The following is a list of courses in the Industrial Environmental Management focal area for the 2015-2016 academic year. For more information, visit the F&ES course page.

**Industrial Ecology**  
*Instructor* Thomas Graedel  
F&ES 884b/ENAS 645b  
3 credits  
Industrial ecology is (1) The study of the flows of materials and energy in industrial and consumer activities; (2) The study of the effects of these flows on the environment; (3) The study of the influences of economic, political, regulatory, and social factors on the flow, use, and transformation of resources. The goals of the course: To define and describe industrial ecology; to demonstrate the relationships among production, consumption, sustainability, and industrial ecology in diverse settings, from firms to cities to international trade flows; To show how industrial ecology serves as a framework for the consideration of environmental and sustainability-related aspects of science, technology, and policy; To define and describe tools, applications, and implications of industrial ecology.

**Energy Systems Analysis**  
*Instructor* Arnulf Grubler  
F&ES 814a/MGT 563  
3 credits  
This lecture course offers a systems analysis approach to describe and explain the basics of energy systems, including all forms of energy (fossil and renewable), all sectors/activities of energy production/conversion, and all energy end-uses, irrespective of the form of market transaction (commercial or noncommercial) or form of technology (traditional as well as novel advanced concepts) deployed. Students gain a comprehensive theoretical and empirical knowledge base from which to analyze energy-environmental issues as well as to participate effectively in policy debates. Special attention is given to introducing students to formal methods used to analyze energy systems or individual energy projects and to discuss also traditionally less-researched elements of energy systems (energy use in developing countries; energy densities and urban energy use; income, gender, and lifestyle differences in energy end-use patterns) in addition to currently dominant energy issues such as climate change. Active student participation is required, including completion of problem sets. Participation in extra credit skill development exercises (presentations, fact-finding missions, etc.) is encouraged. Invited external speakers complement topics covered in class. This class will not be offered in 2016.

**Advanced Industrial Ecology Seminar**  
*Instructor* Marian Chertow  
F&ES 883b  
3 credits  
This seminar examines in a small-course, interactive setting current integrative themes related to industrial ecology such as nexus issues related to energy/food/water/materials. A specific theme is chosen each year. Prerequisites: two completed industrial environmental management courses, related energy
courses, or related business courses, and/or permission of the instructor. This class will not be offered in 2016.

**Green Engineering and Sustainable Design**  
*Instructor* Julie Zimmerman  
F&ES 885b/ENVE 360b/ENAS 660b/360b  
3 credits

This hands-on course highlights the key approaches to advancing sustainability through engineering design. The class begins with discussions on sustainability, metrics, general design processes, and challenges to sustainability. The current approach to design, manufacturing, and disposal is discussed in the context of examples and case studies from various sectors. This provides a basis for what and how to consider when designing products, processes, and systems to contribute to furthering sustainability. The fundamental engineering design topics to be addressed include toxicity and benign alternatives, pollution prevention and source reduction, separations and disassembly, material and energy efficiencies and flows, systems analysis, biomimicry, and life cycle design, management, and analysis. Students tackle current engineering and product design challenges in a series of class exercises and a final design project.

**Life Cycle Assessment Practicum**  
*Instructor* Tom Swarr  
F&ES 950a  
3 credits

Life Cycle Assessment (LCA) is an environmental modeling method that has become increasingly popular within business and academia for evaluating the environmental impacts of products or systems. LCA considers impacts along the entire life cycle, from production to consumption to disposal, and generally provides quantitative information for a range of different environmental issues. In this practicum course, students work on real projects with industry partners in order to achieve skills and training as analysts in this field. The course begins with a review of the intellectual foundation of LCA, the computational structure of the method, and the international standards that govern its use. Students then receive several hands-on training modules for commercial LCA software packages, and work examples for model products and systems. This initial training prepares students to carry out their independent group projects over the remainder of the course. Special topics in LCA research and implementation are also covered later in the course, including, e.g., carbon and water footprinting, environmentally extended input-output analysis, and buildings. Regular project updates occur in class and individually with the instructor, and results are presented to industry partners at the end of the course in a professional consulting context.

**Corporate Environmental Management and Strategy**  
*Instructor* Marian Chertow  
F&ES 807a/MGT 688a/Law 20490  
3 credits

This survey course focuses on understanding how adroit environmental management and strategy can enhance business opportunities; reduce risk, including resource dependency; promote cooperation; and
decrease environmental impact. The course combines lectures, case studies, and class discussions and debates on management theory and tools, legal and regulatory frameworks shaping the business-environment interface, and the evolving requirements for business success (including how to deal with diverse stakeholders, manage in a world of transparency, and how to address rising expectations related to corporate responsibility).

**Seminar: Interdisciplinarity in Environmental Research**  
*Instructor* Marian Chertow, Anjali Gupta  
F&ES 749a  
3 credits

The goal of this seminar is to create a space where research scholars can learn and discuss what it means to do interdisciplinary research in the field of environmental studies/sciences, why it is important, and how it can be done. This course is intended to stimulate critical thinking about the role of interdisciplinarity in answering complex socio-ecological questions and to provide students with conceptual tools, grounded in concrete examples, to pursue interdisciplinary research within environmental studies/sciences.

**Energy Technology Innovation**  
*Instructor* Arnulf Grubler  
F&ES 818a/MGT 561  
3 credits

This advanced seminar aims at providing essential knowledge as well as a forum for students to discuss energy technology innovation strategies and policies from a systemic perspective. The first half of the seminar provides basic knowledge on technological change in general and on energy technology innovation in particular from an interdisciplinary perspective, including history of technology, engineering, management science, systems theory, economics, and social sciences including diffusion theory. Focus is on introducing students to the main patterns, drivers, policy leverages, and constraints in energy technology innovation systems. Core theoretical concepts introduced include inter alia technological inertia and lock-in, uncertainty, knowledge accumulation (learning) and depreciation, dynamic economic feedbacks like increasing returns to adoption, and knowledge and technology spillover effects. The second part of the seminar focuses on student-led discussions of selected case studies of energy technology innovation and/or policy approaches in both energy supply and energy end-use. Student proposals on case studies are welcome. In order to maximize discourse possibilities and levels, enrollment limited to twelve. Students apply for seminar admission via email outlining motivation and meeting of prerequisites criteria. Prerequisites: F&ES 814a, an equivalent of 3 credits of energy courses obtained outside F&ES, or two years professional experience in the energy industry including energy finance. Other highly motivated students, including undergraduates, can also apply for admission through a 1-page motivational statement and a three-page summary of a relevant energy technology innovation publication chosen by the applicant. The seminar will not be offered in 2016.
Climate Change Mitigation and Industrial Ecology

*Instructor* Edgar Hertwich
F&ES 870 01 (23972)
3 credits

This course will examine the mitigation of greenhouse gas emissions from energy production, industry, buildings, transport and land use. It focuses on the contribution of industrial ecology to understanding the system that gives rise to the emissions, the interlinkages among sectors, and the driving forces behind recent increases in emissions. On this basis, this seminar addresses the analysis of options for emission reductions, using industry and electricity production as examples. It provides a background on selected research methods used to produce results used by the Intergovernmental Panel on Climate Change in its most recent assessment report on climate change mitigation and discusses the implications of methods and assumptions behind models for policy support statements. A few exercises serve to provide an insight into the methods. Students learn to synthesize the scientific literature, develop effective presentations of the findings, and lead discussions. The active participation of students in exercises and classes is required. Grading is based on class participation and a written exam. Limited to 20