EMISSION FREE EUROPEAN UNIVERSITIES

Strategic Development of Students' Sustainability Competences in Engineering Sciences

Work Package #3

Curriculum ad Module Development

EFEU Teaching Units

DHBW Duale Hochschule Baden-Württemberg Stuttgart

Helsinki Metropolia University of Applied Sciences

Université Polytechnique HAUTS-DE-FRANCE

POLITÉCNICO DE LEIRIA

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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 anlysis 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 and a set of slides for four of the developed units is available via the project website at:

https://www.dhbw-stuttgart.de/efeu

1 Teaching Units: Sustainable Development & International Regulations

1.1 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**
   - 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**
   - 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

Shmelev, S. E. (2012). Ecological Economics. Springer Netherlands. https://doi.org/10.1007/978-94-007-1972-9

1.2 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.

1.3 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.

1.4 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

1.5 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

- « AR6 Synthesis Report: Climate Change 2023 — IPCC ». Consulté le 27 février 2025. https://www.ipcc.ch/report/sixth-assessment-report-cycle/.
- Jean-Baptiste Fressoz, Sans transition. Une nouvelle histoire de l'énergie. Œconomia. History, Methodology, Philosophy, no 14-2 (1 juin 2024): 449-55. https://doi.org/10.4000/120ol.
- « "Organisons-nous ! Manuel critique" - www.education-populaire.fr », 1 octobre 2019. https://www.education-populaire.fr/organisons-nous-le-livre/.
- Problèmes posés par la vision solutionniste - Sophie DUBUISSON-QUELLIER, 2024. https://www.youtube.com/watch?v=75CQRP9nZGk.
- The Academy for Systems Change. « Leverage Points: Places to Intervene in a System ». Consulté le 27 février 2025. https://donellameadows.org/archives/leverage-points-places-to-intervene-in-a-system/.
- Wagner, Thomas. « La carte des pensées écologiques ». Bon Pote, 2 octobre 2024. https://bonpote.com/la-carte-des-pensees-ecologiques/.
- ET SI J'AVAIS QQ DIZAINES DE MINUTES POUR CAUSER DU SUJET CARBONO-CLIMATIQUE? Gérémy Panthou, Université Grenoble-Alpes, 25 Février 2025

2 Teaching Units: Sustainable Production & Life Cycle Assessment, Decarbonation Process by Recycling and Circular Economy

2.1 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**
   - 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

Kalmykova, Y., Sadagopan, M., & Rosado, L. (2018). Circular economy – From review of theories and practices to development of implementation tools. Resources, Conservation and Recycling, 135, 190–201. https://doi.org/10.1016/j.resconrec.2017.10.034

2.2 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

- Karl T. Ulrich, Steven D. Eppinger, Maria C. Yang. Product Design and Development, McGraw-Hill, 2020
- Juha Jeronen, Tero Tuovinen, Matti Kurki. Fundamental Mathematical Modeling of Additive Manufacturing. Springer, 2024.
- K. Deb. Optimization for Engineering Design: Algorithms And Examples. PHI, 2001.
- 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.

2.3 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
- Lice 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
- Environnemental 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.
- Duranthon Georges et Grisel Laurent, Pratiquer l'écoconception – Lignes directrices, AFNOR, septembre 2001, 128 p., AFNOR pratique collection
- Boeglin Nadia et Wetterwald Philippe, Autodéclarations : la promotion environnementale des produits, la norme NF ISO 14021, AFNOR éd., 2001.
- Teulon, Hélène, Le Guide de l'éco-innovation, éditions Eyrolles, 2014, 280 p.

2.4 Introduction to Life Cycle Assessment

Coordinating University:
Metropolia University of Applied Sciences, Helsinky

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 Rossi

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

2.5 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

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

2.6 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. **Understand the Concept of Electrical Waste**
    - Define electrical and electronic waste (e-waste) and recognize its importance as a global environmental challenge.
    - Identify common types of electrical waste and their environmental and health impacts when improperly managed.
2. **Explore E-Waste Regulations and Policies**
    - Understand international frameworks, such as the Basel Convention and EU WEEE Directive, governing e-waste management.

- Analyze national and regional laws concerning e-waste recycling, including producer responsibility and waste disposal standards.
- Examine the role of regulatory compliance in fostering sustainable recycling practices.

3. **Learn E-Waste Collection and Sorting Processes**
   - Identify methods and technologies used in the collection and categorization of electrical waste.
   - Discuss the significance of proper waste sorting in optimizing recycling efficiency and reducing contamination.
4. **Examine Recycling Technologies for E-Waste**
   - Gain an overview of mechanical, chemical, and thermal processes used in recycling electronic waste.
   - Explore cutting-edge technologies, such as hydrometallurgy, pyrometallurgy, and bioleaching, in recovering valuable materials like rare earth metals.
   - Evaluate the benefits and limitations of different recycling methods.
5. **Understand the Role of Circular Economy in E-Waste**
   - Learn how e-waste recycling contributes to the circular economy by reclaiming valuable resources and minimizing landfill dependency.
   - Discuss opportunities for reuse, refurbishment, and remanufacturing of electronics to extend product lifecycles.
6. **Develop Awareness of Environmental and Social Impacts**
   - Assess the environmental consequences of improper e-waste handling, including pollution and resource depletion.
   - Recognize the social implications, such as the health and safety of informal recyclers and community impacts.
7. **Engage with Industry and Technological Trends**
   - Investigate emerging trends in e-waste recycling technologies, including robotics and AI in automated sorting.
   - Understand the role of innovation and private-sector initiatives in addressing e-waste challenges.
8. **Apply Practical Knowledge in E-Waste Management**
   - Design a basic e-waste recycling plan considering regulatory, technological, and economic factors.

- Analyze case studies of successful e-waste recycling programs to identify best practices and lessons learned.

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