Department of Urban Planning and Policy Development, Rutgers University, Revised 8/24/05

970:571 Industrial Ecology

Tuesdays 9:50 am to 12:30 pm
Fall 2004
Civic Square Building, Room CSB 369

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Class World Wide Web Page: <http://policy.rutgers.edu/andrews/courses/571.htm>

This graduate seminar course explores the powerful industrial ecology analogy, testing the blossoming field's claim that it is a framework for implementing sustainable development. Industrial ecology takes a systematic view of the use and environmental implications of materials, energy, and products in industrial societies. It attempts, in practical terms, to bridge the disciplines of economics and ecology. It exploits the ecological analogy by placing industrial activity in its environmental context and by drawing on nature as a model. It relies on microeconomics for a theory of agency and to explain the behavior of actors in industrial ecosystems. We will evaluate four aspects of current research and practice in industrial ecology:

- **Macro**: At the industrial ecosystem level, what do the flows of materials and energy look like? Is there any waste? Is the system sustainable?
- **Meso**: At the community level, what is the structure of each web of industrial actors? What actors are present and what are their roles? Are there vacant ecological niches?
- **Organizational**: At the super-micro or organizational level, what motivates individual firms? Which survival strategies do they employ? If a niche is vacant, why have firms not filled it? How can we attract firms to fill a vacant niche? How do organizations work? How do/ought they transform materials and energy?
- **Micro**: At the micro level, what motivates individual humans? Why do they create firms and governments? Why do they consume, pollute, or stop polluting?

Class Project: In order to ground the course in real data and practical concerns, we will focus collectively on a specific application area. This year's focus is the ***metabolism of Rutgers University, starting with the Civic Square Building***. We will examine energy and material flows in and out of our building (and campus-wide to the extent feasible) and also evaluate possible improvements. We will decide in class whether to organize the work as a group project or a set of individual papers.

The course employs a research seminar format, in which the instructor provides a conceptual overview of the day's topic, and then student volunteers take responsibility for leading discussion on the

application of the concepts to a specific case. Thus each class will address both conceptual and practical issues.

No special disciplinary or mathematical background is required but students will be encouraged to use whatever they have. Course requirements include active participation in classroom cases/exercises and discussions (5% of grade); leading the classroom discussion of one or more practicum topics (depending on the size of the class) (10%); preparing a 3-5 page written reflection on the readings for each of Parts I, II, III, and IV of the course (10% each); and a final paper that contributes to the class project (45%). No exams.

Readings:

All of the assigned readings except those in the required book listed here are stored in electronic form as pdf files in the class directory at (Knight\Common)S:\571-f05\Readings.

Required:

Graedel, T.E., and B.R. Allenby (2003) *Industrial Ecology*, 2nd ed., Upper Saddle River, NJ: Prentice Hall.

Recommended:

Ayres, R.U., and L.W. Ayres, eds. (2002) *A Handbook of Industrial Ecology*, Edward Elgar, Northampton, MA. [If enough people want this expensive book I can make a bulk order at a substantial discount]

Schedule of Classes

WEEK	DATE	LECTURE TOPIC
		Part I Background
1	Sept. 6	Introduction and Overview
2	Sept. 13	People and Places
3	Sept. 20	Begin Metabolism Study of Civic Square Building
		Part II Macro-Level Issues
4	Sept. 27	Disruption and Repair of the Grand Nutrient Cycles
5	Oct. 4	Toxics and the Environment
6	Oct. 11	Economic Flows
		Part III Meso-Level Issues
7	Oct. 18	Structure in Ecological Communities
8	Oct. 25	Economics of Industrial Organization
		Part IV Organizational Issues
9	Nov. 1	Organizational Behavior
10	Nov. 8	Strategy and Accounting
11	Nov. 15	Design for Environment
	Thanksgiving	
12	Nov. 29	Life Cycle Assessment
		Part V Micro-Level Issues, Final Presentations
13	Dec. 6	Consumer, Producer, and Citizen Behavior
14	Dec. 13	Final Student Presentations

Schedule of Topics, Readings, and Assignments

Part I Background

September 6 Introduction and Overview

Introduction and course overview, the ecological analogy, central issues and perspectives

Practicum: Measuring classroom energy and materials use.

Required Reading:

Graedel, T.E., and B.R. Allenby (2003) *Industrial Ecology*, 2nd ed., Upper Saddle River, NJ: Prentice Hall, ch. 1-3 (pp. 1-38).

Recommended Reading:

Socolow, R.H. (1994) "Six perspectives from industrial ecology," pp. 3-16 in R.H. Socolow, C.J. Andrews, F. Berkhout, and V.M. Thomas, eds., *Industrial Ecology and Global Change*, Cambridge University Press, New York.

September 13 People and Places

History of industrialization, planning and public policy implications

Practicum: Consider the implications of industrial transformation for urban planning, public policy at the state level, and public policy at the national level. Three volunteers will each prepare and hand out a short (1 page) summary of one of these public decision domains, and briefly present their findings to the class (10 minutes). These presentations should not merely regurgitate the required readings; they should go beyond them (i.e., rely on the recommended readings and your own sources).

Required Reading:

Graedel, T.E., and B.R. Allenby (2003) *Industrial Ecology*, 2nd ed., Upper Saddle River, NJ: Prentice Hall, ch. 4-7 (pp. 39-93).

Andrews, C.J. (1999). "Putting Industrial Ecology into Place: Evolving Roles for Planners." *Journal of the American Planning Association* **65** (4): 364-375.

Recommended Reading:

Andrews, C.J. (2002) "Industrial ecology and spatial planning," pp. 476-487 in R.U. Ayres and L.W. Ayres, eds., *A Handbook of Industrial Ecology*, Edward Elgar, Northampton, MA.

Douglas, I., and N. Lawson. (2002) "Material flows due to mining and urbanization," pp. 351-364 in R.U. Ayres and L.W. Ayres, eds., *A Handbook of Industrial Ecology*, Edward Elgar, Northampton, MA.

Gordon, J., and J. Coppock. (1997) "Ecosystem management and economic development," pp. 37-48 in M.R. Chertow and D.C. Estey, eds., *Thinking Ecologically: The Next Generation of Environmental Policy*, Yale University Press, New Haven.

Grubler, A. (1994) "Industrialization as a historical phenomenon," pp. 43-68 in R.H. Socolow, C.J. Andrews, F. Berkhout, and V.M. Thomas, eds., *Industrial Ecology and Global Change*, Cambridge University Press, New York.

Powers, C.W., and M.R. Chertow. (1997) "Industrial ecology: Overcoming policy fragmentation," pp. 19-36 in M.R. Chertow and D.C. Estey, eds., *Thinking Ecologically: The Next Generation of Environmental Policy*, Yale University Press, New Haven.

September 20 Begin Metabolism Study of Civic Square Building

We will launch the class project with a look at the design features and performance of the Bloustein School's home, a building some of you think you know well. We will plan the elements of the class project including studies of energy and materials usage, occupant behavior, design choices, and external context.

Reflection on readings #1 due

Required Reading:

NJHEPS (New Jersey Higher Education Partnership for Sustainability) (2004) Campus Energy Toolkit, report prepared for the New Jersey Board of Public Utilities, downloadable at http://www.njheps.org/projects/energy+emissions.htm.

Lutzenhiser, L. (2002) "Marketing household energy conservation: The message and the reality," pp. 49-66 in T. Dietz and P.C. Stern, eds., *New Tools for Environmental Protection: Education, Information, and Voluntary Measures*, National Academy Press, Washington, DC. Available online at http://www.nap.edu/books/0309084229/html/.

Recommended Reading:

U.S. Green Building Council (2003) *LEED-NC Reference Guide*, Version 2.1, Washington, DC.

Part II Macro-Level Issues

September 27 Disruption and Repair of the Grand Nutrient Cycles

Human impacts on carbon, nitrogen, phosphorus, and sulfur cycles; efforts to reduce human perturbations of these cycles; energy policy; agricultural policy

Practicum: Evaluate the efforts to reduce carbon cycle impacts (climate change) that could be undertaken at the Civic Square Building, including (1) solar photovoltaics, (2) fuel cells, (3) energy efficient mechanical systems/outside air, and (4) energy efficient lighting/daylighting. Four volunteers will each prepare and hand out a short (1 page) summary of one of these topics, and briefly present their findings to the class (10 minutes). These presentations should not merely regurgitate the required readings; they should go beyond them (i.e., rely on the recommended readings and your own sources).

Required Reading:

Graedel, T.E., and B.R. Allenby (2003) *Industrial Ecology*, 2nd ed., Upper Saddle River, NJ: Prentice Hall, ch. 11, 25 (pp. 137-148, 316-327).

Pacala, S. and R.H. Socolow (2004) "Stabilization wedges: Solving the climate problem for the next 50 years with current technologies," *Science* 305 (13 August): 968-972.

Smil, V. (2002) "Global biogeochemical cycles," pp. 249-259 in R.U. Ayres and L.W. Ayres, eds., *A Handbook of Industrial Ecology*, Edward Elgar, Northampton, MA.

Recommended Reading:

De Bruyn, S. (2002) "Dematerialization and rematerialization as two recurring phenomena of industrial ecology," pp. 209-222 in R.U. Ayres and L.W. Ayres, eds., *A Handbook of Industrial Ecology*, Edward Elgar, Northampton, MA.

Frankel, E. (1997) "Coexisting with the car," pp. 189-199 in M.R. Chertow and D.C. Estey, eds., *Thinking Ecologically: The Next Generation of Environmental Policy*, Yale University Press, New Haven.

Runge, C.F. (1997) "Environmental protection from farm to market," pp. 200-216 in M.R. Chertow and D.C. Estey, eds., *Thinking Ecologically: The Next Generation of Environmental Policy*, Yale University Press, New Haven.

Soka, L., R. Antikainen and P. Kauppi. (2004) "Flows of nitrogen and phosphorus in municipal waste: a substance flow analysis in Finland," *Progress in Industrial Ecology* 1 (1/2/3): 165-186.

October 4 Toxics and the Environment

Impacts of xenobiotic or man-made materials; efforts to reduce these impacts; materials accounting data and technques

Practicum: Evaluate the efforts to reduce toxic materials use and exposures that could be undertaken at the Civic Square Building, including (1) construction materials management, (2) choice of materials, (3) building operations, esp. cleaning, and (4) air quality monitoring. Four volunteers will each prepare and hand out a short (1 page) summary of one of these topics, and briefly present their findings to the class (10 minutes). These presentations should not merely regurgitate the required readings; they should go beyond them (i.e., rely on the recommended readings and your own sources).

Required Reading:

Graedel, T.E., and B.R. Allenby (2003) *Industrial Ecology*, 2nd ed., Upper Saddle River, NJ: Prentice Hall, ch. 10, 23 (pp. 118-136, 284-298).

Berkhout, F. (1994) "Nuclear power: An industrial ecology that failed?," pp. 319-330 in R.H. Socolow, C.J. Andrews, F. Berkhout, and V.M. Thomas, eds., *Industrial Ecology and Global Change*, Cambridge University Press, New York.

Recommended Reading:

Guinée, J.B., and E. van der Voet. (2002) "Risks of metal flows and accumulation," pp. 382-390 in R.U. Ayres and L.W. Ayres, eds., *A Handbook of Industrial Ecology*, Edward Elgar, Northampton, MA.

Rogich, D.G., and G.R. Matos. (2002) "Material flow accounts: The USA and the world," pp. 260-287 in R.U. Ayres and L.W. Ayres, eds., *A Handbook of Industrial Ecology*, Edward Elgar, Northampton, MA.

Thomas, V., and T. Spiro. (1994) "Emissions and exposure to metals: Cadmium and lead," pp. 297-318 in R.H. Socolow, C.J. Andrews, F. Berkhout, and V.M. Thomas, eds., *Industrial Ecology and Global Change*, Cambridge University Press, New York.

Stigliani, W.J., P. Jaffe, and S. Anderburg. (1994) "Metals loading of the environment: Cadmium in the Rhine Basin," pp. 287-296 in R.H. Socolow, C.J. Andrews, F. Berkhout, and V.M. Thomas, eds., *Industrial Ecology and Global Change*, Cambridge University Press, New York.

October 11 Economic Flows

Income and products accounts; regional economic analysis; global financial flows and their environmental implications.

Reflection on readings #2 due

Practicum: Investigate the net environmental effects of globalization on three countries: United States, Vietnam, and Kenya. Three volunteers will each prepare and hand out a short (1 page) summary of one of these topics, and briefly present their findings to the class (10 minutes). These presentations should not merely regurgitate the required readings; they should go beyond

them (i.e., rely on the recommended readings, especially the relevant chapters in the Mol book, and your own sources).

Required Reading:

Graedel, T.E., and B.R. Allenby (2003) *Industrial Ecology*, 2nd ed., Upper Saddle River, NJ: Prentice Hall, ch. 20 (pp. 245-255).

Dietz, T., and E.A. Rosa. (1997) "Effects of population and affluence on CO_2 emissions," *Proceedings of the National Academy of Sciences* 94: 175-179.

Mol, A.P.J. (2001) *Globalization and Environmental Reform: The Ecological Modernization of the Global Economy*, MIT Press, Cambridge, MA, ch. 2-4 (pp. 17-93).

Recommended Reading:

Bartelmus, P. (2002) "Environmental accounting and material flow analysis," pp. 165-176 in R.U. Ayres and L.W. Ayres, eds., *A Handbook of Industrial Ecology*, Edward Elgar, Northampton, MA.

Chen, R.S. (1994) "The human dimension of vulnerability," Pp. 85-105 in R.H. Socolow, C.J. Andrews, F. Berkhout, and V.M. Thomas, eds., *Industrial Ecology and Global Change*, Cambridge University Press, New York.

Dowdeswell, E., and S. Charnovitz. (1997) "Globalization, Trade, and Interdependence," PP. 91-102 in M.R. Chertow and D.C. Estey, eds., *Thinking Ecologically: The Next Generation of Environmental Policy*, Yale University Press, New Haven, CT.

Huq, S. (1994) "Global industrialization: A developing country perspective," Pp. 107-113 in R.H. Socolow, C.J. Andrews, F. Berkhout, and V.M. Thomas, eds., *Industrial Ecology and Global Change*, Cambridge University Press, New York.

Mol, A.P.J. (2001) *Globalization and Environmental Reform: The Ecological Modernization of the Global Economy*, MIT Press, Cambridge, MA, remainder of book.

Nordhaus, W.D. "The ecology of markets." *Proceedings of the National Academy of Sciences of the USA*. 89 (February 1992): 843-850.

Part III Meso-Level Issues

October 18 Structure in Ecological Communities

Community ecology, morphological analysis methods, applications to industrial ecosystems

Practicum: As an in-class exercise, develop a morphology of actors and materials/energy flows within (1) Civic Square Building, and (2) Rutgers University.

Required Reading:

Graedel, T.E., and B.R. Allenby (2003) *Industrial Ecology*, 2nd ed., Upper Saddle River, NJ: Prentice Hall, ch. 22 (pp. 268-283).

Recommended Reading:

Allenby, Braden R. and William E. Cooper. 1994. "Understanding industrial ecology from a biological systems perspective." *Total Quality Environmental Management*. Spring: 343-354.

Graedel, Thomas E. 1996. "On the concept of industrial ecology." *Annual Review of Energy and Environment*. 2:69-98.

McGraw-Hill Co. (2002) BioCourse.com online tutorials. Browse content on ecosystems at http://www.biocourse.com/.

October 25 Economics of Industrial Organization

Microeconomic basis for industry structures, environmental implications

Practicum: Investigate ways to reduce environmental impacts given a more sophisticated view of industrial organization, via (1) supply chain management, (2) vertical restructuring, and (3) extended producer responsibility. Three volunteers will each prepare and hand out a short (1 page) summary of one of these topics, and briefly present their findings to the class (10 minutes). These presentations should not merely regurgitate the required readings; they should go beyond them (i.e., rely on the recommended readings and your own sources).

Required Reading:

Graedel, T.E., and B.R. Allenby (2003) *Industrial Ecology*, 2nd ed., Upper Saddle River, NJ: Prentice Hall, ch. 19, 21 (pp. 237-244, 256-267).

Andrews, C.J. (2001) "Building a micro foundation for industrial ecology." *Journal of Industrial Ecology*, 4(3): 35-51.

Shugart, W.F., II. (1990) *The Organization of Industry*. Boston: BPI-Irwin, pp. 44-64.

Recommended Reading:

Andrews, C.J. (1994) “Policies to encourage clean technology,” Pp. 405-422 in R.H. Socolow, C.J. Andrews, F. Berkhout, and V.M. Thomas, eds., *Industrial Ecology and Global Change*, Cambridge University Press, New York.

Andrews, C.J. (2001) “Does electricity deregulation promote eco-efficiency? The case of distributed generation” Paper presented at the American

Collegiate Schools of Planning annual conference, Cleveland, OH. Available online at http://radburn.rutgers.edu/andrews/projects/energy/.

Elliott, E.D. (1997) "Toward ecological law and policy," Pp. 170-188 in M.R. Chertow and D.C. Estey, eds., *Thinking Ecologically: The Next Generation of Environmental Policy*, Yale University Press, New Haven, CT.

Gertsakis, J., N. Morelli and C. Ryan. (2002) "Industrial ecology and extended producer responsibility," pp. 521-529 in R.U. Ayres and L.W. Ayres, eds., *A Handbook of Industrial Ecology*, Edward Elgar, Northampton, MA.

Guile, B., and J. Cohon. (1997) "Sorting out a service-based economy," Pp. 76-90 in M.R. Chertow and D.C. Estey, eds., *Thinking Ecologically: The Next Generation of Environmental Policy*, Yale University Press, New Haven, CT.

Seuring, S. (2004) "Integrated chain management and supply chain management comparative analysis and illustrative cases," *Journal of Cleaner Production* 12: 1059-1071.

Stavins, R., and B. Whitehead. (1997) "Market-based environmental policies," Pp. 105-117 in M.R. Chertow and D.C. Estey, eds., *Thinking Ecologically: The Next Generation of Environmental Policy*, Yale University Press, New Haven, CT.

Part IV Organizational Issues

November 1 Organizational Behavior

Internal workings of the firm, relationship of internal organization and the behavior of firms, principal-agent problems, conspiring to reform large organizations

Practicum: In-class exercise using multi-agent simulation model of organizational behavior developed under Prof. Andrews' USEPA research project.

Required Reading:

Andrews, C.J., A.I. Baptista and S. Patton, "Grounded theory and multi-agent simulation for a small firm," in T. Terano, H. Kita, T. Kaneda, K. Arai, and H. Deguchi, eds., *Agent-Based Simulation: From Modeling Methodologies to Real-World Applications*, Tokyo: Springer-Verlag, 2005.

Axtell, R., C.J. Andrews, and M. Small. (2002) "Agent-based modeling and industrial ecology," *Journal of Industrial Ecology* 5(4): 10-13.

Nelson, K. (1994) "Finding and implementing projects that reduce waste," Pp. 371-382 in R.H. Socolow, C.J. Andrews, F. Berkhout, and V.M.

Thomas, eds., *Industrial Ecology and Global Change*, Cambridge University Press, New York.

Ochsner, Michelle, Caron Chess, and Michael Greenberg. 1996. "Pollution prevention at the 3M Corporation: Case study insights into organizational incentives, resources, and strategies." *Waste Management*. 15(8): 663-672.

Recommended Reading:

Allenby, Braden R. 1997. "Environmental constraints and the evolution of the private firm." Pp. 101-113 in Deanna J. Richards, ed., *The Industrial Green Game*. Washington, DC: National Academy Press.

Panayotou, T., and C. Zinnes. (1994) "Free-lunch economics for industrial ecologists," Pp. 383-397 in R.H. Socolow, C.J. Andrews, F. Berkhout, and V.M. Thomas, eds., *Industrial Ecology and Global Change*, Cambridge University Press, New York.

Kleindorfer, P.R., H.C. Kunreuther and P.J. Schoemaker. *Decision Sciences: An Integrative Perspective*. Cambridge: Cambridge University Press, 1993, pp. 289-343 (ch. 8: organizational decision making).

Smart, B., ed. *Beyond Compliance: A New Industry View of the Environment*. Washington DC: World Resources Institute, 1992, pp. 83-120, 139-149 (ch. 4, 5, 7).

Young, L.H. "The claimants for influence with the corporation." In W.R. Dill, ed., *Running the American Corporation*. Englewood Cliffs, NJ: Prentice-Hall, 1978, pp. 38-57.

November 8 Strategy and Accounting

Environmentally important functions of the firm, accounting and finance issues, strategic decision-making in firms, influence of public policy and other factors, innovative strategies

Practicum: In-class exercise using multi-agent simulation model of green niche market development developed under Prof. Andrews' USEPA research project.

Required Reading:

Graedel, T.E., and B.R. Allenby (2003) *Industrial Ecology*, 2nd ed., Upper Saddle River, NJ: Prentice Hall, ch. 24 (pp. 299-315).

Andrews, C.J. (1998) "Environmental business strategy: Corporate leaders' perceptions," *Society and Natural Resources* 11: 531-540.

Todd, Rebecca. (1994). "Zero-Loss Environmental Accounting Systems." Pp. 191-200 in Braden Allenby & Deanna Richards, eds. *The Greening of Industrial Ecosystems*. Washington, DC: National Academy Press.

Recommended Reading:

Bunker, S. (1994) "The political economy of raw materials extraction and trade," Pp. 437-450 in R.H. Socolow, C.J. Andrews, F. Berkhout, and V.M.

Thomas, eds., *Industrial Ecology and Global Change*, Cambridge University Press, New York.

Paton, B. (1994) "Design for environment: A management perspective," Pp. 349-358 in R.H. Socolow, C.J. Andrews, F. Berkhout, and V.M. Thomas, eds., *Industrial Ecology and Global Change*, Cambridge University Press, New York.

Piasecki, B. "Industrial ecology: an emerging management science." Colloquium paper. *Proceedings of the National Academy of Sciences USA*. 89 (February 1992): 873-875.

Schmidheiny, S., and B. Gentry (1997) "Privately financed sustainable development," Pp. 118-135 in M.R. Chertow and D.C. Estey, eds., *Thinking Ecologically: The Next Generation of Environmental Policy*, Yale University Press, New Haven, CT.

Shepherd, W.G. *The Economics of Industrial Organization*. Englewood Cliffs NJ: Prentice-Hall, 1979, pp. 75-107 (chapter on the nature of the firm).

Smart, B., ed. *Beyond Compliance: A New Industry View of the Environment*. Washington DC: World Resources Institute,1992, pp. 121-138 (ch. 6).

Stahel, Walter. (1994). "The Utilization-Focused Service Economy: Resource Efficiency and Product-Life Extension." Pp. 178-190 in Braden Allenby & Deanna Richards, eds. *The Greening of Industrial Ecosystems.* Washington, DC: National Academy Press.

November 15 Design for Environment

Product and process innovation, the design process, design-for-x

Practicum: Using the LEED-EB design guidance to improve the performance of Civic Square Building.

Required Reading:

Graedel, T.E., and B.R. Allenby (2003) *Industrial Ecology*, 2nd ed., Upper Saddle River, NJ: Prentice Hall, ch. 8-9, 12-14 (pp. 94-117, 149-182).

U.S. Green Building Council (2005) *LEED-EB Pilot Reference Guide*, Washington, DC.

Recommended Reading:

Diwekar, U., and M.J. Small. (2002) "Process analysis approach to industrial ecology," pp. 114-137 in R.U. Ayres and L.W. Ayres, eds., *A Handbook of Industrial Ecology*, Edward Elgar, Northampton, MA.

Pfahl, R.C., Jr. "Design for environment: an R&D manager's perspective." In B.R. Allenby and D.J. Richards, eds. *The Greening of Industrial Ecosystems.* Washington DC: National Academy Press, 1994, pp. 208-213.

Preston, J.T. (1997) "Technology innovation and environmental progress," Pp. 136-149 in M.R. Chertow and D.C. Estey, eds., *Thinking Ecologically: The Next Generation of Environmental Policy*, Yale University Press, New Haven, CT.

Steen, B. (2002) "Impact evaluation in industrial ecology," pp. 149-161 in R.U. Ayres and L.W. Ayres, eds., *A Handbook of Industrial Ecology*, Edward Elgar, Northampton, MA.

U.S. Congress, Office of Technology Assessment. *Green Products by Design*. OTA-E-541. Washington DC: U.S. Government Printing Office, 1992, pp. 23-63 (ch. 2-4).

November 29 Life Cycle Assessment

Life-cycle perspective, distinction between life-cycle costing and life-cycle impact analysis, data and tool availability and efficacy

Practicum: In-class exercise applying a life-cycle assessment tool to analyze the design of the Civic Square Building.

Required Reading:

Graedel, T.E., and B.R. Allenby (2003) *Industrial Ecology*, 2nd ed., Upper Saddle River, NJ: Prentice Hall, ch. 15-18 (pp. 183-236).

Scheuer, C., G.A. Keoleian, and P. Reppe (2003) "Life cycle energy and environmental performance of a new university building: Modeling challenges and design implications," *Energy and Buildings* 35: 1049-1064.

Recommended Reading:

Udo de Haes, H.A. (2002) "Industrial ecology and life cycle assessment," pp. 138-148 in R.U. Ayres and L.W. Ayres, eds., *A Handbook of Industrial Ecology*, Edward Elgar, Northampton, MA.

Part V Micro-Level Issues, Final Presentations

December 6 Consumer, Producer, and Citizen Behavior

Theory of agency for industrial ecology; individual choices; multiple roles of individuals as consumers, producers, and citizens

Reflection on readings #4 due

Practicum: Evaluate the efficacy of efforts to promote green consumerism and citizenship toward the built environment, including eco-labels, public information programs (e.g., energy efficiency), and regulatory or incentive programs (e.g., recycling). Three volunteers will each prepare and

hand out a short (1 page) summary of one of these topics, and briefly present their findings to the class (10 minutes). These presentations should not merely regurgitate the required readings; they should go beyond them (i.e., rely on the recommended readings and your own sources).

Required Reading:

Graedel, T.E., and B.R. Allenby (2003) *Industrial Ecology*, 2nd ed., Upper Saddle River, NJ: Prentice Hall, ch. 26 (pp. 328-338).

Frankel, C. (1998) *In Earth's Company: Business, Environment, and the Challenge of Sustainability*, New Society Publishers, Gabriola Island, BC, pp. 135-148.

Stern, P. (2002) "Changing behavior in households and communities: What have we learned?" pp. 201-211 in T. Dietz and P.C. Stern, eds., *New Tools for Environmental Protection: Education, Information, and Voluntary Measures*, National Academy Press, Washington, DC. Available online at http://www.nap.edu/books/0309084229/html/.

Recommended Reading:

Andrews, C.J., F. Berkhout, and V. Thomas (1994) "The industrial ecology agenda," Pp. 469-477 in R.H. Socolow, C.J. Andrews, F. Berkhout, and V.M. Thomas, eds., *Industrial Ecology and Global Change*, Cambridge University Press, New York.

Esty, D.C., and M.R. Chertow (1997) "A vision for the future," Pp. 231-240 in M.R. Chertow and D.C. Estey, eds., *Thinking Ecologically: The Next Generation of Environmental Policy*, Yale University Press, New Haven, CT.

Kleindorfer, P.R. (1999) "Understanding individuals' environmental decisions: A decision science approach," pp. 37-56 in K. Sexton, A.A. Marcus, K.W. Easter, and T.D. Burkhardt, eds., *Better Environmental Decisions: Strategies for Governments, Businesses, and Communities*, Island Press, Washington, DC.

Thøgersen, J. (2002) "Promoting "green" consumer behavior with eco-labels," pp. 83-104 in T. Dietz and P.C. Stern, eds., *New Tools for Environmental Protection: Education, Information, and Voluntary Measures*, National Academy Press, Washington, DC. Available online at http://www.nap.edu/books/0309084229/html/.

Schultz, P.W. (2002) "Knowledge, information, and household recycling: The knowledge-deficit model of behavior change," pp. 67-82 in T. Dietz and P.C. Stern, eds., *New Tools for Environmental Protection: Education, Information, and Voluntary Measures*, National Academy Press, Washington, DC. Available online at http://www.nap.edu/books/0309084229/html/.

Stead, W.E. and J.G. Stead. (1992) *Management for a Small Planet: Strategic Decision Making and the Environment*. Newbury Park CA: Sage Publications, pp. 143-165 (ch. 8: The Green Stakeholders).

December 13 Final Student Presentations

Present results of student projects in class; solicit feedback

Final written paper due at 5 pm on Thursday, December 15th. Give me an electronic version and also a hard copy.