

## Course guides

### 295109 - 295II024 - Sustainability & Circular Economy

Last modified: 04/06/2021

**Unit in charge:** Barcelona East School of Engineering  
**Teaching unit:** 713 - EQ - Department of Chemical Engineering.

**Degree:** ERASMUS MUNDUS MASTER'S DEGREE IN ADVANCED MATERIALS SCIENCE AND ENGINEERING (Syllabus 2014). (Optional subject).  
MASTER'S DEGREE IN CHEMICAL ENGINEERING (Syllabus 2019). (Compulsory subject).  
MASTER'S DEGREE IN INTERDISCIPLINARY AND INNOVATIVE ENGINEERING (Syllabus 2019). (Compulsory subject).  
MASTER'S DEGREE IN MATERIALS SCIENCE AND ADVANCED MATERIALS ENGINEERING (Syllabus 2019). (Compulsory subject).

**Academic year:** 2021    **ECTS Credits:** 6.0    **Languages:** English

#### LECTURER

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**Coordinating lecturer:** CESAR ALBERTO VALDERRAMA ANGEL

**Others:** Primer quadrimestre:  
VERÒNICA MARTÍNEZ SÀNCHEZ - T11, T12  
ÍNGRID MUNNÉ COLLADO - T11, T12  
CESAR ALBERTO VALDERRAMA ANGEL - T11, T12

Segon quadrimestre:  
VERÒNICA MARTÍNEZ SÀNCHEZ - T10  
ÍNGRID MUNNÉ COLLADO - T10  
CESAR ALBERTO VALDERRAMA ANGEL - T10

#### DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

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##### Specific:

CEMUEQ-10. To adapt to the structural changes of society motivated by factors or phenomena of an economic, energetic or natural character and to contribute with technological solutions with a high commitment of sustainability

CEMUEII-06. Evaluate the sustainability of the proposed technological solutions and their associated risks to address a problem in a quantitative and objective manner, as well as propose schemes that favor the reutilization of resources and the circular economy.

##### General:

CGMUEQ-01. Ability to apply the scientific method and the principles of engineering and economics, to formulate and solve complex problems in processes, equipment, facilities and services, in which the matter undergoes changes in its composition, state or energy content, characteristic of the chemical industry and other related sectors among which are the pharmaceutical, biotechnological, materials, energy, food or environmental

CGMUEQ-06. Have the capacity to analyze and synthesize the continuous progress of products, processes, systems and services using safety, economic viability, quality and environmental management criteria

CGMUEQ-07. Integrate knowledge and face the complexity of making judgments and decisions, based on incomplete or limited information, including reflections on the social and ethical responsibilities of professional practice

CGMUEII-03. Analyze the economic, social and environmental impact of technical solutions to base strategic decisions on criteria of objectivity, transparency and professional ethics.

##### Transversal:

02 SCS. SUSTAINABILITY AND SOCIAL COMMITMENT. Being aware of and understanding the complexity of social and economic phenomena that characterize the welfare society. Having the ability to relate welfare to globalization and sustainability. Being able to make a balanced use of techniques, technology, the economy and sustainability.

03 TLG. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in with the future needs of the graduates of each course.

## TEACHING METHODOLOGY

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The following activities will be carried out, either in or outside the classroom, in the development of the course:

1. Lectures, participative sessions and problem solving sessions
2. Homework and assignments
3. Project
4. Mid-term and final Exam

Detailed project information regarding the scope, content, format, deadlines, etc., will be presented in an attached document.

The methodology designed for this course is the Project based learning (PBL), the students would use the Gabi software (Think step) and the support of Isabel Fullana (Sustainability Solution Manager Think step- Responsible Spain & Portugal). Other software can be used as OpenLCA and Ccal.

Invited speakers are experts who work on sustainable assessment and can participate in the definition of the system and supervising the progress of the teams.

## LEARNING OBJECTIVES OF THE SUBJECT

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At the end of the course the student will be able to:

- Distinguish between the concepts of the use of resources and efficiency in terms of sustainable development and the linkage of thermodynamics science and environmental impact.
- Perform a sustainable assessment of a technological system by using the exergy analysis.
- Demonstrate a good knowledge and understanding of the tools used for sustainability analysis with emphasis on carbon footprint, Life cycle assessment and Life cycle costing.
- Evaluate the technological, environmental and economic feasibility of a system through the life cycle perspective.

## STUDY LOAD

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Type	Hours	Percentage
Self study	96,0	64.00
Hours large group	36,0	24.00
Hours small group	18,0	12.00

**Total learning time:** 150 h



## CONTENTS

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### 1. Introduction to Circular Economy

**Description:**

Definition and principles. Key characteristics and enabling factors of a circular economy. Resource, environmental, economic and social benefits of circular economy. Circular economy in the European and global context. Revalorisation of waste to energy, products. Description of the main routes of characterization of wastes/raw materials to quantify their energetic or material valorisation potential.

**Specific objectives:**

The student will develop a basic understanding of the concept of circular economy and its potential application in the framework of the European context.

The student will learn how to characterize wastes and how they can be revalorized according to its properties in a circular economy context

**Related activities:**

Homework assignment: Short exercises

**Full-or-part-time:** 10h

Theory classes: 6h

Guided activities: 2h

Self study : 2h

### 2. Sustainability exergy analysis

**Description:**

Sustainability and exergy. Preliminary quantification methods: Sustainable Resource Utilization Parameter, Exergy Efficiency, The Environmental Compatibility. Novel accounting methods (LCA perspective).

**Specific objectives:**

Distinguish between the concepts of the use of energy resources and energy efficiency in terms of sustainable development and the linkage of thermodynamics science and environmental impact.

**Related activities:**

Homework assignment: Short exercises

**Full-or-part-time:** 4h

Theory classes: 2h

Self study : 2h



### 3. Methodologies of economic and environmental evaluation (LCA/LCC)

**Description:**

LCA target audience and applications. LCA framework, goal and scope. Inventory analysis, allocation Impact assessment. Carbon footprint methodology. LCC as complement of LCA. LCC methodology. Key concepts of LCC.

**Specific objectives:**

The student will be able to identify the different stages of a life cycle analysis and how to align the economic issues associated through the LCC.

The student will be able to develop a basic inventory from a system/industrial process and to perform a carbon footprint analysis.

**Related activities:**

Homework assignment: Short exercises

Project: LCA and carbon footprint analysis through the CCalC, a general life cycle methodology and decision support tool.

**Full-or-part-time:** 14h

Theory classes: 8h

Guided activities: 4h

Self study : 2h

### 4. Social life cycle assessment (S-LCA)

**Description:**

Introduction. Categories of Sustainability Assessment. Social assessment methods. S-LCA Methodologies. Goal and Scope. Inventory analysis. Impact Assessment. Interpretation. Tools used in the S-LCA.

**Specific objectives:**

The students will be able to develop a step-by-step S-LCA analysis of a case study for an energy system.

**Related activities:**

Co-operative learning approach based on a case study of S-LCA.

**Full-or-part-time:** 6h

Theory classes: 2h

Guided activities: 2h

Self study : 2h



## 5. Waste processing technologies for the production of energy

### Description:

Introduction to waste to energy (WtE) conversion. WtE conversion plants in the framework of Circular Economy Policy. WtE technology options: co-processing, anaerobic digestion, landfill gas collection, thermal treatment of municipal solid waste (MSW), pyrolysis / gasification, incineration. Types of feedstock for WtE systems and their characteristics. WtE systems, engineering and technology: Pre- processing and treatment of municipal solid waste (MSW) prior to incineration, Municipal solid waste (MSW) combustion plants, Waste firing in large combustion plants, WtE systems for district heating. Environmental impacts of WtE conversion plants. Pollution control systems for waste to energy technologies.

### Specific objectives:

The student will be able to analyse and estimate the potential energy recovery from feedstock and the significant benefits that represent their valorisation in waste-to-energy systems. The student will be able to evaluate a waste-to-energy conversion plant from a sustainable perspective

### Related activities:

Homework assignment: Short exercises

Project: Conversion of Municipal Solid Waste (MSW) to produce Electricity through the Solid and Gaseous Biomass Carbon Calculator software.

### Full-or-part-time: 10h

Theory classes: 4h

Guided activities: 2h

Self study : 4h

## 6. Solid waste processing technologies for the production of products

### Description:

Solids wastes are generated in large extension in the industrial and urban cycles and processing routes to recover added values or by-products will be developed. Definition of treatment flow-sheets identification of treatment or processing technologies, development of associated mass and energy balance will be defined. Routes of valorisation for different industrial applications will be selected and requirements of quality will be provided.

### Specific objectives:

The student will be able to analyse and estimate the potential material recovery from solid wastes and the significant benefits that represent their valorisation in waste-to-products systems.

### Related activities:

Activity 1: Solving problems related to the unit content.

### Full-or-part-time: 12h

Theory classes: 4h

Guided activities: 4h

Self study : 4h



## 7. Water regeneration and recycling technologies

### Description:

Water in the context of circular economy. Current water resources and uses. Alternative hydric resources. Water regeneration and recycling. Water treatment technologies. Membrane-based technologies. Innovative hybrid systems. Industrial wastewater valorisation and reuse. Potential circularity in water sector. Industrial symbiosis.

### Specific objectives:

The student will learn which routes and technologies are available today for the regeneration and reuse of wastewater in a circular economy context.

### Related activities:

Activity 1: Solving problems related to the unit content.

### Full-or-part-time: 12h

Theory classes: 4h

Guided activities: 4h

Self study : 4h

## 8. Urban Energy Sustainability and Smart Cities

### Description:

Cities are complex entities, in which numerous actors and diverse scenarios are superimposed. Urban energy sustainability should be aimed at improving the balance of raw material flows and the production of waste/pollutants, which will unfailingly improve urban habitability, as well as favour the global goals of sustainable development. Indicators for Urban Energy Sustainability are presented. Smart energy systems are analysed and the concept of Smart Cities is presented.

### Specific objectives:

The student will learn to evaluate Urban Energy Sustainability and impact of Smart Cities.

### Related activities:

Activity: Solving problems related to the unit content.

### Full-or-part-time: 11h

Theory classes: 5h

Guided activities: 4h

Self study : 2h

## GRADING SYSTEM

The final grade is determined according to the following equation:

$$\text{Final grade} = \text{MEX} \cdot 0.17 + \text{FEX} \cdot 0.23 + \text{HOM} \cdot 0.17 + \text{PRO} \cdot 0.43$$

Homework and assignments (HOM)

Project (PRO)

Mid-term (MEX)

and final Exam (FEX)

In this course there is no retake exam and since the learning methodology is project-based learning, the project activity should be carried out throughout the semester to pass the course.

## BIBLIOGRAPHY

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### Basic:

- Hunkeler, David; Lichtenwort, Kerstin; Rebitzer, Gerald. Environmental life cycle costing [on line]. Pensacola, Fla.: SETAC, 2008 [Consultation: 21/04/2020]. Available on: <https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=570462>. ISBN 9781420054736.
- Klinghoffer, Naomi B.; Castaldi, Marco J. Waste to energy conversion technology [on line]. Oxford: Elsevier Science & Technology, 2013 [Consultation: 21/04/2020]. Available on: <https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=1574937>. ISBN 9780124051904.
- Dinçer, Ibrahim; Rosen, Marc A. Exergy : energy, environment, and sustainable development [on line]. Amsterdam ; Boston: Elsevier, 2007 [Consultation: 21/04/2020]. Available on: <https://www.sciencedirect.com/science/book/9780080445298>. ISBN 9780080531359.

## RESOURCES

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### Other resources:

- Spire Circular Economy Road-Map: <https://www.spire2030.eu/intro>
- EU Circular economy Road Map: [https://ec.europa.eu/growth/industry/sustainability/circular-economy\\_en](https://ec.europa.eu/growth/industry/sustainability/circular-economy_en)
- Scientific papers from different databases: Science Direct, Scopus
- Use the remote access to the UPC library: [https://apps.bibliotecnica.upc.edu/discovery/bases\\_dades/](https://apps.bibliotecnica.upc.edu/discovery/bases_dades/)
- Energy Ebook Package Springer Link: <http://link.springer.com/search?facetcontenttype=%22Book%22&package=40367&showAll=false>
- SHDB tutorial: <https://www.youtube.com/watch?v=WTLlhrSr4aU&t=517s>
- Social Hotspots Database (SHDB) tutorial: <https://www.youtube.com/watch?v=WTLlhrSr4aU&t=517s>
- UNEP-SETAC, United Nations Environment Programme (UNEP) (2009), Guidelines for social life cycle assessment of products. UNEP/SETAC Life Cycle Initiative. Available at: [http://www.unep.org/pdf/DTIE\\_PDFS/DTIx1164xPA-guidelines\\_sLCA.pdf](http://www.unep.org/pdf/DTIE_PDFS/DTIx1164xPA-guidelines_sLCA.pdf)
- UNEP-SETAC (2013) The methodological sheets for subcategories in Social Life Cycle Assessment. Available at: [https://www.lifecycleinitiative.org/wp-content/uploads/2013/11/S-LCA\\_methodological\\_sheets\\_11.11.13.pdf](https://www.lifecycleinitiative.org/wp-content/uploads/2013/11/S-LCA_methodological_sheets_11.11.13.pdf)
- GRI (2011) Sustainability Reporting Guidelines" Global Reporting Initiative <https://www.globalreporting.org/resource/library/G3.1-Guidelines-Incl-Technical-Protocol.pdf>