

## 250462 - ANCIVIAVSO - Life-Cycle Analysis and Sustainability Assessment

Coordinating unit:	250 - ETSECCPB - Barcelona School of Civil Engineering
Teaching unit:	751 - DECA - Department of Civil and Environmental Engineering
Academic year:	2015
Degree:	MASTER'S DEGREE IN ENVIRONMENTAL ENGINEERING (Syllabus 2014). (Teaching unit Compulsory) MASTER'S DEGREE IN CIVIL ENGINEERING (PROFESSIONAL TRACK) (Syllabus 2012). (Teaching unit Optional) MASTER'S DEGREE IN ENVIRONMENTAL ENGINEERING (Syllabus 2009). (Teaching unit Optional) MASTER'S DEGREE IN CIVIL ENGINEERING (RESEARCH TRACK) (Syllabus 2009). (Teaching unit Optional)
ECTS credits:	5
Teaching languages:	Spanish, English

### Teaching staff

Coordinator:	ALEJANDRO JOSA GARCIA-TORNEL
Others:	ALEJANDRO JOSA GARCIA-TORNEL

### Opening hours

Timetable:	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
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### Degree competences to which the subject contributes

#### Specific:

8162. Knowledge of all kinds of structures and materials and the ability to design, execute and maintain structures and buildings for civil works.

### 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 (slides and videos).

### Learning objectives of the subject

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.

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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).

### Study load

Total learning time: 125h	Theory classes:	19h 30m	15.60%
	Practical classes:	9h 45m	7.80%
	Laboratory classes:	9h 45m	7.80%
	Guided activities:	6h	4.80%
	Self study:	80h	64.00%

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### Content

<p>1. INTRODUCTION TO THE SUBJECT</p>	<p>Learning time: 2h 24m Theory classes: 1h Self study : 1h 24m</p>
<p>Description:</p> <ul style="list-style-type: none"> <li>1.1. OBJECTIVES</li> <li>1.2. ORGANIZATION AND DOCUMENTATION <ul style="list-style-type: none"> <li>1.2.1. Approach</li> <li>1.2.2. Development</li> <li>1.2.3. Program and bibliography</li> <li>1.2.4. Evaluation</li> </ul> </li> </ul> <p>Specific objectives:</p> <p>Knowledge of basic contents and objectives of the subject and general aspects of its organization (focus, development, schedule, bibliography and qualification).</p>	
<p>2. SUSTAINABILITY CONCEPT AND LIFE CYCLE</p>	<p>Learning time: 8h 24m Theory classes: 3h 30m Self study : 4h 54m</p>
<p>Description:</p> <ul style="list-style-type: none"> <li>2.1. SUSTAINABLE DEVELOPMENT AND SUSTAINABILITY <ul style="list-style-type: none"> <li>2.1.1. Background and historical development</li> <li>2.1.2. Application to the construction and infrastructures sector</li> </ul> </li> <li>2.2. LIFE CYCLE PROCESSES AND PRODUCTS <ul style="list-style-type: none"> <li>2.2.1. Relevance of the concept</li> <li>2.2.2. Application for infrastructure</li> </ul> </li> </ul> <p>Specific objectives:</p> <p>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.</p>	

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<p><b>3. ENVIRONMENTAL ASSESSMENT PROCESS AND PRODUCTS. LIFE CYCLE ANALYSIS</b></p>	<p>Learning time: 10h 48m Theory classes: 4h 30m Self study : 6h 18m</p>
<p>Description:</p> <ul style="list-style-type: none"> <li>3.1. DEFINITION OF LIFE CYCLE ANALYSIS AND MAIN STAGE</li> <li>3.2. FLOW CHART AND INVENTORY OF THE LIFE CYCLE. ALLOCATION OF IMPACTS</li> <li>3.3. LIFE CYCLE IMPACTS ASSESSMENT <ul style="list-style-type: none"> <li>3.3.1. Classification. Impact categories</li> <li>3.3.2. Characterization</li> <li>3.3.3. Normalization, clustering and weighting</li> <li>3.3.4. Types of models and methodologies</li> </ul> </li> <li>3.4. CARBON TRACES AND WATER</li> <li>3.5. TYPES OF ENVIRONMENTAL ASSESSMENTS. ISO AND EUROPEAN STANDARDS</li> </ul> <p>Specific objectives:</p> <p>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.</p>	
<p><b>4. TOOLS FOR THE APPLICATION OF LIFE CYCLE ANALYSIS</b></p>	<p>Learning time: 10h 48m Practical classes: 4h 30m Self study : 6h 18m</p>
<p>Description:</p> <ul style="list-style-type: none"> <li>4.1. COMPUTER TOOLS AND DATABASES</li> <li>4.2. PRESENTATION OF A SPECIFIC INFORMATION TOOL <ul style="list-style-type: none"> <li>4.2.1. Background</li> <li>4.2.2. Main databases</li> <li>4.2.3. Impact Methodologies</li> <li>4.2.4. User Interface</li> </ul> </li> <li>4.3. APPLICATION EXAMPLE OF THE COMPUTER TOOL <ul style="list-style-type: none"> <li>4.3.1. Objectives and scope</li> <li>4.3.2. Entering inventory data</li> <li>4.3.3. Creating assemblies and life cycle stage of the process or product</li> <li>4.3.4. Presentation and interpretation of results. Analysis and comparison</li> </ul> </li> </ul> <p>Specific objectives:</p> <p>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.</p>	

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<p><b>5. EXAMPLES OF INFRASTRUCTURE ENVIRONMENTAL ASSESSMENT</b></p>	<p>Learning time: 7h 11m Practical classes: 3h Self study : 4h 11m</p>
<p>Description:</p> <ul style="list-style-type: none"> <li>5.1. PAVEMENTS IN AREAS OF LOW TRAFFIC INTENSITY (INDUSTRIAL AND URBAN) <ul style="list-style-type: none"> <li>5.1.1. Approach and background. Methodology</li> <li>5.1.2. Objectives, functional unit and system boundaries</li> <li>5.1.3. Life cycle inventory</li> <li>5.1.4. Assessment of impacts</li> <li>5.1.5. Results and analysis</li> </ul> </li> <li>5.2. OTHER EXAMPLES FROM THE LITERATURE <ul style="list-style-type: none"> <li>5.2.1. Railroad sleepers</li> <li>5.2.2. Urban wastewater</li> <li>5.2.3. Road pavements</li> <li>5.2.4. Bridges</li> </ul> </li> </ul> <p>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.</p>	
<p><b>6. SUSTAINABILITY ASSESSMENT. MULTICRITERIA DECISIONS</b></p>	<p>Learning time: 3h 35m Theory classes: 1h 30m Self study : 2h 05m</p>
<p>Description:</p> <ul style="list-style-type: none"> <li>6.1. PARAMETERS FOR THE SUSTAINABILITY ASSESSMENT <ul style="list-style-type: none"> <li>6.1.1. Parameter types</li> <li>6.1.2. Deterministic and probabilistic approaches</li> <li>6.1.3. Necessity of methodologies to multi-criteria decision</li> <li>6.1.4. Opened models and closed models</li> </ul> </li> <li>6.2. EXAMPLES OF PARAMETERS IN INFRASTRUCTURE <ul style="list-style-type: none"> <li>6.2.1. Environmental pillar</li> <li>6.2.2. Economic pillar</li> <li>6.2.3. Social pillar</li> <li>6.2.4. Other parameters</li> </ul> </li> </ul> <p>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.</p>	

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### 7. VALUE ANALYSIS AND THEORY MULTIATTRIBUTE UTILITY

Learning time: 7h 11m

Theory classes: 3h

Self study : 4h 11m

#### Description:

- 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.

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<p><b>8. MODELS OF SUSTAINABILITY ASSESSMENT</b></p>	<p>Learning time: 7h 11m Theory classes: 3h Self study : 4h 11m</p>
<p>Description:</p> <ul style="list-style-type: none"> <li>8.1. GENERAL APPROACH TO OPEN MODELS <ul style="list-style-type: none"> <li>8.1.1. Requirements tree</li> <li>8.1.2. Components</li> <li>8.1.3. Life cycle</li> </ul> </li> <li>8.2. WEIGHTING, VALUATION AND AGGREGATION <ul style="list-style-type: none"> <li>8.2.1. Direct weighting and comparison by pairs</li> <li>8.2.2. Value functions</li> <li>8.2.3. Aggregation procedure</li> </ul> </li> <li>8.3. ANALYSIS OF RESULTS <ul style="list-style-type: none"> <li>8.3.1. Selection criteria</li> <li>8.3.2. Matrix of relative variation</li> </ul> </li> <li>8.4. PROBABILISTIC APPROACH. PROCEDURE AND RESULTS</li> </ul> <p>Specific objectives:</p> <p>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.</p>	
<p><b>9. OPEN TOOL FOR ASSESSMENT OF SUSTAINABILITY</b></p>	<p>Learning time: 7h 11m Practical classes: 3h Self study : 4h 11m</p>
<p>Description:</p> <ul style="list-style-type: none"> <li>9.1. STRUCTURE AND ACCESS TO THE APPLICATION</li> <li>9.2. UTILIZATION METHODOLOGIES <ul style="list-style-type: none"> <li>9.2.1. Modules and interfaces between them</li> <li>9.2.2. Programming module</li> <li>9.2.3. User module</li> <li>9.2.4. Report module</li> </ul> </li> <li>9.3. OUTPUT DATA AND RESULTS, AND ANALYSIS</li> <li>9.4. APPLICATION PROCEDURES AND WEBSITE</li> </ul> <p>Specific objectives:</p> <p>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.</p>	

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<p>10. EXAMPLES OF ASSESSMENT OF SUSTAINABLE INFRASTRUCTURE</p>	<p>Learning time: 7h 11m Practical classes: 3h Self study : 4h 11m</p>
<p>Description:</p> <ul style="list-style-type: none"> <li>10.1. SEWERAGE PIPES <ul style="list-style-type: none"> <li>10.1.1. Approach and background. Methodology</li> <li>10.1.2. Requirements tree</li> <li>10.1.3. Weighing</li> <li>10.1.4. Value functions</li> <li>10.1.5. Alternatives</li> <li>10.1.6. Results and analysis</li> </ul> </li> <li>10.2. CONCRETE STRUCTURES (13th ANNEX OF EHE-08) <ul style="list-style-type: none"> <li>10.2.1. Approach and background. Methodology</li> <li>10.2.2. Requirements tree and weighting for the environmental index</li> <li>10.2.3. Value functions</li> <li>10.2.4. Sustainability index</li> <li>10.2.5. Probabilistic approach</li> </ul> </li> <li>10.3. OTHER EXAMPLES <ul style="list-style-type: none"> <li>10.3.1. Concrete industrial floors</li> <li>10.3.2. Infrastructure for rainwater utilization</li> <li>10.3.3. Electric mobility infrastructures</li> </ul> </li> <li>10.4. BUILDING SYSTEMS EVALUATION</li> </ul> <p>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.</p>	
<p>EVALUATION</p>	<p>Learning time: 21h 36m Laboratory classes: 9h Self study : 12h 36m</p>

### Qualification system

The overall result of the course is obtained from all course grades (exams - 50 %, assignments- 50 % and class activities).

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 other subjects that may be approved.

Exams may include theoretical or applied questions .



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### Regulations for carrying out activities

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.

### Bibliography

#### Basic:

World Commission on Environment and Development. Our common future. Oxford: Oxford University, 1987. ISBN 019282080X.

Mulder, K. Desarrollo sostenible para ingenieros [on line]. Reimpresión de la primera edición. Barcelona: Edicions UPC, 2007 [Consultation: 22/09/2016]. Available on: <<http://hdl.handle.net/2099.3/36831>>. ISBN 9788483018927.

Scientific Applications International Corporation (SAIC). Life cycle assessment principles and practice. Reston, VA, Estados Unidos, 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.