REM 658 – Energy and Materials System Modeling

School of Resource and Environmental Management
Simon Fraser University

SPRING 2012
Syllabus Updated: January 3, 2011

Instructor:
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Class:
Wednesday: 5:30-9:20pm
Location: HCC 3122 **SFU Harbour Centre**

https://sites.google.com/site/rem658spring2012/

"All models are wrong. Some are more useful" – G. Box

This course is open to graduate students and professionals who seek a better understanding of energy and materials modeling for sustainability.

Prerequisites: Because the course is taught from a basic level, a strong quantitative background is not required to do well in this course. There are no course prerequisites, but approval of the instructor is required.

Course Objectives:

1. To gain familiarity with the major types of models being used to design and assess sustainability-oriented policy. We emphasize models that explore energy and/or material flows within energy and economic systems.
2. To gain a preliminary understanding of key principles of model design and practical issues in application, including representations of technology, behavior, economic feedbacks and policy.
3. To be able to assess the strengths and weaknesses of these models and their relative usefulness for different policy objectives.

The goal is for students to understand the foundational principles of sustainable energy modeling, and develop the ability to apply models to real-world problems regarding the environment, sustainability and public policy.

Course Evaluation

The course grade will be determined as follows:

1. **Participation (10%):** Attendance and participation in discussions and activities.
2. **Lab assignments (40%)**: Excel-based assignments that give students hands on experience with models, including optimization/linear-programming (LP) modeling, basic econometrics, hybrid simulation modeling (CIMS) and lifecycle analysis (LCA).
3. **Mid-term exam (15%):** Testing foundational course concepts and applications.
4. **Modeling project (35%)**: A student-selected project exploring one modeling methodology in-depth. This project can be used to help advance the student's thesis project.
    - In-class presentation (10%)
    - Term Paper (25%)

Class Format

The course involves a mix of **lectures**, **seminars** and **labs**. In seminars, students are expected to play an active role in understanding and discussing the various modeling techniques and their appropriateness for different policy and research objectives. Students will gain hands-on experience by applying modeling tools to simplified problems in labs and assignments. The course sections correspond to the main modeling topics that will be covered, although there is room for some alteration depending on the preferences and expertise of students in a particular year.

Below is a draft of the schedule (will be finalized after Week 1):

Week (Date)	Topics	Readings	Lab/ Assignment	Notes
1 Jan 11	• Epistemology • Overview of sustainable energy models	Oreskes (2003) Watt (1997) Jaccard (2002) IPCC (2001)		
2 Jan 18	• Optimization / Linear Programing (LP) • Introduction to risk and uncertainty	Chinneck (2001) Markal Jaccard (2002) ETSAP (1996)	LP Lab LP assign	
3 Jan 25	**Jonn in DC**		LP Due	
4 Feb 1	• Input-Output (IO) models • Risk & uncertainty (con't)	Pearce (1994) Armstrong (1988) Wiedmann (2009) Anderson (1998)	IO lab	
5 Feb 8	• Basic econometrics and statistics • Risk & uncertainty (con't)	Wonnacot (1985) Economist (1987) Loughran (2004)	Econ lab Econ assign	
6 Feb 15	**SFU Reading Break**		Econ due	
7 Feb 22	• Modeling induced technological change • Comparing models	Loschel (2002) McDonald (2001) Mundaca (2011)		**Guest: Mark Jaccard**
8 Feb 29	• Computable general equilibrium (CGE) models	Bergman (2003) Rivers-Prod (2009) Rivers-CGE (2010) Sterman (2003)	CGE lab	Paper proposal
9 Mar 7	• Hybrid simulation models • CIMS	Jaccard (2009) Wolinetz (2009)	CIMS lab CIMS assign	**Guest: Cam Matheson**
10 Mar 14	• **Midterm exam** • Integrated assessment models	Nordhaus (1992) Rivers (2005)		
11 Mar 21	• Representing technology • Lifecycle-analysis (LCA)	Axsen (2011) Gleick (2007) Farrel (2006)	LCA lab LCA assign	Student Pres.
12 Mar 28	• Models of consumer behavior • Discrete Choice Modeling (DCM)	Jackson (2005) Potoglou (2007) Thaler (2000)	DCM lab	Student Pres.
13 Apr 4	• Collecting empirical data: surveys, interviews, and secondary sources	Schaeffer (2003) Krosnick (1999)		Student Pres.
14 Apr 11	• Special topics: e.g. Transportation and/or agent-based modeling	TBD		Paper due

Readings: available on the EMRG website: https://sites.google.com/site/rem658spring2012/

Detailed Outline:

Week 1: Introduction to Energy Models

A: Modeling and Human Knowledge: possibilities and limitations

- Oreskes (2003). The role of quantitative models in science, in *The Role of Models in Ecosystem Science,* edited by Canham, Cole, and Lauenroth (Princeton: Princeton University Press).
- Watt (1977). Why won't anyone believe us? *Simulation*, 28:1.

B: Schema of Model Types: current model types and where are we headed?

- Jaccard (2002). Energy planning and management: Methodologies and tools, *Encyclopedia of Life Support Systems,* (New York: Elsevier).
- IPCC (2004). Modeling and cost assessment, (http://www.grida.no/climate/ipcc_tar/wg3/309.htm)

Optional/Reference:

- McGinn (2002). Looking for a black swan, *New York Review of Books*, Nov.21, 2002
- Kemfert and Truong (2009). Energy-economy-environment modeling: a survey, In Evans and Hunt (eds.) *International Handbook on the Economics of Energy*.
- Menand (2005). Everybody's an expert, *The New Yorker*, December 5, 2005.

Week 2: Optimization Methods (LP Lab)

A: Linear programming: objective functions, constraints, solutions and interpretation.

- Chinneck, J. (2001). Chapter 2: Introduction to Linear Programming, in *Practical Optimization: A Gentle Introduction*. Carleton University. http://www.sce.carleton.ca/faculty/chinneck/po.html
- The MARKAL Model – short text reading.
- Jaccard, Loulou et al (2003). Methodological contrasts in costing greenhouse gas abatement policies: optimization and simulation modeling of micro-economic effects in Canada. *European Journal of Operational Research*.

B: Introduction to risk and uncertainty

- ETSAP News (1996). Uncertainty: Talking the talk, *ETSAP*.

Lab: LP application
Assignment: LP assignment, due January 25 (10 marks).

Optional/Reference:

- Grubler, and Messner (1998). Technological change and timing of mitigation measures, *Energy Economics,* 20, 495-512.
- Messner and Strubegger (1995). *Model-Based Decision Support in Energy Planning*, Working Papre, WP-95-119, IIASA.

- Borba, Szklo and Schaeffer (2012). Plug-in hybrid electric vehicles as a way to maximize the integration of variable renewable energy in power systmes: The case of wind generation in northeastern Brazil, *Energy*, 37, 469-481.

Week 3: NO CLASS

Week 4: Input-Output (IO) Models (IO Lab)

A: Input-Output Modeling: Understanding of fixed coefficient models linking inputs to outputs and their application to environmental sustainability policy analysis.

- Pearce and Turner (1994). *Environmental Economics*, chapter 2.
- Armstrong and Taylor (1988). *Regional Economics and Policy*, chapter 2.
- Wiedmann (2009). A review of recent multi-region input-output models used for consumption-based emission and resource accounting, *Ecological Economics*, 69, 211-222.

B: Addressing Risk and Uncertainty: What are the options for addressing uncertainty?

- Anderson (1998). Enhancing Communication About Uncertainty, B.C. Ministry of Forests, July 1998.

Lab: I-O application

Optional/Reference:

- Wu and Chen (1990). On the application of input-output analysis to energy issues, *Energy Economics*, 12(1), 71.
- Tarancon and Rio (2012). Assessing energy-related CO2 emissions with sensitivity analysis and input-output techniques, *Energy*, 37, 161-170.
- Hawdon and Pearson (1995). Input-output simulations of energy, environment, economy interactions in the U.K., *Energy Economics*, 17(1), 73-86.

Week 5: Basic Econometrics and Statistics (Econ Lab)

Techniques of linear regression with application to electric utility demand-side management (DSM) programs.

- Wonnacott and Wonnacott (1985). *Econometrics*, Chapter 1.
- Economist (1987). Economics brief: The art of crunching numbers, *Economist*.
- Loughran and Kulick (2004). Demand-side management and energy efficiency in the United States. *The Energy Journal*.

Lab: Econometrics application
Assignment: Econometrics assignment, due February 15 (10 marks).

Optional/Reference:

- Rivers and Jaccard (2011). Electric utility demand side management in Canada, *The Energy Journal*, 32(4), 95-118.

Week 6: READING BREAK (NO CLASS)

Week 7: Modeling Induced Technology Change (Guest: Dr. Mark Jaccard)

Key issues and model designs for estimating the impacts and costs of policies to induce technological change, especially for environmental objectives.

- Loschel (2002). Technological change in economic models of environmental policy: a survey, *Ecological Economics*.
- McDonald and Schrattenholzer (2001). Learning rates for energy technologies. *Energy Policy*.
- Mundaca et al. (2011). Evaluating energy efficiency policies with energy-economy models, *Annual Review of Environment and Resources*, 35, 305-44.

Optional/Reference:

- Nakata (2011). Application of energy system models for designing a low-carbon society, *Energy and Combustion Science*, 37, 462-502.

Week 8: Computable General Equilibrium Models (CGE Lab)

Design and application of computable general equilibrium models.

- Bergman and Henrekson (2003). CGE modeling of environmental policy and resource management. *Stockholm School of Economics*. http://www.ictp.trieste.it/~eee/workshops/smr1533/Bergman%20-%20Handbook-1.doc
- Rivers (2009). *Primer on production functions*.
- Rivers (2010). *A Simple CGE Model in Excel*.
- Sterman (2002). All models are wrong: Reflections on becoming a systems scientist, *System Dynamics Review,* 18(4), 501-531.

Lab: CGE application
Assignment: Paper Proposal Due

Week 9: Hybrid Simulation Models (CIMS Lab)

Design and application of models that combine technological, behavioural and macro-economic representations for simulating policies to induce long-run technological change.

- Jaccard (2009). Combining top down and bottom up in energy economy models. In Evans and Hunt (eds), *International Handbook on the Economics of Energy*.
- Wolinetz (2009). *CIMS User Guide*.

Lab: CIMS application
Assignment: CIMS assignment, due March 11 (10 marks).

Optional/Reference:

- Beugin and Jaccard (2011). Statistical simulation to estimate uncertain behavioural parameters of hybrid energy-economy models, *Environmental Modeling & Assessment*, 14(2).

Week 10: Integrated Assessment Models (Midterm Exam)

Models that combine economic systems with natural systems, especially as applied to climate policy analysis.

- Nordhaus (1992). An optimal transition path for controlling greenhouse gases. *Science*.
- Rivers (2005). *Summary of DICE model*.

Optional/Reference:

- Nordhaus (2009). The impact of treaty nonparticipation on the costs of slowing global warming, *The Energy Journal*, 30(2), 39-52.

Week 11: Representing Technology and Lifecycle Analysis (LCA Lab)

Explore how technology is represented in sustainable energy models. We look in depth at one technology-focused approach: lifecycle analysis.

- Axsen, Kurani, McCarthy and Yang (2011). Plug-in hybrid vehicle GHG impacts in California: Integrating consumer-informed recharge profiles with an electricity-dispatch model, *Energy Policy*, 39(3), 1617-1629.
- Gleick (2007). Hummer versus Prius: "Dust to Dust" Report Misleads the Media and Public with Bad Science, *Pacific Institute*.
- Farrell et al. (2006), Ethanol can contribute to Energy and Environmental Goals, *Science*, 311, p507.

Lab: LCA application
Assignment: LCA assignment, due: March 26 (pass/fail).

Optional/Reference:

- Samaras and Meisterling (2008). Life cycle assessment of greenhouse gas emissions from plug-in hybrid vehicles: Implications for policy*, Environmental Science and Technology*, 42, 3170-3176.

Week 12: Models of Consumer Behaviour and Discrete Choice (DCM Lab)

Compare and assess the different models of consumer behaviour, and explore discrete-choice modelling in more depth.

- Jackson (2005). *Motivating Sustainable Consumption: A Review of Evidence on Consumer Behaviour and Behavioural Change*, Sustainable Development Research Network.
- Potoglou and Kanaroglou (2007). Household demand and willingness to pay for clean vehicles, *Transportation Research Part D*, 264-274.
- Thaler (2000). From homo economicus to homo sapiens, *Journal of Economic Perspectives,* Winter:133-141.

Lab: DCM modelling

Optional/Reference:

- Moxnes (2004). Estimating customer utility of energy efficiency standards for refrigerators, *Journal of Economic Psychology*, 25, 707-724.
- Axsen, Mountain and Jaccard (2009). Combining stated and revealed choice research to simulate the neighbour effect: The case of hybrid-electric vehicles*, Resource and Energy Economics*, 31, 221-238.
- Turrentine and Kurani (2007). Car buyers and fuel economy? *Energy Policy*, 35, 1213-1223.

Week 13: Collecting Empirical Data: Surveys, Interviews, Secondary Sources

Design of surveys and interviews to collect energy and sustainability-related data, as well as collection of secondary data.

- Schaeffer and Presser (2003). The science of asking questions, *Annual Review of Sociology*, 29, 65-88.
- Krosnick (1999). Survey research, *Annual Review of Psychology*, 50, 537-67.

Week 14: Special Topics (Term Paper Due)

Specific topic(s) to be determined. Potential topics include:

- Agent-based modelling
- Transportation modelling
- Diffusion modelling