August 31 2012

**Energy and Environmental Analysis**

Instructor: Valerie Thomas. Office: 415 Groseclose

Students learn core concepts and methods to analyze energy and environmental impacts of industrial systems and product lifecycles including production, transport, use, and end-of-life. Part 1 will focus on energy and environmental fundamentals. Part 2 will focus on analysis methods, using the fundamentals from Part 1.

**Part 1:**

Energy: Energy calculations for mass, fuel energy value, electricity generation, energy efficiency, and applying energy knowledge to calculate energy resources and constraints.

Water: Water mass balances, water needed for electricity generation; combined energy/water analysis for industrial systems.

Greenhouse Gas Emissions: Greenhouse gas accounting, global warming potential calculations, and greenhouse gas emission inventories.

Transportation Energy: Energy use by transport mode. Supply chain energy use and environmental impacts.

One more environmental topic: For 2012: *Air Pollution*: Health impact and monetized health costs of air pollutant emissions, including particulates, sulfur, nitrogen oxides, tropospheric ozone, and carbon monoxide.

**Part 2:**

Environmental Lifecycle Assessment (LCA) – Green supply chains. Lifecycle environmental impact including production, distribution, use, and recycling or disposal.

Environmental Risk Analysis – Risks of air pollutants from energy generation and use; contrast of risk-type calculations (location specific fate and transport modeling) with LCA-type (not localized) calculations.

Economic Approaches to Environmental Management. Cost-benefit analysis of air pollution reduction. Supply curves for global greenhouse gas reduction measures. Environmental externalities, Pigouvian taxes, market mechanisms for environmental protection, and tradable permits markets.

Material flow accounting and industrial ecology – Global and national materials use, waste as raw materials.

Resource constraints and availability – Fossil fuels, water, solar energy, biomass potential, food production; calculations with population, technology, consumption and emissions.

**Class Requirements:**

August 31 2012

Participation – 10%  Homework – 20%
Midterm 1 – 15%  Midterm 2 – 15%
Projects – 20%  Final Exam – 20%

**Text and readings**: Lecture notes will be posted, supplemented by journal articles.

**References:**
Consider a Spherical Cow: Adventures in Environmental Problem Solving, John Harte, 1988.
Consider a Cylindrical Cow: More Adventures in Environmental Problem Solving, John Harte, 2001.
Should We Risk It? Exploring Environmental, Health, and Technological Problem Solving. Kammen and Hasenzahl, 2001.
The Physics of Societal Issues: Calculations on National Security, Environment, and Energy, David Hafemeister, 2007.

**Outcomes:** At the end of the course, students will be able to:

- Develop, solve, and evaluate quantitative models of the relationship of technology, environment, and the economy;
- Evaluate lifecycle environmental impacts of a product or service;
- Use basic knowledge of human population, US and world economy, energy systems, water, and key environmental impacts to scope and develop environmental assessments

| **Course outcome \ Program Outcomes** | **a. apply math** | **b. data** | **c. IE method** | **d. team** | **e. problem solving** | **f. prof/ and ethical responsibilities** | **g. communication** | **h. global, eco, envi and soc context** | **i. continue to improve** | **j. current issues** | **k. participate in an organization** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Develop, solve, and evaluate quantitative models of the relationship of technology, environment, and the economy. | H | H | M | | M | M | | H | | H | |
| Evaluate lifecycle environmental impacts of a product or service; | M | H | H | | M | M | L | H | M | H | |
| Use basic knowledge to scope and develop environmental assessments | H | M | M | | H | M | H | H | | H | |
| Small group project | H | H | M | H | H | M | H | H | | H | H |

August 31 2012

**Schedule**

Week 1. August 20, 22. **Overview** – Earth System

Week 2. August 27, 29. **Energy.** Energy calculations for mass, fuel energy value, electricity generation, energy efficiency, and applying energy knowledge to calculate energy resources and constraints.
August 27. Guest speaker. David Spitzley, Kimberly-Clark, Global Sustainability.

Week 3. September 5. (No class September 3; Labor Day). **Water.** Water mass balances, water needed for electricity generation; combined energy/water analysis for industrial systems.

Week 4. September 10, 12. **Air Pollution.** Health impact and monetized health costs of air pollutant emissions, including particulates, sulfur, nitrogen oxides, tropospheric ozone, and carbon monoxide.

Week 5. September 17, 19. **Greenhouse Gas Emissions.** Greenhouse gas accounting, global warming potential calculations, and greenhouse gas emission inventories.

Week 6. September 24, 26. **Transportation Energy.** Energy use by transport mode. Supply chain energy use and environmental impacts.

Week 7. October 1 **Midterm 1**.
October 3: Guest Lecture. Ben Jordan, Director, Supplier Sustainability, Global Sustainable Procurement, The Coca-Cola Company

**Part II. Analysis**

Week 8. October 8, 10. **Life Cycle Assessment (LCA)**
LCA development using fundamental science and engineering to derive lifecycle energy, water, and greenhouse gas emissions profiles for products and supply chains.

Week 9. October 15. Fall Break, no class.
October 17. Guest speaker. Steve Leffin, UPS (date will probably change)

Week 10. October 22, 24.
**Sustainability in Industry and Business.**
Metrics of sustainability. Metrics of social impact.
**Risk Analysis:** Air pollutant health impact data, emission data, exposure data, and statistical analysis for monetization of risk.

Week 11. October 29, 31. **Economic Approaches to Reducing Environmental Impacts.**
**Midterm 2.**
• Standard cost benefit analysis

• Energy and greenhouse gas reduction supply curves
• Monetization of environmental externalities including health impacts.
• Pigouvian taxes, market mechanisms, and tradable permits.

Week 12. November 5,7. **Resource Constraints**
Material flow analysis, box models, environmental residence times.
• Resources, Population and Environment: An Oversupply of False Bad News. J. Simon, *Science* 208, 1431-1437, 1980.
• Betting the Planet. J. Tierney. *New York Times*, 1990.

Week 13. November 12, 14. **Project Presentations**

Week 14. November 19, 21. **Supply Chain Environmental Impacts.**

Week 15. November 26, 28. **Modeling Environmental Constraints** (Project Due)
Modeling the relation of technology, costs, and earth system constraints.
Forrester Limits to Growth approach v. Nordhaus Cobb-Douglas approach.

Week 16. December 3, 5. **Extensions and Review**