 2008. http://www.nap.edu/catalog.php?record_id=12204

Blog Response, due by noon on 2/5:

- Please provide your thoughts and questions about today's reading *What You Need to Know About Energy*, including any questions that you might have. Also provide your brief feedback on Thomas Friedman's documentary. Do you have specific comments about the solutions that he proposes? Considering your personal carbon footprint calculations from assignment 1, do you think the solutions highlighted in the documentary will be enough to solve the global warming challenge?

Monday, February 10th: Project team meetings

We will devote today's class to allowing project teams time to work as a group. The instructors will be available to each team to help guide their work. If needed, we will use the beginning of the class discussion to complete the lecture on energy and sustainability.

Wednesday, February 12th: The Energy Challenge – Petroleum, Part 1

We will discuss the past, present, and future of oil, as well as key terms and concepts necessary for understanding conversations about oil.

Required reading:

- Yergin, Daniel. *The Prize: The Epic Quest for Oil, Money, and Power*. Free Press. New York. 2009. Pp. xii-xvii.
- Margonelli, Lisa. *Oil on the Brain*. New York: Broadway Books, 2007. Pp. 1-65.

Blog Response, due by noon on 2/12:

- Please provide your thoughts and questions about today's assigned readings.

Monday, February 17th: The Energy Challenge – Petroleum, Part 2

We will continue our discussion about oil.

Required reading:

- Ise, John. *The United States Oil Policy*. New Haven: Yale University Press, 1926. Selected excerpts.
- Margonelli, Lisa. *Oil on the Brain*. New York: Broadway Books, 2007. Pp. 66-137

Blog Response, due by noon on 2/17:

- Please provide your thoughts and questions about today's assigned readings.

Wednesday, February 19th: Completion of Petroleum lecture, discussion of project progress

We will complete our discussion about oil. The remaining time will be granted to project teams to meet together and to ask questions of the instructors as needed.

Monday, February 24th: Quiz 2 + Project Team Meetings

Today's quiz will focus on the material covered since the first quiz. The remaining time is available to project teams to work together on their projects.

Wednesday, February 26th: Project Team Updates

The project teams will each provide an informal update of their project progress to the class.

Monday, March 3rd: No Class – Spring Break**Wednesday, March 5th: No Class – Spring Break****Monday, March 10th: The Energy Challenge – Natural Gas, Part 1**

We will discuss the past, present, and future of natural gas and will introduce key terms and concepts necessary for understanding discussions about natural gas.

Required reading:

- “The Future of Natural Gas,” An Interdisciplinary MIT Study, Chapter 1, 2011
http://web.mit.edu/mitei/research/studies/documents/natural-gas-2011/NaturalGas_Report.pdf
- “Drilling Down: Insiders Sound an Alarm Amid a Natural Gas Rush,” *The New York Times*, June 25, 2011, Sec. A:1.

Blog Response, due by noon on 3/10:

- Please provide your thoughts and questions about today's assigned readings.

Wednesday, March 12th: The Energy Challenge – Natural Gas, Part 2

We will complete our discussion about natural gas.

Monday, March 17th: The Energy Challenge – Coal, Part 1

We will discuss the past, present, and future of coal and will introduce key terms and concepts necessary for understanding discussions about coal.

Required Reading:

- Excerpts from “The Coal Question; An Inquiry Concerning the Progress of the Nation, and the Probable Exhaustion of Our Coal-Mines,” W. Stanley Jevons, McMillan, London, 1865.

Blog Response, due by noon on 3/17:

- Please provide your thoughts and questions about today’s assigned reading.

Wednesday, March 19th: The Energy Challenge – Coal, Part 2

We will complete our discussion about coal.

Required Reading:

- T.W. Patzek and G.D. Croft, “A global coal production forecast with multi-Hubbert cycle analysis,” *Energy*, 35 (2010) 3109-3122.

Blog Response, due by noon on 3/19:

- Please provide your thoughts and questions about today’s assigned readings.

Monday, March 24th: Quiz 3 + Project Team Work Session

Today’s quiz will focus on the material covered since the second quiz. The remaining time is available to project teams to work together on their projects.

Section 3: Evaluating Alternative Energy and Climate Change Solutions

The remainder of the class sessions will focus on *solutions*: energy solutions, climate change solutions, environmental solutions, or all of the above (they sometimes conflict!). We will carefully review and analyze each solution, applying tools and concepts from earlier in the class, to better understand the potential and pitfalls. Our discussions of solutions will be at global, national, regional, and campus scales.

Wednesday, March 26th: Potential Solutions – Carbon Capture and Sequestration

For the remainder of the course, we will turn our attention to a discussion and evaluation of energy and climate change solutions. Today’s lecture will focus on carbon capture and sequestration, including biochar.

Required reading:

- Socolow, Robert. “Can We Bury Global Warming?” *Scientific American*. July 2005.

- Socolow, Robert and Stephen Pacala. “A Plan to Keep Carbon in Check.” *Scientific American*. September 2006.

Blog Response, due by noon on 3/26:

- Please provide your thoughts and questions about today’s assigned readings.

Monday, March 31st: Potential Solutions – Biofuels, Part 1

We will discuss the past, present, and future of biofuels and will introduce key terms and concepts necessary for understanding discussions about biofuels.

Required Reading:

- Hugh Christopher Greenwell et al, “Biofuels, science, and society,” *Interface Focus*, 3 (2013).
- Dermot J. Roddy, “Biomass in a petrochemical world,” *Interface Focus*, 3 (2013).
- Patricia Thornley and Paul Gilbert, “Biofuels: balancing risks and rewards,” *Interface Focus*, 3 (2013).

Blog Response, due by noon on 3/31:

- Please provide your thoughts and questions about today’s assigned readings.

Wednesday, April 2nd: Potential Solutions – Biofuels, Part 2

We will complete our discussion about biofuels.

Required reading:

- *Biofuels: Ethical Issues*. London: Nuffield Council on Bioethics, April 2011 (Chapters 2, 3 and 6). <http://www.nuffieldbioethics.org/chapter-downloads>

Blog Response, due by noon on 4/2:

- Please provide your thoughts and questions about today’s assigned reading.

Monday, April 7th: Potential Solutions – Green Building and LEED

Buildings consume approximately 40% of all of the energy in the US. We will discuss approaches to green building and in particular the US Green Building Council’s Leadership in Energy and Environmental Design (LEED) program, using examples from Rice and beyond to illustrate key concepts.

Required reading:

- Fowler, Kim et al. “Re-Assessing Green Building Performance: A Post Occupancy Evaluation of 22 GCA Buildings,” Pacific Northwest National Laboratory, September 2011. http://www.pnl.gov/main/publications/external/technical_reports/PNNL-19369.pdf

Blog Response, due by noon on 4/7:

- Please provide your thoughts and questions about today’s assigned reading.

Wednesday, April 9th: Mitigating Carbon Emissions

Today's lecture will explore a variety of topics, from dematerialization to Environmental Kuznets Curves to solutions for reducing emissions from transportation fuels and electric power generation.

Monday, April 14th: Potential Solutions: Student Group Lectures

2-3 student groups will provide mini-lectures on alternative energy sources. Please be prepared that today's class could run late. Alert the instructors if you need to leave right at 4:15.

Wednesday, April 16th: Potential Solutions: Student Group Lectures

2-3 student groups will provide mini-lectures on alternative energy sources. Please be prepared that today's class could run late. Alert the instructors if you need to leave right at 4:15.

Monday, April 21st: Group Project Final Presentations, Day 1

The group project teams will give their final presentations to the class.

Wednesday, April 23rd: Group Project Final Presentations, Day 2

The group project teams will give their final presentations to the class.

Friday, April 25th: Deadline

Group Project Final Papers are due by 5PM. The papers and all related spreadsheets must be submitted via OWL-Space.

Self and Team Member Evaluations are due by midnight, and must be submitted via OWL-Space. These evaluations will help the instructors to assess each individual's performance on the group project. Students may not consult with one another in completing the evaluations.

The final will be due on the last day of exams.

Grading

We anticipate using the following percentages to determine your final grade:

- Blog Responses, Class Participation, and completion of Assignment 1: 10%
- Quizzes: 15% total (5% each)
- Group Lecture: 20%
- Group Project: 25%
- Final exam: 30%

Attendance and Participation: We will track attendance and class participation, and we reserve the right to adjust your grade based on attendance and class participation. In particular, we reserve the right to adjust your participation grade if you are found to be using your laptop or other electronic devices to

engage in web-surfing, texting, social networking, etc. that is unrelated to the class. If you anticipate missing a class, please send advanced notice to both instructors. Otherwise, we expect you to be present for and engaged with all classes.

We also reserve the right to change the weighting of how grades are calculated, as well as the number of assignments, and even whether a final is distributed. This is a dynamic and deliberately flexible syllabus, subject to change.

Please be advised that this class relies heavily upon your ability to work on a project team. As such, your performance may impact the grades of others. We reserve the right to adjust your grade on any group assignment to reflect your actual level of contribution and participation, whether positive or negative.

Any student with a documented disability needing academic adjustments or accommodations is requested to contact the instructors during the first two weeks of class. All discussions will remain confidential. Students with disabilities should also contact Disability Support Services in the Ley Student Center.

Contacts

Kyriacos Zygorakis, kyzy@rice.edu, x5208

Richard Johnson, rj@rice.edu, x5003