

**FALL 2008**

**ENVR SCI 203: ENERGY AND THE ENVIRONMENT: THE AUTOMOBILE**

MWF 1-1:50 pm, Tech L211  
T 12:30-1:50 pm, Ford ITW Classroom

**PROFESSOR KIMBERLY GRAY**

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**COURSE DESCRIPTION:**

Envr Sci 203 uses the example of the automobile to provide students with an **integrated** study of fundamental chemistry (thermodynamics, atmospheric chemistry, free radical mechanisms of reaction, catalysis), industrial production, energy use, and public policy from an environmental perspective. The course begins with a review of the fundamentals of energy, and moves on to an explanation of how the internal combustion engine works. The history and innovations, as well as the social and economic consequences, associated with automobile manufacturing are covered. The use of life cycle assessment to evaluate comprehensively the environmental costs associated with automobile manufacturing and use is explained. The efficiency and feasibility of various fuels, ranging from gasoline to diesel to hydrogen, and fuel additives are compared. The automobile's impacts to land, water and air are evaluated. The way in which the catalytic converter reduces the effects of exhaust emission on air quality is explained. Finally, strategies and policy approaches to lessen the impacts of the automobile, especially as it relates to CO<sub>2</sub> emissions, fuel efficiency, renewable fuels, sustainable transportation systems and alternative technologies, are discussed. Students are evaluated by homeworks, quizzes, a final project and participation.

**PREREQUISITES:**

- MATH 214-2 or equivalent, CHEM 103 or CHEM 172 or equivalent.

**OFFICE HOURS:**

- M, W 2-3 pm or by appointment (Gray)
- F 3:30-4:30 or by appointment (Zanella)

**TIME:**

- Class meets MWF (50 minute class period) 1-1:50 pm; A review session will be held on Tues., 12:30-1:50 pm.

**OBJECTIVES:**

- Review/learn basic chemical concepts (energy balance, combustion, atmospheric chemistry of NO<sub>x</sub> and CO<sub>2</sub>, catalysis) within an environmental context as developed through the example of automobile use.
- Analyze energy sources, supply, alternatives and consequences related to the automobile.
- Evaluate the cascading impacts on human and ecological systems, both positive and negative, of the many innovations associated with automobile technology and manufacturing.

- Consider ways to lessen impacts and enhance sustainability of automobile (life cycle analysis, public policy, feasibility of alternative energy sources and modes of transportation).
- Develop a conceptual design for a sustainable automobile or transportation system by working in an interdisciplinary team.
- Reinforce/integrate learning by drawing connections to other courses in curriculum (particularly the Envr. Sci. 201-203 sequence) - contributor to CO<sub>2</sub> build-up and climate change, habitat loss, landscape changes, settlement patterns, energy use (manufacture and operation).

**OUTCOMES\*** - Upon successful completion of this course, students have:

- an ability to apply knowledge of mathematics, science, and engineering (including chemistry, physics, earth science, biological science, and fluid mechanics) (ABET a)
- an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability (ABET c)
- an ability to function on multi-disciplinary teams (ABET d)
- an ability to identify, formulate, and solve engineering problems (ABET e)
- an understanding of professional and ethical responsibility (ABET f)
- an ability to communicate effectively (ABET g)
- the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental and social context (ABET h)
- a recognition of the need for, and an ability to engage in life-long learning (ABET i)
- a knowledge of contemporary issues (ABET j)

**TEXT:**

- Course packet of selected readings (Quartet Copying, 825 N. Clark Evanston, IL, 60201, Phone: 847 328-0720 – **CALL FIRST**)

**EVALUATION:**

- 7 homework assignments (problems, short answer, short position papers) (25%)
- Two quizzes (20%)
- Group project that will involve a conceptual design of a sustainable automobile or transportation system (35%; 15% instructor evaluation, 20% peer evaluation).
- Participation – Class attendance, discussion, presentations (20%)

\* OUTCOMES correspond to Environmental Engineering Outcomes which are adopted from the ABET “(a)-(k)”.

**SCHEDULE OF LECTURES:**

**Week 1-2: Energy, Chemistry & Society (Sept 24- Oct. 10<sup>th</sup>)**

Topics: Fundamentals of Energy – First and Second Laws of Thermodynamics; Mass & Energy Transfer; Energy Supply & Demand – United States and Global; Hubbert Curve; Energy Units & Efficiency; Internal Combustion Engine - Otto Cycle, Two-stroke, Diesel Engines

Reading: J.M. Diamond (2004) “Lessons from Environmental Collapses of Past Societies” (pdf on Blackboard)  
James Hansen (2008) “Global Warming Twenty Years Later: Tipping Points Near,” June 23, 2008 testimony to Congress. (pdf on Blackboard)

G. Chazan (2007) "In Caspian, Big Oil Fights Ice, Lethal Fumes – and Kazakhs," *Wall Street Journal*, 08/28/07. (pdf on Blackboard)

[http://www.rigzone.com/news/article.asp?a\\_id=49533](http://www.rigzone.com/news/article.asp?a_id=49533)

R. Gold & A. Davis (2007) "Oil Officials See Limit Looming on Production," *Wall Street Journal*, 11/19/07. (pdf on Blackboard)

[http://www.rigzone.com/news/article.asp?a\\_id=53040](http://www.rigzone.com/news/article.asp?a_id=53040)

**Oct. 3<sup>rd</sup> - Homework 1** (Short position paper on Diamond, Hansen, & WSJ articles – There is no shortage of oil. . .)

Reading: R. L. Hirsch, R. Bezdek, R. Wendling (2007) "Peaking of World Oil Production and Its Mitigation," in **Driving Climate Change**, C. Spering & J.S. Cannon, eds. (Academic Press, NY), Chapter 2, p. 9-27. (course packet)

*Chapter 1 Mass & Energy Transfer-* Introduction to Environmental Science and Engineering, 3<sup>rd</sup> Edition (G.M. Masters, Prentice Hall, 2008). (course packet)

*Chapter 4 Energy, Chemistry & Society-* Chemistry in Context: Applying Chemistry to Society, 4<sup>th</sup> Edition (McGraw Hill, 2004). (course packet)

<http://auto.howstuffworks.com/engine.htm>

**Oct. 10<sup>th</sup> - Homework 2** (problems)

**Week 3-4: Manufacturing (Oct. 13<sup>th</sup> - 24<sup>th</sup>)**

Topics: History of automobile, production, assembly lines, materials, residuals, lean manufacturing, recycling, life cycle assessment

Reading: R. Morales (1992). "Place and Auto Manufacture in the Post-Fordist Era." In **The Car and The City** (The University of Michigan Press) p. 204-221. (course pack)

F. Thompson, "Fordism, post-Fordism and the flexible system of production," (course pack) ([http://www.willamette.edu/~fthomps/MgmtCon/Fordism\\_&\\_Postfordism.html](http://www.willamette.edu/~fthomps/MgmtCon/Fordism_&_Postfordism.html))

T.E. Graedel, B.R. Allenby (1998). **Industrial Ecology and the Automobile**. (Prentice Hall) Chap. 2,4,7,11,12. (course pack)

**Oct. 17<sup>th</sup> & 20<sup>th</sup> – Project Progress Reports (oral & written)**

**Oct. 24<sup>th</sup> - Homework 3 (Film Review)**

**Oct. 28<sup>th</sup> – Homework 4 (Short answers + problems)**

**Week 5: Conventional Fuels & Additives (Oct. 27<sup>th</sup> – Oct. 31<sup>st</sup>)**

Topics: Fossil fuels - Carbon cycle, extraction and refining; Gasoline, diesel, & additives (oxygenates)

Reading: <http://www.eia.doe.gov/neic/brochure/gas04/gasoline.htm>

[http://www.eia.doe.gov/pub/oil\\_gas/petroleum/presentations/2004/ustrans/index.html](http://www.eia.doe.gov/pub/oil_gas/petroleum/presentations/2004/ustrans/index.html)

Salopek, Paul. A tankful of gas, a world of trouble, **The Chicago Tribune**, July 29, 2006 (pdf on Blackboard).

Kitman, Jamie Lincoln (2000) The Secret History of Lead, **The Nation**, March 20, p. 11-43.

**Nov. 4<sup>th</sup> – Quiz 1**

**Nov. 10<sup>th</sup> – Homework 5** – (Critique of Secret History of Pb)

**Week 6: Impacts – Air (Nov. 3<sup>rd</sup> – Nov. 7<sup>th</sup>)**

Topics: Tropospheric Chemistry of Smog – NO<sub>x</sub> photochemistry and ozone; Hydroxyl Radical - oxidation of hydrocarbons; Other pollutants – e.g., particles

Reading: *Chapter 7 Air Pollution* - Introduction to Environmental Science and Engineering, 3<sup>rd</sup> Edition (G.M. Masters, Prentice Hall, 2008) (course packet)

**Week 6-7: Control of Impacts (Nov. 7<sup>th</sup> & Nov. 11<sup>th</sup>)**

Topics: Clean Air Act, Catalytic converters

Reading: G.R. Lester (1983) *The Development of Automotive Exhaust Catalysts* (American Chemical Society).

<http://auto.howstuffworks.com/catalytic-converter.htm>

[www.epa.gov/air/transport.html](http://www.epa.gov/air/transport.html)

[www.epa.gov/air/nonroad.html](http://www.epa.gov/air/nonroad.html)

**Week 7: Impacts – Climate Change (Nov. 10<sup>th</sup>-14<sup>th</sup>)**

Topics: CO<sub>2</sub>; Climate Change

Reading: *Chapter 8 Global Atmospheric Change* - Introduction to Environmental Science and Engineering, 3<sup>rd</sup> Edition (G.M. Masters, Prentice Hall, 2008). (course packet)

G.F. Will (2007). "Inconvenient Kyoto Truths," *Newsweek*, 02/12/07. (course packet)

The Climate of Man – Elizabeth Kolbert, 3 part series on global climate change, from *New Yorker*, April, 2005 (pdf on Blackboard).

J. Broome (2008) "The Ethics of Climate Change," *Scientific American*, 298:6:97-102.

**Nov. 18<sup>th</sup> – Homework 6** (Problems/short answer).

**Week 8-9: Impacts – Land-use and Patterns of Travel (Nov. 17-21<sup>th</sup>)**

Topics: Demographics, auto dominance, consequences, rational basis of choice, social marketing, underpriced use of automobile, smart growth.

Reading: A.P. Bandivadekar & J.B. Heywood (2007) "Coordinated Policy Measures for Reducing the Fuel Use of the U.S. Light-Duty Vehicle Fleet," in **Driving Climate Change**, C. Sperling & J.S. Cannon, eds. (Academic Press, NY), Chapter 4, p. 41-70. (course packet)

D. M. Reiner (2007) "From Public Understanding to Public Policy: Public Views on Energy, Technology, and Climate Science in the United States," in **Driving Climate Change**, C. Sperling & J.S. Cannon, eds. (Academic Press, NY), Chapter 12, p. 201-216. (course packet)

S.M. Wheeler & T. Beatley (2004). **The Sustainable Urban Development Reader** (Routledge, NY); "The Next American Metropolis," (Peter Calthorpe, 1993); "Urban Planning in Curitiba," (J. Rabinovitch & J. Leitman); "Planning for Sustainability in European Cities: A Review of Practices in Leading Cities," (2003) (T. Beatley). (course packet)

J.H. Kunstler (1993). **The Geography of Nowhere** (Simon & Schuster, NY), Ch. 11 (Three Cities) 189-216). (course packet)

Video – Urban Sprawl

**Nov. 25<sup>th</sup> – Quiz 2**

**Week 9 & 10:** Alternatives – Fuel & Vehicles (Nov. 24<sup>th</sup> - Dec. 3<sup>th</sup>)

Topics: Biofuels, hydrogen/fuel cells, natural gas; electric cars/batteries, hybrid technology.

- Reading: J. Andrews & N. Jelley (2007) **Energy Science** (Oxford University Press, NY), Chap. 8 (Biomass). (course packet)  
A.E. Garrell, R.J. Plevin, B.T. Turner, A.D. Jones, M. O’Hare, D.M. Kammen (2006), Ethanol can contribute to energy and environmental goals, *Science*, 311:506-508. (course packet)  
J.L. Schnoor (2006). Biofuels and the environment. *Environmental Science and Technology*, 40(13) 4042. (course packet)  
J.P.W. Scharlemann & W.F. Laurance (2008) “How Green Are Biofuels?” *Science*, 319:43-44. (course packet)  
R. Zah et al. (2007) “Life Cycle Assessment of Energy Products: Environmental Impact Assessment of Biofuels,” Executive Summary of Swiss Report. (course packet).  
R. Dominguez-Faus, S. E. Powers, J.G. Burken, P.J. Alvarez (2008) “The Water Footprint of Biofuels: A Drink or Drive Issue?” Draft, *Environmental Science & Technology*, in review.  
Energy Independence and Security Act of 2007: A Summary of Major Provisions; CRS Report for Congress. (pdf on Blackboard).  
M.L. Wald (2005) Questions about a hydrogen economy. *Scientific American*, 290 (5):66-73. (course pack)  
P. Hawken, A. Lovins, L.H. Lovins (1999). “Reinventing the Wheels: Hypercars and the Neighborhood,” in **Natural Capitalism** (Little, Brown and Company) p. 22-47. (course pack)  
C. Thompson (2007) “Motorhead Messiah,” *FastCompany*, 11/07, 74-83. (pdf on Blackboard)

**Dec. 3<sup>rd</sup> – Homework 7–** (Short answer and problems)

**Dec. 5<sup>th</sup>** - Final Project Presentation

**Dec. 8<sup>th</sup>** - Final Project Presentation (7-9 pm)

**SCHEDULE**

<b>Sept. 24 - W</b>	<b>Introduction</b>
<b>Sept. 26 – M</b>	<b>Energy</b>
<b>Sept. 29– M</b>	<b>Energy</b>
<b>Sept. 30– T</b>	<b>Groups/Projects; Discuss Readings</b>
<b>Oct. 1 – W</b>	<b>Hubbert Curve/Peak Oil – Homework 1(Position Paper)</b>
<b>Oct. 3 – F</b>	<b>Energy Flows</b>
<b>Oct. 6– M</b>	<b>Energy Efficiency</b>
<b>Oct. 7 – T</b>	<b>Homework session/Discuss Energy Issues (Peak Oil)</b>
<b>Oct. 8 – W</b>	<b>Guest Speaker - Dr. Paul Sanders – Ford Research</b>
<b>Oct. 10 – F</b>	<b>Internal Combustion Engines – Homework 2 (Problems)</b>
<b>Oct. 13 – M</b>	<b>Manufacturing</b>

Oct. 14 – T	<b>Manufacturing</b>
Oct. 15 – W	<b><u>Guest Speaker</u> – Dr. Alan Taub, GM</b>
Oct. 17 – F	<b>Progress Reports</b>
Oct. 20 – M	<b>Progress Reports/Industrial Ecology</b>
Oct. 21 – T	<b><i>Who Killed the Electric Car</i></b>
Oct. 22 – W	<b><i>Who Killed the Electric Car/Industrial Ecology</i></b>
Oct. 24 – F	<b>Industrial Ecology – Homework 3 (Film Review)</b>
Oct. 27 – M	<b>Fuel/Additives</b>
Oct. 28 – T	<b><i>Discuss Tankful of Gas &amp; Lead articles – Homework 4 (Short Ans. + Problems)</i></b>
Oct. 29 – W	<b>Oxygenates</b>
Oct. 31 – F	<b>Air Impacts</b>
Nov. 3 – M	<b>Air Impacts</b>
Nov. 4 – T	<b><i>QUIZ 1;Video – Urban Sprawl</i></b>
Nov. 5 – W	<b>Air Impacts</b>
Nov. 7 – F	<b>Catalytic Converter</b>
Nov. 10 – M	<b>Climate - Homework 5 (Pb Critique)</b>
Nov. 11 – T	<b><u>Guest Speaker</u> – Keith Harley, Mobile Sources</b>
Nov. 12 – W	<b>Climate Change</b>
Nov. 14 – F	<b>Climate Change</b>
Nov. 17 – M	<b>Transportation – New Urbanism</b>
Nov. 18 – T	<b><u>Guest Speaker</u> – John Huston, Polar Explorer - Homework 6 ((Short Answer + Problems)</b>
Nov. 19 – W	<b>Transportation Policy</b>
Nov. 21 – F	<b><u>Guest Speaker</u> – Marshall Lindsey, Smart Growth: Density and VMT in Chicago</b>
Nov. 24 – M	<b>Alternatives</b>
Nov. 25 – T	<b><i>QUIZ 2</i></b>
Nov. 26 – W	<b>NO CLASS - THANKSGIVING</b>
Nov. 28 – F	<b>NO CLASS - THANKSGIVING</b>
Dec. 1 – M	<b>Alternatives</b>
Dec. 2 – T	<b><i>Discuss Alternatives</i></b>
Dec. 3– W	<b>Alternatives – Homework 7 (Short Answer + Problems)</b>
Dec. 5 – F	<b>Presentations</b>
Dec. 8– M	<b>Presentations (6 - 9 pm)</b>

**Whew – we made it.  
HAPPY HOLIDAYS**