

GSOE9740

Industrial Ecology and Sustainable Engineering

Term 3, 2022



Course Overview

Staff Contact Details

Convenors

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School Contact Information

[Engineering Student Support Services](#) – The Nucleus - enrolment, progression checks, clash requests, course issues or program-related queries

[Engineering Industrial Training](#) – Industrial training questions

[UNSW Study Abroad](#) – study abroad student enquiries (for inbound students)

[UNSW Exchange](#) – student exchange enquiries (for inbound students)

[UNSW Future Students](#) – potential student enquiries e.g. admissions, fees, programs, credit transfer

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Course Details

Units of Credit 6

Summary of the Course

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.

Course Aims

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 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

Course Learning Outcomes

After successfully completing this course, you should be able to:

Learning Outcome	EA Stage 1 Competencies
1. Understand 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.	PE1.1, PE1.3, PE1.4, PE1.6, PE2.1, PE3.1
2. Critically evaluate sustainability problems (practiced in presentations and assignments).	PE1.1, PE1.6, PE2.1, PE2.4, PE3.2
3. Describe and contrast different quantitative evaluation methods and conduct simple life cycle, footprint and input-output analyses.	PE1.2, PE2.1, PE2.4, PE3.2
4. Decide which method to choose for quantitative sustainability assessment.	PE1.6, PE2.2, PE2.4
5. Work together in interdisciplinary groups to investigate the environmental sustainability of households, companies and projects.	PE2.1, PE3.1, PE3.2, PE3.3, PE3.6
6. Interpret the outcomes from each assessment method, know the limitations inherent in the different approaches and make recommendations towards more sustainable decision-making processes.	PE1.2, PE1.6, PE2.4, PE3.1, PE3.5

At the end of this course, students will be able to critically evaluate sustainability problems (practiced in quizzes, 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 online 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.

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.
- Watch **all** lecture, exercise and workshop videos and answer the questions therein.
- Participate in online discussions and work out provided example problems.
- Ask questions online on how the content of lectures applies to assignment questions.
- Read announcements on course changes.

Workshops

- Work actively through all exercises provided online.
- Be guided by auxiliary material and additional reading.
- Attempt all questions in practice quizzes.
- Practice solving set problems.
- Ask questions and discuss solutions with other students via Moodle.

Private Study

- Review lecture material, reference books, and resources on UNSW Moodle.
- Work in groups on online assignments.
- Reflect on set 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.)

- Take all quizzes at the set time! These are **summative** assessments and count towards your final course mark.
- Demonstrate your knowledge and skills in online discussions 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 online workshops.

Additional Course Information

The course assumes familiarity with environmental and sustainability issues and will involve computational activities. Familiarity with matrix algebra is beneficial. Microsoft Office Excel will be used in exercises and assignments. The basics of Matlab programming will be taught.

Prerequisites: Knowledge of life cycle assessment (LCA) is **essential**; courses that teach LCA and are recognised as prerequisites are CVEN9892, GSOE9340 and SOLA9015. Students must have successfully completed one of these courses or provide evidence of equivalent training in LCA.

This is a **100% online course** which will be fully delivered asynchronously via Moodle. As such there are no set contact hours. However, note that there will be two live online discussion forums with compulsory attendance and several live Q&A sessions, which are voluntary. It is expected that you invest **at least 6 hours per week** of private study in this course. You need to **complete all tasks on Moodle every week** to keep up with the course progress!

Assessment

There will be no final examination in this course. Instead, there will be three online quizzes, worth 30% of the total course mark, one individual assignment (30%) with an individual presentation (10%) and one group assignment (30%).

If you are unwell or have other extenuating circumstances which prevent you from completing an assessment, you **always have** to apply for Special Consideration through official University channels (before the deadline, if possible): <https://student.unsw.edu.au/special-consideration>. Otherwise the fit-to-submit rule applies, i.e. by sitting or submitting an assessment on the scheduled assessment date, the student is declaring that they are fit to do so and cannot later apply for Special Consideration.

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 assignment 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. Make sure you do not exceed the imposed page limits.

Penalties for late submissions of all assignments apply. Where applicable (see table below), late work will be penalised at the rate of **5% per day** after the due time and date have expired. There is no extension for quizzes.

Assessment task	Weight	Due Date	Course Learning Outcomes Assessed
1. Individual Assignment	30%	14/10/2022 09:00 PM	1, 2, 3, 6
2. Oral presentation	10%	28/10/2022 09:00 PM	1, 2, 3, 6
3. Group assignment	30%	18/11/2022 09:00 PM	2, 3, 5, 6
4. Quizzes	30%	Fri 30 Sept, Fri 4 Nov and Fri 11 Nov 2022, 9:00 PM	1, 2, 4

Assessment 1: Individual Assignment

Assessment length: 6 pages

Due date: 14/10/2022 09:00 PM

Deadline for absolute fail: One week after deadline.

Marks returned: Two weeks after deadline.

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 an online presentation (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. 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).

This assignment is submitted through Turnitin and students do not see Turnitin similarity reports.

Assessment criteria

A marking rubric based on the following criteria is made available to the students with the assignment:

- Introduction / context / background (16.7%)
- Methods & data section (16.7%)
- Results/presentation/discussion (16.7%)
- Presentation / formatting (16.7%)
- Conclusions (16.7%)
- Overall clarity and quality (16.7%)

Assessment 2: Oral presentation

Assessment length: 5 minutes

Due date: 28/10/2022 09:00 PM

Deadline for absolute fail: One week after deadline.

Marks returned: Two weeks after deadline.

Oral presentation of findings from individual assignment.

Assessment criteria

A marking rubric based on the following criteria is made available to the students before the presentation:

- Development and explanation of topic (25%)
- Organisation and structure (specific introduction and conclusion, sequenced material within the body, and transitions; 25%)
- Delivery (Use of technology, posture, gesture, eye contact, and vocal expressiveness; max. 25%)
- Ability to answer audience questions (25%)

Assessment 3: Group assignment

Assessment length: 10 pages

Due date: 18/11/2022 09:00 PM

Deadline for absolute fail: One week after deadline

Marks returned: Two weeks after submission

Sustainability assessment of an engineering project (group assignment). Major assignment for small groups of students. Includes quantitative and qualitative evaluation, following the triple-bottom-line methodology. 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.

This assignment is submitted through Turnitin and students do not see Turnitin similarity reports.

Assessment criteria

A marking rubric based on the following criteria is made available to the students with the assignment:

- Abstract / introduction / background (10%)
- Understanding of TBL/LCA Framework and application to water resources management (20%)
- Description of three WSOs and the technologies involved (20%)
- MCDA application, calculations and results (20%)
- Final conclusions and consideration of uncertainty and future research needs (20%)
- Overall clarity and quality (10%)

Assessment 4: Quizzes

Assessment length: 15 mins each

Submission notes: Moodle Quiz

Due date: Fri 30 Sept, Fri 4 Nov and Fri 11 Nov 2022, 9:00 PM

Three quizzes throughout the course, each worth 10% of the total course mark. The quizzes will test the students' ability to synthesise the overall course, demonstrate understanding of main principles and implement them in given situations. They may include calculations. All material presented during the session will be examinable in the quizzes unless otherwise noted.

Assessment criteria

The quizzes will test the student's ability to synthesise the material taught, demonstrate understanding of main principles and apply them in a given context.

Attendance Requirements

Students are strongly encouraged to attend all classes and review lecture recordings.

Course Schedule

A table of online lectures, workshops and activities is provided below. Please note that this course is being delivered **100% online** via Moodle. It has the usual weekly structure and you need to **complete all tasks on Moodle every week** to keep up with the course progress!

[View class timetable](#)

Timetable

Date	Type	Content
Week 1: 12 September - 16 September	Lecture	Introduction to sustainability concepts, definitions and principles
	Workshop	IPAT activity
Week 2: 19 September - 23 September	Lecture	Input-Output Analysis I (basics, mathematics, environmental extensions)
	Workshop	Live Online Discussion Forum on supply chain / life-cycle thinking (attendance compulsory); Online Practice Quiz
Week 3: 26 September - 30 September	Lecture	Input-Output Analysis II (production layer decomposition)
	Workshop	IOA and PLD exercises; Assignment 1 briefing; 1st Online Quiz
Week 4: 3 October - 7 October	Lecture	Fundamental programming concepts (loops, scripts, functions, strings, etc.)
	Workshop	Matlab basics; Assignment 1 workshop
Week 5: 10 October - 14 October	Lecture	Input-Output Analysis III, Industrial Ecology and Sustainable Engineering
	Workshop	IELab; Assignment 1 due
	Assessment	Individual Assignment
Week 6: 17 October - 21 October	Homework	Assignment 2 briefing; peer-mark Assignment 1 and work on Assignment 2
Week 7: 24 October - 28 October	Lecture	Advanced analytical techniques of Industrial Ecology I (structural path analysis and mixed-unit

		IOA)
	Workshop	SPA and MU-IOA exercises; Peer-marking of Assignment 1 and Assignment 2 due (oral presentation)
	Assessment	Oral presentation
Week 8: 31 October - 4 November	Lecture	Practical tools and models: Triple Bottom Line tool for the water industry
	Workshop	Assignment 3 briefing; 2nd Online Quiz
Week 9: 7 November - 11 November	Lecture	Advanced analytical techniques of Industrial Ecology II (hybrid LCA)
	Workshop	Matrix Augmentation exercise; 3rd Online Quiz
Week 10: 14 November - 18 November	Lecture	Industrial Ecology Practice (Live Online Webinar, attendance compulsory)
	Workshop	Hybrid LCA exercise; Assignment 3 due
	Assessment	Group assignment

Resources

Prescribed Resources

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>

Recommended Resources

Textbook and Readings

There is not compulsory textbook for this course. However, we strongly recommend the following two:

- 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>
Note from the UNSW Bookshop: If you would like to order a copy, the book is printed to order locally in Sydney, so it would only take a week to supply.
- Peters, G. and Svanström, M. 2019. **Environmental Sustainability for Engineers and Applied Scientists**. Cambridge University Press, Cambridge. <https://doi.org/10.1017/9781316711408>
[Available through UNSW Library at <https://www.library.unsw.edu.au>].

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. 23, Series: Eco-Efficiency in Industry and Science: Springer.
<http://www.springer.com/earth+sciences/geostatistics/book/978-1-4020-4083-2>
- Thijs ten Raa (Ed.) 2017 Handbook of Input-Output Analysis. Edward Elgar Publishing.
<http://dx.doi.org/10.4337/9781783476329>
- 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>

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.

Course Evaluation and Development

We welcome student feedback throughout the course - either through the Discussion Forum or the weekly Feedback tool on Moodle. This is very important to us – let us know what you think works well and what we can do better. This information will be used to continually improve the course.

Submission of Assessment Tasks

Please refer to the Moodle page of the course for further guidance on assessment submission.

UNSW has a standard late submission penalty of:

- 5% per day, for all assessments where a penalty applies, capped at five days (120 hours), after which a student cannot submit an assessment, and no permitted variation.

Academic Honesty and Plagiarism

Beware! An assignment that includes plagiarised material will receive a 0% Fail, and students who plagiarise may fail the course. Students who plagiarise are also liable to disciplinary action, including exclusion from enrolment.

Plagiarism is the use of another person's work or ideas as if they were your own. 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 Information

Final Examinations:

Final exams in T3 2022 will be held online between 25th November - 8th December 2022 inclusive, and supplementary exams between 9th - 13th January 2023 inclusive. You are required to be available on these dates. Please do not to make any personal or travel arrangements during this period.

ACADEMIC ADVICE

- Key Staff to Contact for Academic Advice (log in with your zID and password): <https://intranet.civeng.unsw.edu.au/key-staff-to-contact-during-your-studies-at-unsw>
- [Key UNSW Dates](#) - eg. Census Date, exam dates, last day to drop a course without academic/financial liability etc.
- CVEN Student Intranet (log in with your zID and password): <https://intranet.civeng.unsw.edu.au/student-intranet>
- Student Life at CVEN, including Student Societies: <https://www.unsw.edu.au/engineering/civil-and-environmental-engineering/student-life>
- Special Consideration: <https://student.unsw.edu.au/special-consideration>
- General and Program-Specific Questions: [The Nucleus: Student Hub](#)
- Book an Academic Advising session: <https://app.acuityscheduling.com/schedule.php?owner=19024765>

Disclaimer

This course outline sets out description of classes at the date the Course Outline is published. The nature of classes may change during the Term after the Course Outline is published. Moodle should be consulted for the up to date class descriptions. If there is any inconsistency in the description of activities between the University timetable and the Course Outline (as updated in Moodle), the description in the Course Outline/Moodle applies.

Image Credit

Kanimbla Valley (photo taken by T. Wiedmann)

CRICOS

CRICOS Provider Code: 00098G

Acknowledgement of Country

We acknowledge the Bedegal people who are the traditional custodians of the lands on which UNSW Kensington campus is located.

Appendix: Engineers Australia (EA) Professional Engineer Competency Standard

Program Intended Learning Outcomes	
Knowledge and skill base	
PE1.1 Comprehensive, theory based understanding of the underpinning natural and physical sciences and the engineering fundamentals applicable to the engineering discipline	✓
PE1.2 Conceptual understanding of the mathematics, numerical analysis, statistics, and computer and information sciences which underpin the engineering discipline	✓
PE1.3 In-depth understanding of specialist bodies of knowledge within the engineering discipline	✓
PE1.4 Discernment of knowledge development and research directions within the engineering discipline	✓
PE1.5 Knowledge of engineering design practice and contextual factors impacting the engineering discipline	
PE1.6 Understanding of the scope, principles, norms, accountabilities and bounds of sustainable engineering practice in the specific discipline	✓
Engineering application ability	
PE2.1 Application of established engineering methods to complex engineering problem solving	✓
PE2.2 Fluent application of engineering techniques, tools and resources	✓
PE2.3 Application of systematic engineering synthesis and design processes	
PE2.4 Application of systematic approaches to the conduct and management of engineering projects	✓
Professional and personal attributes	
PE3.1 Ethical conduct and professional accountability	✓
PE3.2 Effective oral and written communication in professional and lay domains	✓
PE3.3 Creative, innovative and pro-active demeanour	✓
PE3.4 Professional use and management of information	
PE3.5 Orderly management of self, and professional conduct	✓
PE3.6 Effective team membership and team leadership	✓