GSOE9740 Industrial Ecology and Sustainable Engineering

Never Stand Still | Faculty of Engineering | School of Civil and Environmental Engineering

COURSE DETAILS

Units of Credit	6	
Contact hours	4 hours per week	
Class	Mondays, 1-3pm	Room: Mathews Theatre D
Workshop	A – Mondays, 3-5pm	Room: Mathews 113
Course Coordinator and Lecturer	Assoc. Prof. Tommy Wiedmann email: t.wiedmann@unsw.edu.au office: Room 312, School of Civil & Environmental Engineering (Bld H20) phone: 02 9385 0142	
Lecturer and Demonstrator	Dr Michalis Hadjikakou	

INFORMATION ABOUT THE COURSE

This course will introduce students to the concepts and methods of sustainable engineering and industrial ecology and their application in work practice and research. Industrial ecology is a rapidly growing field that uses natural systems as a model for designing sustainable industrial systems. It helps to redesign the uses and flows of resources, materials and energy in a way that minimises environmental impacts and waste. Building upon the principles of the industrial ecology framework, the course introduces fundamental tools for assessing sustainability quantitatively such as input-output analysis, hybrid life cycle assessment and environmental footprint assessment. The focus will be on environmental impacts, but economic and social impacts will be dealt with as well.

The course assumes some familiarity with environmental and sustainability issues and will involve computational activities. Knowledge of life cycle assessment (LCA) is essential; courses that teach LCA and are recognised as prerequisites are CVEN9892, GSOE9340 and SOLA9051.

HANDBOOK DESCRIPTION

Sustainability means living well within the limits of a finite planet. More than ever, engineers need to find holistic and effective solutions to currently unsustainable practices of production and consumption, to protect our vital life support systems and meet the social and economic needs of a growing human population at the same time.

This course teaches concepts and methods to analyse and assess the environmental impacts of industrial systems and economies. It aims to equip students with the ability to understand challenges of sustainability from a local to global scale, to think critically, holistically and with a life cycle perspective

and to apply sustainability assessment methods and tools (such as input-output analysis, hybrid life cycle assessment and environmental footprint assessment) in real-world examples.

http://www.handbook.unsw.edu.au/postgraduate/courses/2017/GSOE9740.html

OBJECTIVES

The aim of the course is to introduce students to the concepts and quantitative methods of sustainable engineering and industrial ecology and their application in work practice and research. Through lectures, workshops, group discussions and presentations, group assignments and the final exam, students will learn to:

- consider the interactions between technical, ecological, social and economic systems and avoid shifting problems from one area to the other;
- define, evaluate and help to resolve issues of sustainability in engineering problems;
- apply quantitative methods, interpret results and understand uncertainty;
- make more informed decisions towards increased sustainable outcomes.

Further outcome attributes of the course include:

- An in-depth engagement with the concepts of industrial ecology and sustainable engineering and their inter-disciplinary context
- Capacity for analytical and critical thinking, life cycle thinking and creative problem solving
- Ability to engage independent and reflective learning
- Skills for collaborative and multi-disciplinary work
- A respect for ethical practice and social responsibility
- Skills for effective communication

TEACHING STRATEGIES

The following teaching strategies will be used in this course. Students are encouraged to direct their own learning to get the most out of their participation in this course.

Lectures	• Find out what you must learn • Take notes on skeleton overheads provided to get a full set of reference notes for the course. • Participate in class discussions and work out example problems in class. • Ask questions on how the content of lectures applies to assignment questions. • Hear announcements on course changes
Workshops	• Work actively in small ad hoc groups on problems set in class. • Be guided by demonstrators, discussion questions and additional reading • Participate and attempt all questions • Practice solving set problems • Ask questions and discuss solutions with other students
Private Study	• Review lecture material, reference books, and resources on UNSW Moodle. • Work in groups on class assignments. • Reflect on class problems and assignments. • Download and work through additional readings provided.

	• Join Moodle discussions of problems • Keep up with notices and find out marks via Moodle
Assessments (quizzes, examinations, assignments, group discussions and presentations etc.)	• Answer quiz questions in class. • Demonstrate your knowledge and skills in workshops and assignments. • Demonstrate ability to work effectively in a group by completing the group assignment. • Demonstrate higher understanding and problem solving on real world problems in hypothetical, but realistic problem settings in workshops.

For each hour of contact it is expected that you will put in at least 1.5 hours of private study!

EXPECTED LEARNING OUTCOMES

At the end of this course, students will be able to critically evaluate sustainability problems (practiced in presentations and assignments) and decide which method to choose for quantitative sustainability assessment. They will be able to describe and contrast different quantitative evaluation methods and conduct simple life cycle, footprint and input-output analyses (practiced in group workshops and assignments). They will also be able to interpret the outcomes from each sustainability assessment method, know the limitations inherent in the different approaches and make recommendations towards more sustainable decision-making processes. Students will get to know the basic principles of industrial ecology and sustainable engineering and their application in work practice and research and formulate reasonable suggestions based on sustainability assessment activities.

ASSESSMENT

The final examination will constitute 30% of the overall course mark. The remaining 70% is comprised of one individual and one group assignment as well as an individual presentation. Details are shown below:

- Each student will individually develop a research topic relevant to the course, conduct the research, and present the research in a journal-style paper (30% of total course mark) and a presentation or poster (10%). The paper will be peer reviewed and marked by other students and the course coordinator through a process similar to a formal academic publication. Reports will be "published" online in the notional *UNSW Course Journal of Industrial Ecology and Sustainable Engineering*. The course coordinator and lecturers will serve as the Editors. Each paper will be reviewed by at least two anonymous reviewers (from the class or other scholars invited by the Editors). The author has the option to revise the paper based on comments made by the reviewers.
- Sustainability assessment of an engineering project (group assignment). Major assignment for small groups of students. Includes quantitative and qualitative evaluation. For the group assignment (worth 30% of the total course mark) students must actively project-manage their group assignment works in order to gain a good mark. Students should expect to spend a significant amount of time working with their team to develop their work.
- Final examination (worth 30% of the total course mark). The exam will test the students' ability to synthesise the overall course. All material presented during the session will be examinable in the exam unless otherwise noted. The formal exam scripts will not be returned. Students who perform poorly in exercises and assignments are recommended to discuss progress with the lecturer during the semester. Note: The course coordinator reserves the right to adjust the final scores by scaling if agreed by the Head of School.

Details of each assessment component, the marks assigned to it, and the dates of submission are set out below.

ASSIGNMENTS

	Assessment details	Issue date	Marks	Due Date
1.	Peer-reviewed research paper for online journal (individual)	8 Aug 2016	30%	11 Sept 2016
2.	Oral presentation of research paper (individual)	5 Sept 2016	10%	19 Sept 2016
3.	Sustainability assessment of an engineering project (group)	19 Sept 2016	30%	16 Oct 2016
4.	Final Exam (individual)	see MyUNSW in about Week 10	30%	see MyUNSW in about Week 10

Note: Discipline (School) specific projects can be chosen for assignments (e.g. Civil Eng., Env. Eng., Chem. Eng., Mining Eng., Renewable Energy Eng. etc.)

Penalties for late submissions of group assignments apply. Late work will be penalised at the rate of 10% per day after the due time and date have expired.

Marking criteria: All assignments will be marked on the basis of whether the student demonstrates an understanding of the material. Where numerical errors can be identified as simple slips, penalties will not be as large as when errors appear to be a result of a conceptual misunderstanding, or the source of the error is difficult to determine from the working. The group assignments will be additionally assessed with respect to the depth of the analysis, the breadth of its consideration of the question at hand and the clarity of the way in which the answer is presented. The use of tables and diagrams is encouraged. **Please make sure you do not exceed the imposed page limits.**

COURSE PROGRAM

SEMESTER 2, 2016

Week	Date	**Topic** (for both lectures and workshops) Lectures are on Mondays, 1-3pm Workshops are on Mondays, 3-5pm	Lec-turer
1	25 Jul	Introduction and sustainability concepts, definitions and principles	TW
2	1 Aug	Sustainable engineering; consumption-based accounting and environmental footprint assessment; Input-Output Analysis I (basics, mathematics)	TW
3	8 Aug	Industrial Ecology; Input-Output Analysis II (environmental extensions); Matlab basics; Assignment 1 briefing	TW
4	15 Aug	Input-Output Analysis III (SUT, production layer decomposition)	TW
5	22 Aug	Fundamental programming concepts (loops, functions, structs, etc.); sustainability-related applications	MH
6	29 Aug	Advanced analytical techniques of Industrial Ecology I: structural path analysis and mixed-unit IOA	TW
7	5 Sep	Process-based Life Cycle Assessment (LCA); principles of hybrid LCA Assignment 1 due (11 Sept.); Assignment 2 briefing	TW
8	12 Sep	Advanced analytical techniques of Industrial Ecology II: IO-based and integrated hybrid LCA;	TW

9	19 Sep	Case studies of TBL analysis of economic sectors = Assignment 2 (due 19 Sept.): Oral presentations of Assignment 1 research papers; Assignment 3 briefing	TW, MH
	26-30 Sep	Mid-session Break	
10	*3 Oct*	Public holiday (Labour Day)	
11	10 Oct	**Guest lecturer Dr Robin Branson** (Director of Qubator and the Australian Industrial Ecology Network; Honorary Associate, School of Geosciences, University of Sydney): Industrial Ecology in practice; principles, strategies, tools and stories from the front line. Assignment 3 workshop	RB, TW, MH
	16 Oct	Assignment 3 due (16th October, 8pm)	
12	17 Oct	**Guest lecturer Robin Mellon** (Chief Executive Officer, Supply Chain Sustainability School): Relevance of sustainable supply chains; procurement decisions in major projects; case study examples about construction and infrastructure projects.	RM, TW
13	24 Oct	Practical tools and models: Industrial Ecology Virtual Laboratory; Triple Bottom Line tool for the water industry	TW, MH

TW = Tommy Wiedmann, MH = Michalis Hadjikakou,

PREREQUISITES

CVEN9892, GSOE9340 and SOLA9015 provide content on LCA that is essential (prerequisite/assumed) knowledge for GSOE9740. Students must have successfully completed at least one of these three courses or provide evidence of equivalent training in LCA.

Furthermore, basic familiarity with environmental and sustainability issues as well as matrix algebra are recommended. Microsoft Office Excel will be used in exercises and assignments.

RELEVANT RESOURCES

UNSW Moodle

- All material required for this course will be provided on UNSW Moodle. It is compulsory for all students to access this resource: **https://moodle.telt.unsw.edu.au/login/index.php**

Textbook and Readings

- The recommended textbook for this course is: Murray, J. and Wood, R. (Eds.), 2010; *The Sustainability Practitioner's Guide to Input-Output Analysis*. Common Ground Publishing LLC, Champaign, Illinois, USA. http://onsustainability.cgpublisher.com/product/pub.197/prod.3
- Readings will be posted on Moodle, unless a URL is provided in the syllabus. Students are required to be familiar with the required reading materials prior the class.

Useful literature

- Suh, S., ed. 2009. *Handbook of Input-Output Economics in Industrial Ecology*. Vol. Vol. 23, Series: Eco-Efficiency in Industry and Science: Springer. http://www.springer.com/earth+sciences/geostatistics/book/978-1-4020-4083-2

- Hoekstra, A. Y. and T. O. Wiedmann. 2014. Humanity's unsustainable environmental footprint. Science 344(6188): 1114-1117. http://dx.doi.org/10.1126/science.1248365
- Hellweg, S. and L. Milà i Canals. 2014. Emerging approaches, challenges and opportunities in life cycle assessment. Science 344(6188): 1109-1113. http://www.sciencemag.org/content/344/6188/1109.abstract
- Duchin, F. and Levine, S. H. (2014) Industrial Ecology. In: *Reference Module in Earth Systems and Environmental Sciences*, Elsevier. http://dx.doi.org/10.1016/B978-0-12-409548-9.09407-0
- Weisz, H., Suh, S. and Graedel, T. E. (2015) Industrial Ecology: The role of manufactured capital in sustainability. *Proceedings of the National Academy of Sciences*, **112**(20), 6260-6264. http://www.pnas.org/content/112/20/6260.short
- Dowling, D., A. Carew, and R. Hadgraft. 2012. *Engineering Your Future: An Australasian Guide*. 2nd Edition ed. Vol. November 2012. http://au.wiley.com/WileyCDA/WileyTitle/productCd-EHEP002525.html

Useful databases for academic journals (accessible via UNSW Library)

- **http://www.sciencedirect.com**
- **http://www.scopus.com**
- **http://scholar.google.com**

DATES TO NOTE

Refer to MyUNSW for Important Dates available at:

https://student.unsw.edu.au/dates

PLAGIARISM

Plagiarism is the unacknowledged use of other people's work, including the copying of assignments written by other students or material found on The Web. Plagiarism is considered a serious offence by the University and severe penalties may apply (**students who plagiarise may fail the course and are liable to disciplinary action, including exclusion from enrolment**). Any plagiarism may be referred to the Head of School for further action.

When it is necessary or desirable to use other people's material you should adequately acknowledge whose words or ideas they are and where you found them (giving the complete reference details, including page number(s)). The Learning Centre provides further information on what constitutes Plagiarism at: **https://student.unsw.edu.au/plagiarism**.

ACADEMIC ADVICE

For information about:

- Notes on assessments and plagiarism,
- School policy on Supplementary exams,
- Special Considerations,
- Solutions to Problems,
- Year Managers and Grievance Officer of Teaching and Learning Committee, and
- CEVSOC.

refer to Academic Advice on the School website available at:

http://www.engineering.unsw.edu.au/civil-engineering/resources/academic-advice

APPENDIX

Definition of Industrial Ecology

Industrial ecology is a rapidly growing field that systematically examines local, regional and global materials and energy uses and flows in products, processes, industrial sectors and economies. The name industrial ecology was coined to emphasize how natural systems can serve as a model for designing sustainable industrial systems. Industrial Ecology places human technological activity – industry in the widest sense – in the context of the larger ecosystems that support it, examining the sources of resources used in society and the sinks that may act to absorb or detoxify wastes.

Industrial Ecology provides a solution-oriented engineering approach to environmental and sustainability problems. Robert White, the former president of the US National Academy of Engineering, summarised these elements by defining industrial ecology as "… the study of the flows of materials and energy in industrial and consumer activities, of the effects of these flows on the environment, and of the influences of economic, political, regulatory, and social factors on the flow, use, and transformation of resources" (White 1994).

The field Industrial Ecology has grown fast in the last years and now several initiatives are taken for education programmes in this area (ISIE flyer 2014). The Journal of Industrial Ecology (since 1997, published by MIT Press, http://mitpress.mit.edu/JIE) and the International Society for Industrial Ecology (since 2001, http://www.yale.edu/is4ie) give Industrial Ecology a strong position in the international scientific community. With the publication of a special section in the top journal *PNAS* in 2015, Industrial Ecology has become a mainstream field of research.

Rationale including Industrial Ecology in the Course Program

Industrial Ecology (and Sustainability Assessment) as an umbrella term and overarching subject is suitable for post-graduate teaching at UNSW for the following reasons:

- IE encompasses and summarises in one term topics and methods that are important to Environmental Engineering. It is based to on a life cycle perspective and on the analysis of materials and energy flows – both longstanding principles of teaching and research at UNSW.
- IE has a focus on industrial activities (viewing firms as agents for environmental improvement) which goes well with UNSW engineering background and relationship to industry.
- IE is not well established at Australian Universities – UNSW occupies an important niche of teaching and research. Internationally there are half a dozen Universities that have significant Master programs in Industrial Ecology.
- IE requires and is well suited for multidisciplinary and interdisciplinary research and analysis – these are increasingly required to solve complex problems.