



EMISSION FREE EUROPEAN UNIVERSITIES
Strategic Development of Students' Sustainability Competences
in Engineering Sciences

Work Package #3
Curriculum and Module Development

EFEU Teaching Units



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Disclaimer

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List of Abbreviations

CSRD - Corporate Sustainability Reporting Directive

DHBW - Duale Hochschule Baden-Württemberg (Baden-Wuerttemberg Cooperative State University)

ECTS – European Credit Transfer and Accumulation System

EFEU – Emission Free European Universities

ESD – Education for Sustainable Development

ESG -Environmental, Social, and Governance

ESPR –Ecodesign for Sustainable Products Regulation

HEIs – Institutes for Higher Education

IPL – Polytechnic Institute of Leiria

LCA – Life Cycle Assessment

Metropolia - Metropolia University of Applied Sciences

SDGs - Sustainable Development Goals

SDSR - Sustainable Development Social Responsibility

UPHF- Université Polytechnique Hauts de France

WPs – Work Packages

About this Publication

This publication presents the collection of transversal and disciplinary teaching units within the third work package of the Erasmus+ Strategic Partnership project, "Emission Free European Universities" (EFEU).

The publication provides the results of an extensive curriculum analysis of the engineering programs, offered in the project partners' schools of engineering. The overarching goal is to provide shared teaching units to interested universities that can be directly implemented.

The teaching modules selected highlight two scopes in order to describe the general concepts for processes and regulations in sustainability:

Scope 1: Sustainable Development & International Regulations

Scope 2: Sustainable Production & Life Cycle Assessment (LCA), Decarbonation
Process by Recycling and Circular Economy

This publication is available via the project website at:

<https://www.dhbw-stuttgart.de/forschung-transfer/technik/projekte/efeu/project-outcomes/>

1 Introduction – The EFEU Project

1.1 Project's Background, Aims & Partners

Education plays a key role in preparing individuals to effectively generate and implement creative and sustainable solutions (Ariza et al., 2021). It equips individuals with the essential knowledge, values, and skills needed to become responsible environmental citizens. The EFEU project is pivotal in addressing this issue by offering impactful approaches to transform learning and teaching activities at the campuses of the partner universities and potentially other institutions of higher learning.

The Emission Free European Universities (EFEU) project aims to enhance sustainability competencies and achieve carbon neutrality in engineering programs at four partner institutions: Baden-Württemberg Cooperative State University (DHBW-Stuttgart), Polytechnic Institute of Leiria (IPL) in Portugal, Metropolia University of Applied Sciences in Helsinki, and Polytechnic University of Hauts-de-France (UPHF) in Valenciennes.

1.2 Project Roadmap

Logical Framework - EFEU Emission free European universities

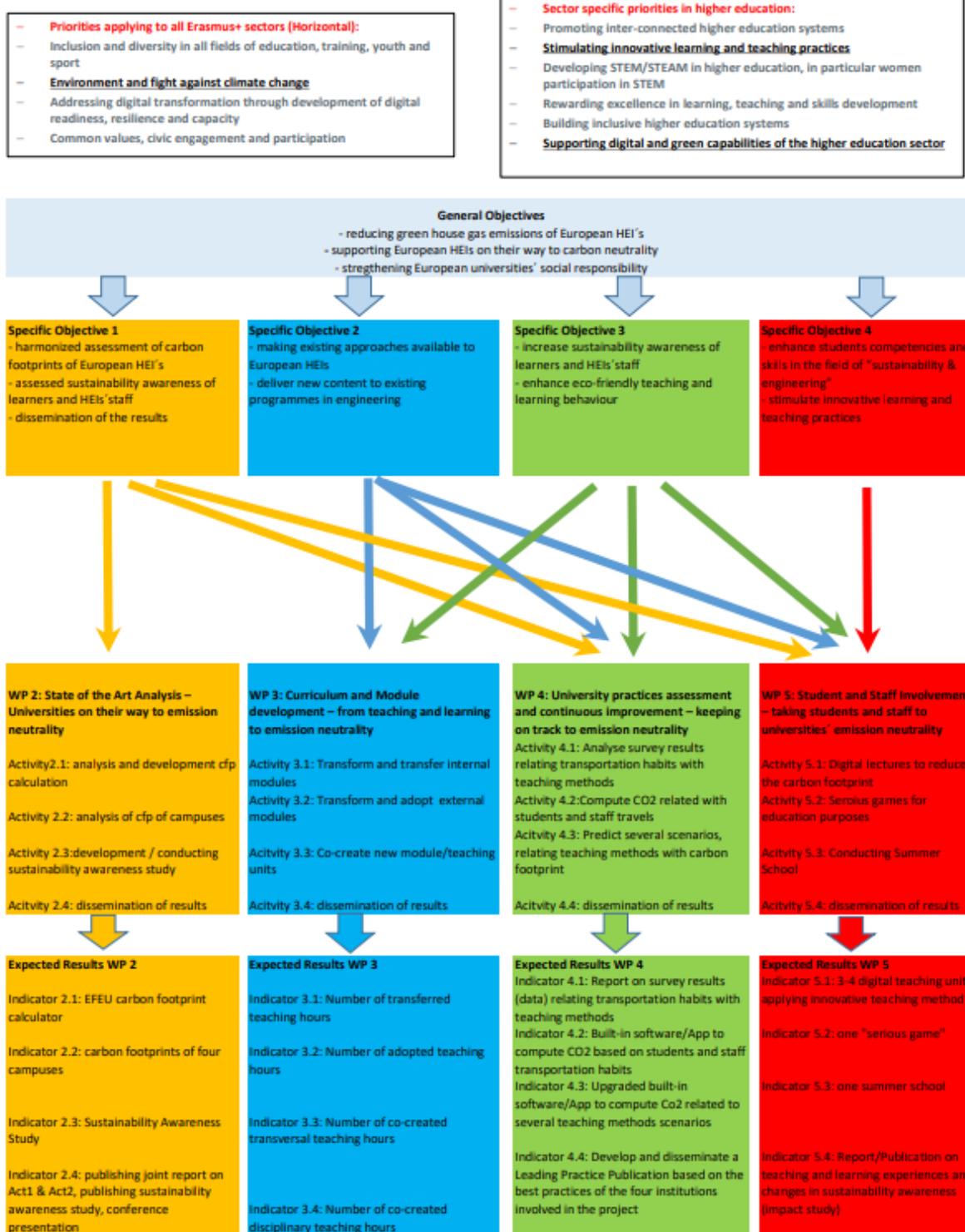


Figure 1: Project Overview EFEU – Work Packages

The project is structured into five work packages - WP (Figure 1). WP1 focuses on the project management activities. The leader of this WP is the DHBW, whom the project partners will strongly support. The objective of this WP is to ensure the utmost success

of the project's implementation through the hosting of project meetings, project tracking, documentation, quality supervision, budget control, time management, risk mitigation, communication and coordination, as well as ensuring inclusion and green practices are being promoted. Support from project partners is expected to ensure the timely and accurate submission of information related to project activities, results and progress, as well as financial matters.

The aims of WP2 are to gather information about the four partner universities' carbon footprint and assess the sustainability awareness of students and staff. The WP will begin with the research and revision of existing tools and end with the development of the EFEU Carbon Footprint Calculator. This tool, intended to be open source, will be used by partner universities and eventually by universities outside of the project consortium (dissemination and replication) to determine their carbon footprint during the use phase.

Accompanying the EFEU CFC will be a description of the methodology to support the utilisation of the calculator. This document will define the system's boundaries, the means of collecting and processing data, and the necessary input values. Once the tool and the methodology are completed, partners will collect data about their university campuses and determine the carbon footprint of at least one university campus. The calculation tool should be seen as a tracker with which each university can monitor their levels of carbon emissions and track their progress in the implementation of sustainability strategies and climate targets. The carbon footprint assessment results will be used to develop the subsequent WPs' content.

The four partner universities will develop and administer a sustainability awareness survey. The results from the sustainability awareness assessment will be used to develop the content of WP3, WP4, and WP5 and, therefore, curricula, teaching methods, and learning activities. The results of the carbon footprint and sustainability awareness survey will be presented in an open webinar at each partner university and at one international conference.

The objectives of WP3 are to target, select, plan, and develop one of the core actions of the EFEU project – develop critical competences and skills of future mechanical,

electrical, industrial and business engineers in the field of sustainability. The outcomes will be critical to the planned activities of WP5. In the development of new teaching material (adoption of external examples or co-creation of brand-new content), two kinds of modules may be considered:

- Transversal modules that do not necessarily belong to a given program but can optionally be attended by any bachelor student, irrespective of the student's discipline (including humanities). This should be the primary target for co-developing a 3 to 5 ECTS module.
- Disciplinary modules that belong to existing programs. Generally, it will not be possible to create an additional module because programs have a fixed amount of teaching hours. In that case, it would rather be a retrofit of an existing disciplinary module in which the Sustainable Development Social Responsibility (SDSR) aspect is inadequately covered.

The maturity of each partner in the many themes covered by the project will be assessed. A partner can be qualified as "uninformed", "aware", "beginner", "qualified", or "expert". WP3 will create the conditions to improve the SDSR maturity of every partner individually and of the EFEU consortium as a whole, employing:

- Combined actions (serial, parallel asynchronous, parallel synchronous);
- Transversal modules transfer, optimisation, adoption or creation from scratch;
- Representative disciplinary modules creation in different domains (mechanical engineering, electrical engineering, industrial engineering and business engineering), and
- Consolidation of best practices applied internally and disseminated externally.
- Making experiences of this work package available to other stakeholders and universities.

Certain agreed-upon methodologies, proceedings, and approaches established by the EFEU team will be used in the execution of the EFEU project and the individual work packages.

2 EFEU Methodology

The Erasmus+ EFEU project adopts an exploratory approach to research and employs an action research methodology. The project consortium has devised a structured five-step process for implementation by utilising a mixed-method approach, resulting in five comprehensive reports and various implementations. Methodologies employed include literature review, qualitative and quantitative surveys, expert interviews, co-creation workshops, and piloting of teaching and learning events.

Based on an extensive curriculum analysis the project identified learning gaps and best practices in teaching sustainability in engineering disciplines. Co-creation workshops involving teachers, academic and industry experts, and practitioners determined the requisite knowledge and skills for integrating sustainable practices into student curricula. In this phase, best practices identified in teaching and learning events will be transferred to the project partners.

Throughout the project, the transfer of learning activities will be encouraged to facilitate closer collaboration with project partners and nurture capacity-building among students and staff. Additionally, emphasis will be placed on dissemination activities to publicise the project outcomes and promote their potential use in academia and industry.

3 Teaching Units: Sustainable Development & International Regulations

3.1 Introduction to Sustainability Principles

Coordinating University:

IPL Polytechnic Institute of Leiria, Portugal

Degree:

Master/Bachelor

Year	Semester	Contact Hours	Workload	ECTS
suitable for all years, with no pre-requisites	suitable for all semester	3h	30h	1

Coordinating Lecturer

Marcelo Gaspar, marcelo.gaspar@ipleiria.pt

Teaching Staff

Marcelo Gaspar et al.

Course Description:

This teaching module aims to introduce the concepts of Sustainability and Sustainable Development. Both these principles have become fundamental frameworks for addressing the pressing global challenges of our time. These concepts are deeply rooted in achieving a balance between economic growth, environmental management, and social well-being to ensure a viable and equitable future for all.

Learning Objectives

1. The Concept of Sustainability

- o Sustainability refers to the ability to meet present needs without compromising the ability of future generations to meet theirs. It seeks to balance three interconnected dimensions:
 - (a) Environmental Sustainability: Protecting ecosystems and natural resources from degradation while promoting responsible resource management.
 - (b) Economic Sustainability: Ensuring stable and inclusive economic growth that provides opportunities for prosperity without depleting finite resources.
 - (c) Social Sustainability: Fostering equity, justice, and community resilience to enhance societal well-being.

2. The Triple Bottom Line (TBL) Approach

- o The Triple Bottom Line (TBL) framework expands traditional measures of success, focusing on three key dimensions, often referred to as the "3 Ps":
 - (a) People: Social equity and the well-being of communities, ensuring fair access to resources, opportunities, and quality of life.
 - (b) Planet: Environmental responsibility, focusing on reducing ecological footprints, conserving biodiversity, and mitigating climate change.
 - (c) Profit: Economic value creation, emphasizing sustainable financial performance and the equitable distribution of wealth.

3. Understanding Sustainable Development

- The concept of sustainable development gained international recognition through the 1987 Brundtland Report, defining it as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs."
- This definition emphasizes responsible and inclusive progress that integrates environmental, economic, and social dimensions.

4. The Need for Sustainability in the Modern Context

- Sustainable development offers a pathway to tackle these challenges by integrating TBL principles into global, national, and local policies. By aligning economic systems with ecological boundaries and social needs, sustainable development ensures progress without exceeding planetary limits.
- Unchecked economic development and resource exploitation have led to pressing global issues, including:
 - (a) Climate change and its cascading impacts.
 - (b) Ecosystem degradation and biodiversity loss.
 - (c) Economic inequalities between developed and developing nations.
 - (d) Social instability stemming from resource scarcity and unsustainable practices.

Syllabus

1. The Concept of Sustainability
2. The Triple Bottom Line (TBL) Approach
3. Understanding Sustainable Development
4. The Need for Sustainability in the Modern Context

Teaching Methodologies

One 3-hour seminar conveyed synchronous/ asynchronous teaching using digital course material

Assessment

Assessment through a final Quiz test made online by the students.

Bibliography

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<https://doi.org/10.1007/978-94-007-1972-9>

3.2 ESG - Compliance and Sustainable Business Practices

Coordinating University:

Baden-Wuerttemberg Cooperative State University Stuttgart (DHBW Stuttgart), Germany

Degree:

Master/Bachelor

Year	Semester	Contact Hours	Workload	ECTS
suitable for all years, with no pre-requisites	suitable for all semester	3h	30h	1

Coordinating Lecturer

Prof. Dr. Klaus Homann, klaus.homann@dhbw-stuttgart.de

Teaching Staff

Prof. Dr. Christian Götz, Prof. Dr. Klaus Homann

Course Description:

This module provides an in-depth understanding of ESG (Environmental, Social, and Governance) regulations and their impact on corporate governance. It explores key regulatory frameworks, disclosure requirements, and the challenges of ESG implementation. The module focuses on the Corporate Sustainability Reporting Directive (CSRD), the European Sustainability Reporting Standards (ESRS), the EU-Taxonomy. Additionally, the history of ESG, the development of ESG reporting, and the concept of green investments will be covered.

Learning Objectives

Students will gain knowledge of European ESG standards and their impact on corporate governance. They will explore key ESG principles and understand the role of regulation in promoting corporate sustainability. The course will enable students to compare major ESG regulatory frameworks, including CSRD, ESRS, and the EU Taxonomy. Additionally, they will assess ESG reporting requirements and compliance mechanisms, evaluating their influence on corporate decision-making. By the end of the module, students will be able to develop strategic recommendations for effectively integrating ESG principles into business operations.

Syllabus:

This teaching unit consists of three learning units:

1. Introduction: Why ESG Matters
2. Corporate sustainability reporting directive (CSRD) and European Sustainability Reporting Standards (ESRS)
3. Best Practices in Corporate Sustainability Reporting – Strategy, Road Map, Case Studies

Teaching Methodologies:

The course is offered as web-based learning or in-person seminar providing digital course materials, such as pre-recorded lectures and academic literature. It consists of

three separate learning units, each with a workload of 10 hours. Students will work independently according to the provided schedule.

Assessment

Students will have assignments that they will share with others. Mutual feedback is required to progress through the course. Assessment through a final Quiz test made online by the students.

Bibliography

t.b.d.

3.3 ESPR – Introduction to the European Ecodesign for Sustainable Products Regulation

Coordinating University:

Baden-Wuerttemberg Cooperative State University Stuttgart (DHBW Stuttgart), Germany

Degree:

Master/Bachelor

Year	Semester	Contact Hours	Workload	ECTS
From year 2, basic knowledge of corporate governance and sustain-ability (recommended)	From semester 3	3h	30h	1

Coordinating Lecturer

Prof. Dr. Klaus Homann, klaus.homann@dhbw-stuttgart.de

Teaching Staff

Prof. Dr. Christian Götz, Prof. Dr. Klaus Homann

Course Description:

This module provides an in-depth understanding of European regulatory framework for the design of sustainable products. It explores the objectives and scope of the regulation and introduces to the requirements for the durability, reusability, reparability and recyclability of products. The module focuses on:

- Circular economy: Concepts for increasing the proportion of recycled materials and promoting the circular economy.
- Pollutant management: Measures to reduce or avoid substances that hinder recyclability.
- Information obligations: Requirements for the provision of product information and transparency towards consumers.

Learning Objectives

Students will gain knowledge of European regulatory framework for the design of sustainable products (ESPR) and their impact on corporate governance. They will explore key ESPR principles and understand the role of the regulation for the future design of industrial products. The module enables students to assess the sustainable design of products and improve their sustainability. Students know the main obligations that manufacturers of physical products have to fulfil, in particular with regard to the provision of digital product passports in accordance with the respective valid list of product groups.

Syllabus:

This teaching unit consists of 3 learning units:

1. Introduction: Why ESPR matters
2. Eco-Design for Sustainable Products Regulation – key principles and scope of the regulation:
 - Resource efficiency
 - Circularity
 - Pollutant reduction
 - Information obligations
3. Best Practices in eco-design of sustainable products

Teaching Methodologies:

The course is offered as web-based learning or in-person seminar providing digital course materials, such as pre-recorded lectures and academic literature. It consists of three separate learning units, each with a workload of 10 hours. Students will work independently according to the provided schedule.

Assessment

Students will have assignments that they will share with others. Mutual feedback is required to progress through the course. Assessment through a final Quiz test made online by the students.

Bibliography

t.b.d.

3.4 Decarbonization & Education: How to modify our Carbon Footprint?

Coordinating University:

UPHF Université Polytechnique Hauts de France, Valenciennes, France

Degree:

Master/Bachelor

Year	Semester	Contact Hours	Workload	ECTS
suitable for all years, with no pre-requisites	suitable for all semester	3h	30h	1

Coordinating Lecturer

El Hadj Dogheche, elhadj.dogheche@uphf.fr

Teaching Staff

Gouy Olivier

Course Description:

The aim of the course is to use cross-disciplinary skills on sustainable development and corporate social responsibility to show students how to act facing the climate change.

Learning Objectives

Students will gain knowledge of the existing sources of energy and their impact for global warming. They will use the carbon footprint calculation as a key tool for the investigation. The module enables students to define some daily actions for the reduction of the initial carbon footprint. Students find and design new indicators for more efficient calculations. They assess the results of this reduction and they develop an educational initiative with the aim of reduction

Syllabus

This teaching unit consists of 3 learning units:

1. Introduction to energy, global warmings and carbon footprint
2. Act for Decarbonation – key principles and scope of the carbon footprint reduction
 - Calculation tools
 - Mobility and Energy
 - Selection of Indicators
 - Transition and adaptability
3. Best Practices for educational initiatives

Teaching Methodologies

One 3-hour seminar conveyed synchronous/ asynchronous teaching using digital course material

Assessment

Teaching unit assessment through a Quiz test made online by the students.

Bibliography

World Without End: An Illustrated Guide to the Climate Crisis Hardcover – March 11, 2025 by Christophe Blain, Jean-Marc Jancovici

3.5 Carbone society, a systemic point of view

Coordinating University:

UPHF Université Polytechnique Hauts de France, Valenciennes, France

Degree:

Master/Bachelor

Year	Semester	Contact Hours	Workload	ECTS
suitable for all years, with no pre-requisites	suitable for all semester	3h	30h	1

Coordinating Lecturer

El Hadj Dogheche, elhadj.dogheche@uphf.fr

Teaching Staff

Eloi Leuret—Ottavi

Course Description:

Nowadays, institutional discourses really are insistent about how society, through technology, individual changes and minor adjustments, will find solutions to mitigate the climate crisis. In French, we have a saying that I find most accurate for the actual situation: “the tree that’s hiding the forest”.

So I imagined that, together, we could take a moment to investigate better why are we facing this crisis, from a systemic point of view. I’m quite sure that with a better understanding of the deep reasons and myths behind our society’s failure, we’ll be capable of discerning alternative pathways. What are the behinds of this systemic, complex and vital challenge our society is facing right now?

Learning Objectives

The learning objectives of the teaching unit are :

- Assess the systemic problems posed by our “fossil fuels-based society”
 - Cite the limits of decarbonization regarding the deep roots of the environmental crisis
 - Investigate alternative paths aiming at the world we would like to live in.
1. Climate crisis : “virtually certain”.
 - a. Auto assessment: how well do I understand the climate crisis?
 - b. Scientific evidences and its major conclusions
 - i. Conclusions of IPCC AR6 group n°1 – physical science basis
 - ii. Conclusions of IPCC AR6 group n°2 – impacts, adaptation and vulnerability
 - iii. Conclusions of IPCC AR6 group n°3 – mitigation of climate change
 2. Myths
 - a. Technology and transitions
 - i. Will technology save us ?
 - ii. There are no transitions

- iii. The systemic approach
- b. Problems posed by a solutionist vision
 - i. Definitions
 - ii. Society's mechanisms of change: a sociology's perspective
3. Alternatives
 - a. Map of the ecological theories
 - b. Acts
 - i. The action grid of Adeline de Lepinay
 - ii. Take actions: examples that inspire

Syllabus

Reduce the greenhouse gases emissions in the mobility sector is one of the biggest and most urgent priorities in order to limit climate change. So, what are the changes that our society needs? What is UE planning in the future? What are the obstacles, and how do we overcome them?

Some questions we'll investigate together, on the path to mitigate climate change.

Teaching Methodologies

One 3-hour seminar conveyed synchronous/ asynchronous teaching using digital course material

Assessment

Assessment through a small "surpriseness report". Write half a page or less to express what surprised me in this lecture ?

Bibliography

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- Problèmes posés par la vision solutionniste - Sophie DUBUISSON-QUELLIER, 2024. <https://www.youtube.com/watch?v=75CQRP9nZGk>.
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4 Teaching Units: Sustainable Production & Life Cycle Assessment, Decarbonation Process by Recycling and Circular Economy

4.1 Eco-Efficiency and Circular Economy Tools

Coordinating University:

IPL Polytechnic Institute of Leiria, Portugal

Degree:

Master/Bachelor

Year	Semester	Contact Hours	Workload	ECTS
suitable for all years, with no pre-requisites	suitable for all semester	3h	30h	1

Coordinating Lecturer

Marcelo Gaspar, marcelo.gaspar@ipleiria.pt

Teaching Staff

Marcelo Gaspar et al.

Course Description:

This teaching module aims at introducing the concepts of Eco-Efficiency and Circular Economy Tools. These tools have emerged as pivotal frameworks to optimize resource use, minimize waste, and promote sustainability across industries..

Learning Objectives

1. The Concept of Eco-Efficiency

- Eco-efficiency combines ecological and economic performance by creating more value with fewer resources and less environmental impact. Consequentially, Eco-Efficiency aims at:
 - (d) Reducing resource intensity: Optimizing material, water, and energy use.
 - (e) Minimizing environmental impacts: Lowering emissions, waste, and ecological disruption.
 - (f) Enhancing product value: Designing durable, recyclable, and resource-efficient products.

2. The Circular Economy: A Paradigm Shift

- The circular economy challenges the traditional linear model by promoting a regenerative system where materials and resources circulate within the economy for as long as possible. It is built upon three core principles:
 - (a) Design out waste and pollution: Eliminating waste at the source through innovative design.
 - (b) Keep products and materials in use: Extending product lifespans through repair, reuse, remanufacturing, and recycling.

- (c) Regenerate natural systems: Enhancing ecosystems by returning valuable nutrients and minimizing environmental extraction.

3. Key Tools for Eco-Efficiency and Circular Economy

- o Several tools enable the practical application of eco-efficiency and circular economy principles, including:
 - (a) Environmental Management Systems (EMS): EMS is a systematic approach for organizations to manage their environmental responsibilities.
 - (b) Environmental Product Declarations (EPD): EPDs provide transparent and standardized information about a product's environmental performance throughout its lifecycle.
 - (c) Life Cycle Engineering (LCE): LCE Integrates sustainability into the design, production, and disposal phases of a product.
 - (d) Life Cycle Assessment (LCA): LCA is a systematic tool used to evaluate the environmental impacts of a product, process, or service throughout its entire life cycle. It provides a comprehensive view by considering every stage, from raw material extraction to manufacturing, distribution, use, and disposal.

Syllabus

1. The Concept of Eco-Efficiency
2. The Circular Economy: A Paradigm Shift
3. Key Tools for Eco-Efficiency and Circular Economy

Teaching Methodologies

One 3-hour seminar conveyed synchronous/ asynchronous teaching using digital course material

Assessment

Assessment through a final Quiz test made online by the students.

Bibliography

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<https://doi.org/10.1016/j.resconrec.2017.10.034>

4.2 Sustainable Design

Coordinating University:

IPL Polytechnic Institute of Leiria, Portugal

Degree:

Master/Bachelor

Year	Semester	Contact Hours	Workload	ECTS
suitable for all years, with no pre-requisites	suitable for all semester	3h	30h	1

Coordinating Lecturer

Marcelo Gaspar, marcelo.gaspar@ipleiria.pt

Teaching Staff

Rui Ruben

Course Description:

Engineering is adapting to the new challenges. So, 21st century engineering is not the same. Design and manufacturing should be sustainable. The main objective of this teaching unit is to understand the new paradigms of sustainable design and the new methods and technology available to design better products with less carbon footprint

Learning Objectives

1. **Design to Sustainable Design**
 - New design methodologies
 - Customized computational tools to characterize new sustainable materials
2. **Sustainable Materials and Additive Manufacturing**
 - From industrial waste to additive manufacturing
 - From food waste to additive manufacturing
3. **Local Industry**
 - Local circular economy and local factory

Syllabus

1. The Concept of Eco-Design
2. Key Tools for Eco-Design

Teaching Methodologies

The curricular unit teaching methodologies are: Synchronous / asynchronous teaching using digital course material

Assessment

Teaching unit assessment ...No

Bibliography

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- Guedes, J.M., Kikuchi, N. (1990). Preprocessing and postprocessing for materials based on the homogenization method with adaptive finite element methods. Computer methods in applied mechanics and engineering 83,143-198.

4.3 Introduction to the concepts of the environmental footprint for a manufactured product

Coordinating University:

UPHF Université Polytechnique Hauts de France, Valenciennes, France

Degree:

Master/Bachelor

Year	Semester	Contact Hours	Workload	ECTS
suitable for all years, with no pre-requisites	suitable for all semester	3h	30h	1

Coordinating Lecturer

El Hadj Dogheche, elhadj.dogheche@uphf.fr

Teaching Staff

Loic Lezzani

Course Description:

This course highlights the problems that our planet faces as a result of our consumption and will understand the environmental processes involved in the production of a product and the concepts of environmental footprint concerned. The "Environmental footprint and eco-design" typically falls under the domain of sustainability engineering, focusing on methods to measure and mitigate environmental impacts of products and services through eco-conscious design practices

Learning Objectives

1-Introduction to Sustainable Production

- Introduction to, background and standards
- Life Cycle Assessment (LCA) theory
- Requirements for Sustainability

2- Environmental footprint and eco-design

- How to carry out an eco-design: SIMAPRO software application
- Sustainable Design
- Environmental Foot Print

3- Multi-criteria analysis

- Ecological Impact
- Resource Management
- Waste Reduction
- Energy Efficiency
- Environmental innovation

Syllabus

- 1- Understanding what design entails
- 2- Be aware of the environmental impacts during product development
- 3- Applying the eco-design analysis approach

Teaching Methodologies

One 3-hour seminar conveyed synchronous/ asynchronous teaching using digital course material

Assessment

Assessment through a small “surpriseness report”. Write half a page or less to express what surprised me in this lecture ?

Bibliography

- ADEME: French Organisation for Sustainability <https://economie-circulaire.ademe.fr/ecoconception>
- ADEME, Étude d'opportunités sur l'écoconception de produits (biens et services), les modèles d'affaires et l'écologie industrielle, étude réalisée pour le compte de l'ADEME par I Care Environnement, ENEA Consulting, 2011.
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- Teulon, Hélène, Le Guide de l'éco-innovation, éditions Eyrolles, 2014, 280 p.

4.4 Introduction to Life Cycle Assessment

Coordinating University:

Metropolia University of Applied Sciences, Helsinki

Degree:

Master/Bachelor

Year	Semester	Contact Hours	Workload	ECTS
suitable for all years, with no pre-requisites	suitable for all semester	3h	30h	1

Coordinating Lecturer

Sergio Rossi, sergior@metropolia.fi

Teaching Staff

Sergio Rossii

Course Description:

This course introduces students to the fundamental concepts and methodologies of Life Cycle Assessment (LCA). LCA is a tool used to assess the environmental impacts of products and systems throughout their entire life cycle, from raw material extraction to disposal. The course covers the four main phases of LCA: goal and scope definition, life cycle inventory, life cycle impact assessment, and interpretation. Students will learn how to apply LCA to various products and systems, and understand its importance in sustainable development.

Learning Objectives:

1. Understand the principles and methodology of Life Cycle Assessment.
2. Learn about the history and development of LCA, including why it was introduced.
3. Understand the four stages of an LCA:
 - a. Goal and scope definition,
 - b. Inventory analysis,
 - c. Impact assessment,
 - d. Interpretation of the results and recommendation.
4. Apply LCA to real-world case studies in various sectors.

Syllabus

- Life Cycle Assessment
- life cycle inventory, life cycle impact assessment

Teaching Methodologies

The course is offered in the form of a web course, students will work independently according to the given schedule. The learning material is mainly in the form of videos,

readings and individual assignments which will be shared with other students. A 1,5-hour interactive, online seminar will follow the individual study part.

Assessment

Assessment through a final Quiz test made online by the students. The students will have one week after the interactive seminar to complete the Quiz test.

Bibliography

Teacher's own materials

4.5 Introduction to Materials Recycling

Coordinating University:

IPL Polytechnic Institute of Leiria, Portugal

Degree:

Master/Bachelor

Year	Semester	Contact Hours	Workload	ECTS
suitable for all years, with no pre-requisites	suitable for all semester	3h	30h	1

Coordinating Lecturer

Marcelo Gaspar, marcelo.gaspar@ipleiria.pt

Teaching Staff

Marcelo Gaspar

Course Description:

This course introduces students to the fundamental concepts of materials recovery. This teaching module aims at introducing the concepts of Engineering Materials Recycling. The recycling of materials plays a crucial role in addressing the pressing global challenges of resource depletion, environmental degradation, and waste management. By promoting the reuse and reprocessing of materials, recycling reduces the demand for raw resources, minimizes waste, and contributes to sustainability and eco-efficiency.

Learning Objectives

1. The Importance of Materials Recycling

- Materials recycling is integral to achieving circularity in the economy. Instead of the traditional "take-make-dispose" model, recycling promotes a closed-loop system where resources are reused, reducing the environmental footprint of human activities. Key-benefits on recycling include:
 - (a) Resource Conservation: Reducing the need for virgin materials and preserving finite natural resources.
 - (b) Energy Savings: Many recycling processes consume less energy compared to primary material production.
 - (c) Waste Reduction: Diverting waste from landfills and minimizing pollution.
 - (d) Economic Opportunities: Creating jobs in recycling industries and generating value from materials once considered waste.

2. Principles of Materials Recycling

- Key-aspects on engineering materials recycling principles and processes.

3. Types of Recyclable Materials

- Recycling encompasses a wide range of materials, each requiring specific methods and technologies:
 - (e) Metals: Ferrous (steel, iron) and non-ferrous (aluminum, copper) metals are extensively recycled due to their high economic value and ease of reprocessing.
 - (f) Plastics: Recycled into new products or raw materials through mechanical or chemical processes.
 - (g) Glass: Easily recyclable without loss of quality, used in industries like packaging and construction.
 - (h) Paper and Cardboard: Recycled into new paper products, reducing deforestation and water use.
 - (i) Composite and Ceramic Materials: Emerging technologies are enabling the recycling of these complex materials, often used in advanced engineering applications.

4. Challenges in Recycling

- An up-to-date discussion on the main challenges that materials recycling faces upon recent technology and social demands:
 - (a) Contamination: Poor sorting and mixing of materials can reduce recycling efficiency and quality.
 - (b) Economic Viability: Recycling processes must be cost-effective to compete with virgin material production.
 - (c) Technological Gaps: Advanced materials, such as composites, require innovative methods for effective recycling.
 - (d) Consumer Awareness: Public participation in proper waste separation is crucial for successful recycling systems.

Syllabus

1. The Importance of Materials Recycling
2. Principles of Materials Recycling
3. Types of Recyclable Materials
4. Challenges in Recycling

Teaching Methodologies

One 3-hour seminar conveyed synchronous/ asynchronous teaching using digital course material

Assessment

Assessment through a final Quiz test made online by the students.

Bibliography

Achillas, D. (2012). *Material recycling: trends and perspectives*. Books.google.com.

4.6 Introduction to electrical waste recycling

Coordinating University:

UPHF Université Polytechnique Hauts de France, Valenciennes, France

Degree:

Master/Bachelor

Year	Semester	Contact Hours	Workload	ECTS
suitable for all years, with no pre-requisites	suitable for all semester	3h	30h	1

Coordinating Lecturer

El Hadj Dogheche, elhadj.dogheche@uphf.fr

Teaching Staff

El Hadj Dogheche et al

Course Description:

This course introduces students to the fundamental concepts of materials recycling for electronic sector. The teaching unit is focusing the growth rate and the technical issues for electrical waste as well as the international regulations. It includes the presentation of existing and the near future solutions for e-waste reduction. In this course, the learner will be confronted with the problems that our planet faces as a result of our consumption and will understand the health and the environmental issues related to e-waste expansion. A secured process of recycling is actually a key solution for reducing the carbon footprint into industrial processes production.

Learning Objectives

The objectives of the teaching unit are related to the growth rate and the technical issues for electrical waste as well as the international regulations. It includes the presentation of existing and the near future solutions for e-waste reduction. In this course, the learner will be confronted with the problems that our planet faces as a result of our consumption and will understand the health and the environmental issues related to e-waste expansion. A secured process of recycling is actually a key solution for reducing the carbon footprint into industrial processes production.

1. Global Definition for electrical Waste Materials

- a. Electrical Waste recycling is considered as a key issue objective in industries enabling a local ecosystem for available resources, improving the reuse, reducing the carbon foot print, providing a circular economy
- b. General Framework for electrical wastes: Legal definitions from official institution are mandatory to clearly define what is e-waste or not? Regulatory definition in the Environment Codes, Some key figures on general waste, UN-alarming report
- c. How do we produce the e-waste? : Investigating the Origin/Nature of e-waste production, Overview of the initial processes for electrical systems requiring the materials resources in micro nanotechnologies, categories of electrical wastes, Materials Composition into electrical wastes
- d. Recycling sites as urban mines: total volume processed by foundries

2. Concept of Extended Producer Responsibility (EPR)

- a. Waste regulations facing Company responsibilities
- b. Regulatory obligations for the collection and treatment of waste
- c. Fighting the planned obsolescence of manufactured products through consumer information
- d. Real cost for e-waste recycling processes, Economical cost for Companies taking action to reduce waste
- e. The production e waste key-aspects on engineering materials recycling principles and processes
- f. Develop re-use by implementing the eco design and increase the quantity of waste prepared for re-use
- g. Gradually extend sorting instructions to all plastic packaging into e-waste throughout UE by 2030, Reduce by 50% the quantities of non-hazardous non-inert waste admitted to landfill by 2030
- h. Pollution control and Risk preventions for the environment and health
- i. Circular economy for a new business model
- j. Basel UN agreement for e waste market

3. Existing and near Future Recycling Technologies

- a. Sorting e waste, Waste recovery recycling and Reusing: list of available materials, existing and potential future methods and technologies, actual limitations for volume treatments:
 - (a) List of e waste materials: metals, rare earth, plastics, ceramics, composites
 - (b) Collect and Recovery of materials: 3 main principles of waste management (3R as reuse, recycle and reduce), official plants, case of international traffic, Implementing a waste management approach
 - (c) Recycling processes: Manual and mechanized processes for materials recovery, overview of existing industrial production sites actual limitations , innovation recycling technologies

- (d) Reusing raw materials into production processes: basic fundamentals, available volume, perspectives using novel technologies existing into industries 4.0

Syllabus

1. Legal Definition of electrical Waste and International Regulations
2. Responsibility from Consumers to Producers
3. Key perspectives for efficient for e waste recovery and recycling

Teaching Methodologies

One 3-hour seminar conveyed synchronous/ asynchronous teaching using digital course material

Assessment

Assessment through a final study case with oral presentation or a Quiz test made online by the students.

Bibliography

- Tanskanen, Pia. "Management and recycling of electronic waste." *Acta materialia* 61.3 (2013): 1001-1011.
- Freyja Liselle Knapp (2020), Global Electronic Waste recycling : construction a new form of resource extraction for an old industry : <http://dissertations.umi.com/berkeley:19822>