Life-Cycle Analysis and Sustainability Assessment (250462)

General Information

School	ETSECCPB
Departments	Departament d'Enginyeria Civil i Ambiental (DECA) Departament d'Enginyeria de Projectes i de la Construcció (EPC)
Credits	5.0 ECTS
Programs	MÀSTER UNIVERSITARI EN ENGINYERIA AMBIENTAL (pla 2014) MÀSTER UNIVERSITARI EN ENGINYERIA DE CAMINS, CANALS I PORTS (pla 2012) MÀSTER UNIVERSITARI EN ENGINYERIA DE CAMINS, CANALS I PORTS (pla 2012) PARS: ENGINYER/A DE CAMINS, CANALS I PORTS (pla 2022)
Course	2024/25

Main teaching language at each group

- Group 10ES2 Spanish (Q2)

Faculty

Responsible Faculty: Sebastian Olivella Pastalle, Ivan Puig Damians
Faculty: Sebastian Olivella Pastalle, Ivan Puig Damians, Alfonso Rodriguez Dono

Objectives of Education

Specialization subject in which knowledge on specific competences is intensified.

Knowledge and skills at specialization level that permit the development and application of techniques and methodologies at advanced level.

Contents of specialization at master level related to research or innovation in the field of engineering.

Understanding the following concepts / ideas:

- Sustainability involves aspects / variables of very different types and quantified with different units
- Multicriteria decision techniques are particularly suitable for assessing / quantifying sustainability
- The consideration of the entire life cycle is essential to properly evaluate the environmental impact or sustainability of a process or product
- The life cycle analysis tools are currently accepted for assessing the environmental impact of a process or product.

Detailed knowledge of the following terms in the field of the subject:

- Functional unit, system boundaries, stages of life cycle analysis, life cycle inventory, impact mapping, stages of assessing the impact of the life cycle, classification, characterization, standardization, value function, ranking, weighting , assessment, evaluation, carbon footprints and water

Capacity planning and development of the following processes:

- Analysis of the complete life cycle of a process or product related to the construction (infrastructure, buildings), including all stages (definition and objectives of the study, functional unit, system boundaries, life

cycle inventory, impact, etc..), and definition of carbon footprint and water.
- Definition of flowcharts arbitrary systems for environmental assessment including a detailed study of the allocation of impacts
- Quantification of all the sustainability of a process or product related to the construction (infrastructure, buildings), including all stages (definition of the ranking, weighting, assessment, evaluation, etc..).
- Application of multiattribute utility theory and value analysis to arbitrary decision-making processes using different weighting schemes (ordinal, cardinal, analytical hierarchical analysis, etc..), Valuation (various functions, etc.).

Knowledge of these aspects within the scope of the subject:

- Types of life cycle analysis, standardization of life cycle analysis, software tools available to carry out life cycle analysis, examples of application of life cycle analysis in the field of infrastructure parameters determine the sustainability of infrastructure, ranking procedures, weighting, evaluation and aggregation of decision parameters, examples of application of sustainability assessment in the field of infrastructure, software tools available to carry out life cycle analysis and sustainability assessment, both open (applicable to arbitrary cases) and closed (eg for the assessment of buildings).

Competencies

Especific

Knowledge of all kinds of structures and materials and the ability to design, execute and maintain structures and buildings for civil works.

Transversal

ENTREPRENEURSHIP AND INNOVATION: Being aware of and understanding the mechanisms on which scientific research is based, as well as the mechanisms and instruments for transferring results among socio-economic agents involved in research, development and innovation processes.
SUSTAINABILITY AND SOCIAL COMMITMENT: Being aware of and understanding the complexity of the economic and social phenomena typical of a welfare society, and being able to relate social welfare to globalisation and sustainability and to use technique, technology, economics and sustainability in a balanced and compatible manner.
TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.

Total hours of student work

		Hours	Percentage
Supervised Learning	Large group	25.5 h	56.67 %
	Medium group	9.75 h	21.67 %
	Laboratory classes	9.75 h	21.67 %
	Guided Activities	0.0 h	0.00 %
Self Study		80.0 h	

Contents

1. INTRODUCTION TO THE SUBJECT

1.1. OBJECTIVES
1.2. ORGANIZATION AND DOCUMENTATION
1.2.1. Approach
1.2.2. Development
1.2.3. Program and bibliography
1.2.4. Evaluation

Specific Objectives

Knowledge of basic contents and objectives of the subject and general aspects of its organization (focus, development, schedule, bibliography and qualification).

2. SUSTAINABILITY CONCEPT AND LIFE CYCLE

2.1. SUSTAINABLE DEVELOPMENT AND SUSTAINABILITY
2.1.1. Background and historical development
2.1.2. Application to the construction and infrastructures sector
2.2. LIFE CYCLE PROCESSES AND PRODUCTS
2.2.1. Relevance of the concept
2.2.2. Application for infrastructure

Specific Objectives

Knowledge, understanding and reasoning ability related to the concepts of sustainability, sustainable development and life cycle processes and products, particularly in the field of construction and infrastructures, knowledge of its historical background and understanding of their relevance and importance in the current context.

3. ENVIRONMENTAL ASSESSMENT PROCESS AND PRODUCTS. LIFE CYCLE ANALYSIS

3.1. DEFINITION OF LIFE CYCLE ANALYSIS AND MAIN STAGE
3.2. FLOW CHART AND INVENTORY OF THE LIFE CYCLE. ALLOCATION OF IMPACTS
3.3. LIFE CYCLE IMPACTS ASSESSMENT
3.3.1. Classification. Impact categories
3.3.2. Characterization
3.3.3. Normalization, clustering and weighting
3.3.4. Types of models and methodologies
3.4. CARBON TRACES AND WATER
3.5. TYPES OF ENVIRONMENTAL ASSESSMENTS. ISO AND EUROPEAN STANDARDS

Specific Objectives

Knowledge, understanding and reasoning ability and full development of individual cases related to the methodology of life cycle analysis with particular focus on its application in the field of construction and infrastructures and including all stages and aspects involved, as allocation or impact categories. Knowledge, understanding and reasoning ability related to the concepts of carbon footprint and water. Knowledge of the types of environmental assessments and standards in relation to life cycle analysis.

4. TOOLS FOR THE APPLICATION OF LIFE CYCLE ANALYSIS

4.1. COMPUTER TOOLS AND DATABASES
4.2. PRESENTATION OF A SPECIFIC INFORMATION TOOL
4.2.1. Background
4.2.2. Main databases
4.2.3. Impact Methodologies
4.2.4. User Interface
4.3. APPLICATION EXAMPLE OF THE COMPUTER TOOL
4.3.1. Objectives and scope
4.3.2. Entering inventory data
4.3.3. Creating assemblies and life cycle stage of the process or product
4.3.4. Presentation and interpretation of results. Analysis and comparison

Specific Objectives

Knowledge of tools and computer databases for the use of the methodology of life cycle analysis. Knowledge, understanding and capacity of life cycle analysis application, with particular focus on its use in the field of construction and infrastructures, using existing software tools, with specific use and seeing throw one of them deeply.

5. EXAMPLES OF INFRASTRUCTURE ENVIRONMENTAL ASSESSMENT

5.1. PAVEMENTS IN AREAS OF LOW TRAFFIC INTENSITY (INDUSTRIAL AND URBAN)
5.1.1. Approach and background. Methodology
5.1.2. Objectives, functional unit and system boundaries
5.1.3. Life cycle inventory
5.1.4. Assessment of impacts
5.1.5. Results and analysis
5.2. OTHER EXAMPLES FROM THE LITERATURE
5.2.1. Railroad sleepers
5.2.2. Urban wastewater
5.2.3. Road pavements
5.2.4. Bridges

Specific Objectives

Knowledge and understanding of the use of the methodology of life cycle analysis in several specific cases in the field of construction and infrastructures.

6. SUSTAINABILITY ASSESSMENT. MULTICRITERIA DECISIONS

6.1. PARAMETERS FOR THE SUSTAINABILITY ASSESSMENT
6.1.1. Parameter types
6.1.2. Deterministic and probabilistic approaches
6.1.3. Necessity of methodologies to multi-criteria decision
6.1.4. Opened models and closed models
6.2. EXAMPLES OF PARAMETERS IN INFRASTRUCTURE
6.2.1. Environmental pillar
6.2.2. Economic pillar
6.2.3. Social pillar
6.2.4. Other parameters

Specific Objectives

Knowledge, understanding and reasoning ability related to required parameters for sustainability assessment and specific examples in the field of construction and infrastructures. Knowledge and understanding of deterministic and probabilistic approaches and open and closed models for sustainability assessment.

7. VALUE ANALYSIS AND THEORY MULTIATRIBUTE UTILITY

7.1. HISTORY, ELEMENTS AND TYPES OF DECISION
7.1.1. Background and approach
7.1.2. Structure and terminology
7.1.3. Classification methods
7.2. SELECTION OF VARIABLES AND RANKING
7.2.1. Characteristics of the variables
7.2.2. Structure of the variables. Requirements tree
7.3. WEIGHTING METHODS
7.3.1. Approach
7.3.2. Direct, ordinal, cardinal and by comparison methods
7.3.3. Analytical hierarchical analysis
7.4. METHODS OF ASSESSMENT, AGGREGATION AND DECISION
7.4.1. Value functions
7.4.2. Aggregation methods
7.4.1. Multiattribute decision techniques

Specific Objectives

Knowledge, understanding and reasoning skills and application of value analysis and multiattribute utility theory, particularly in the field of sustainability assessment in the field of construction and infrastructures, including the selection and ranking of relevant variables, the weighting procedures with different methodologies (ordinal, cardinal, analytical hierarchical analysis), and measurement methods, aggregation

and mediating different multicriteria decision procedures. Knowledge and understanding of the background and methodologies available to the application of value analysis and multiattribute utility theory.

8. MODELS OF SUSTAINABILITY ASSESSMENT

8.1. GENERAL APPROACH TO OPEN MODELS
8.1.1. Requirements tree
8.1.2. Components
8.1.3. Life cycle
8.2. WEIGHTING, VALUATION AND AGGREGATION
8.2.1. Direct weighting and comparison by pairs
8.2.2. Value functions
8.2.3. Aggregation procedure
8.3. ANALYSIS OF RESULTS
8.3.1. Selection criteria
8.3.2. Matrix of relative variation
8.4. PROBABILISTIC APPROACH. PROCEDURE AND RESULTS

Specific Objectives

Knowledge, understanding and reasoning ability and application, particularly in the field of construction and infrastructures, models for sustainability assessment based on value analysis and multiattribute utility theory including all their phases (selection and ranking of variables, weighting, evaluation, assessment, aggregation and analysis). Knowledge and understanding of deterministic and probabilistic settings.

9. OPEN TOOL FOR ASSESSMENT OF SUSTAINABILITY

9.1. STRUCTURE AND ACCESS TO THE APPLICATION
9.2. UTILIZATION METHODOLOGIES
9.2.1. Modules and interfaces between them
9.2.2. Programming module
9.2.3. User module
9.2.4. Report module
9.3. OUTPUT DATA AND RESULTS, AND ANALYSIS
9.4. APPLICATION PROCEDURES AND WEBSITE

Specific Objectives

Knowledge, understanding and reasoning ability and application, particularly in the field of construction and infrastructures, open software tools for sustainability assessment based on value analysis and multiattribute utility theory including all modules (developer, user, report, analyzer) and use.

10. EXAMPLES OF ASSESSMENT OF SUSTAINABLE INFRASTRUCTURE

10.1. SEWERAGE PIPES
10.1.1. Approach and background. Methodology
10.1.2. Requirements tree
10.1.3. Weighing
10.1.4. Value functions
10.1.5. Alternatives
10.1.6. Results and analysis
10.2. CONCRETE STRUCTURES (13th ANNEX OF EHE-O8)
10.2.1. Approach and background. Methodology
10.2.2. Requirements tree and weighting for the environmental index
10.2.3. Value functions
10.2.4. Sustainability index
10.2.5. Probabilistic approach
10.3. OTHER EXAMPLES
10.3.1. Concrete industrial floors
10.3.2. Infrastructure for rainwater utilization
10.3.3. Electric mobility infrastructures
10.4. BUILDING SYSTEMS EVALUATION

Specific Objectives

Knowledge and understanding of the use of methodologies and tools for sustainability assessment in several specific cases, in the field of construction and infrastructures, including open and closed methods and deterministic and probabilistic settings.

EVALUATION

Activities

INTERNAL CONFERENCES

During the course, and depending on circumstances and availability, conferences on topics of interest to the subject can be orgenised at the school

Dedication

3h

EXTERNAL CONFERENCES

During the course, and depending on circumstances and availability,the attendance at external conferences on topics of interest for the subject can be organised, preferably in the geographical environment of the school to optimize time and resources

Dedication

3h

Teaching Methodology

The course consists of 3 hours per week of classes in the classroom in one group.De three scheduled weekly hours typically devoted two sessions to more exhibitions focusing on conceptual and theoretical and practical aspects in resolution of problems and exercises, including practical informàtiques.S uses material support through the virtual campus Athena (content, programming and evaluation activities of learning and literature). The course is trying to encourage participation of students and their work before and after classes. For classes not taught all the material included in the program but these focus on issues of major importance and difficulty, leaving the rest to work with the help of students' personal notes and additional documentation provided in the context of the subject. Additionally voluntary consultation sessions organized and, eventually, conferences and visits. A class is basically used the blackboard, and complementarily, audiovisual materials (Internet, slides and videos).

Although most of the sessions will be given in the language indicated, sessions supported by other occasional guest experts may be held in other languages.

Grading Rules

(*) The evaluation calendar and grading rules will be approved before the start of the course.

The overall result of the course is obtained from all course grades (exams - 30 %, assignments - 60 % and class activities - 15 %).

According to the above criteria, those students who participate in the continuous assessment are graded at 105%. In contrast, those who decide to go to the final exam directly, the weighting of the exam is 100% of the grade.

There will be at least a final individual exam and a group paper related, the latter, to the life cycle analysis (50 %) and the sustainability assessment (50 %) of civil engineering products, construction solutions or any other subject that may be approved.

Exams may include theoretical or applied questions.

Test Rules

To pass the course the student must have completed the course assignment and reach, globally, a score greater than or equal to 5/10 or have passed the individual final exam.

Office Hours

Hours of assistance to students are carried out both during the intervals between classes and through personally agreed hours or agreed hours by e-mail

Bibliography

Basic

- World Commission on Environment and Development. Our common future. Oxford: Oxford University, 1987. ISBN 019282080X.
- Mulder, K. Desarrollo sostenible para ingenieros. Reimpresión de la primera edición. Barcelona: Edicions UPC, 2007. ISBN 9788483018927.
- Scientific Applications International Corporation (SAIC). Life cycle assessment: principles and practice. Cincinnati: National Risk Management Research Laboratory, 2006.
- European Commission - Joint Research Centre - Institute for Environment and Sustainability. International Reference Life Cycle Data System (ILCD) Handbook - General guide for Life Cycle Assessment - Detailed guidance. First edition. Luxembourg.: Publications Office of the European Union, 2010. ISBN 978-92-79-19092-6.
- Sergio Barba-Romero Casillas y Jean-Charles Pomerol. Multicriterion Decision in Management: Principles and Practice. Softcover reprint of the original 1st ed. 2000. Springer, 2012. ISBN 978-1461370086.
- Carlos Romero. Análisis de las Decisiones Multicriterio. Primera edición. Madrid: Isdefe - Ingeniería de Sistemas, 1996. ISBN 84-89338-14-0.

Complementary

- Mark Goedkoop, An De Schryver, Michiel Oele, Sipke Durksz y Douwe de Roest. SimaPro 7 - Introduction into LCA. Report version 4.5. Amersfoort, Holanda: Pré Consultants, 2010.
- Mark Goedkoop, An De Schryver, Michiel Oele, Douwe de Roest, Marisa Vieira y Sipke Durksz. SimaPro 7 Tutorial. Report version 3.5. Amersfoort, Holanda: Pré Consultants, 2010.
- labein-tecnalia - UPV-EHU - UPC. La medida de la sostenibilidad en edificación industrial - Modelo Integrado de Valor de Edificios Sostenibles (MIVES). 1ª Edición. Bilbao: Eduardo Rojí - coordinador, 2006. ISBN 84-690-2629-1.