ME-409

Energy conversion and renewable energy

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Cursus	Sem.	Type
Electrical and Electronical Engineering	MA1, MA3	Opt.
Energy Science and Technology	MA1, MA3	Obl.
Energy minor	H	Opt.
Environmental Sciences and Engineering	MA1, MA3	Opt.
Minor in Engineering for sustainability	H	Opt.
Nuclear engineering	MA1	Opt.

Language of teaching	English
Credits	4
Session	Winter
Semester	Fall
Exam	Written
Workload	120h
Weeks	14
Hours	**4 weekly**
Courses	2 weekly
Exercises	1 weekly
Project	1 weekly
Number of positions	

Summary

This course presents an overview of (i) the current energy system and uses (ii) the main principles of conventional and renewable energy technologies and (iii) the most important parameters that define their efficiency, costs and environmental impacts.

Content

The course gives an **overview** of:

- **Energy systems and uses**
- **Thermodynamic, economic and environmental principles** relevant for energy conversion systems (energy and exergy efficiencies, levelised cost of energy, emission factors)
- **Power cycles** (Rankine, Brayton and combined cycles)
- **Thermal power plants** (coal, natural gas and nuclear)
- **Carbon capture, storage** and **use**
- **Heat pumps** and **Geothermal**
- **Wind** and **Hydro**
- **Solar (PV** and **Thermal)**
- **Biomass**
- **Energy storage**
- **Fuel cells**

Focus is on the presentation of the current energy system and uses (electricity, heat and mobility) and of the main conversion technologies (thermodynamics and processes) to satisfy our energy demands. The course does **not** go in details in the physics of each technology. The first half of the course is on the presentation of the **energy system**, **thermodynamics and conventional power sources**, and the other half on the **main renewable sources**. The **goal** is therefore (i) to describe the relation between the energy system and our demands, (ii) to explain the principles of each energy conversion technology and resources and assess their costs and impacts, (iii) assess their role in future energy systems.

Keywords

Energy system ; Energy conversion ; Fossil and renewable sources

Learning Prerequisites

Required courses

Physics I
Physics II

Recommended courses

This course is **recommended** to master students in their **first year** - as it presents different topics covered in more details in other courses, it is **NOT recommended** to take it in the second year if possible.

Important concepts to start the course

- Thermodynamics (conservation laws - 1st and 2nd principles)
- Conservation principles (energy, mass, momentum)

Learning Outcomes

By the end of the course, the student must be able to:

- Model energy conversion systems and industrial processes
- Draw the energy balances of an energy conversion system
- Elaborate energy conversion scenarios
- Describe the principles and limitations of the main energy conversion technologies
- Explain the efficiency and the main emission sources of energy conversion processes
- Quantify the efficiency and the main emission sources of energy conversion processes
- Compare energy conversion systems
- Describe Describe and explain the main thermodynamic cycles E5
- Explain Explain and apply the concepts of thermodynamic efficiency E6
- Explain Explain the principles and limitations of the main energy conversion technologies E7
- Characterize Characterize fossil and renewable energy resources and their corresponding conversion technologies E8
- Explain Explain and calculate the main emission sources of energy conversion processes E23
- Explain Understand the challenges related to energy: resources, energy services, economic and environmental impacts E9
- Compare energy conversion systems (efficiency, economics and impacts)
- Describe the main thermodynamic cycles
- Apply the concepts of thermodynamic efficiencies
- Model energy conversion systems and industrial processes
- Explain the main principles and limitations of energy conversion and storage technologies
- Characterize fossil and renewable energy resources and their corresponding conversion technologies
- Assess / Evaluate the challenges related to energy: resources, energy services, economic and environmental impacts
- Derive the energy balances of an energy conversion system

Transversal skills

- Use a work methodology appropriate to the task.
- Demonstrate the capacity for critical thinking
- Write a scientific or technical report.
- Access and evaluate appropriate sources of information.
- Identify the different roles that are involved in well-functioning teams and assume different roles, including leadership roles.

Teaching methods

Ex-cathedra lectures of 2 hours per week, completed by 1-2 hours of exercice/project sessions with the teaching assistants

Expected student activities

- Active participation to the **lecture sessions**
- **Exercices** consisting of theory questions and case studies, for the exam preparation
- **Mini-project** consisting in proposing an energy transition pathway for Switzerland

Assessment methods

- Written exam at the end of the semester
- Final project report and milestones

Supervision

Office hours	Yes
Assistants	Yes
Forum	Yes

Resources

Notes/Handbook

The course material consists of the following:

- Course compendium (lectures, exercises, solutions, project and former exams with corrections), available as a .pdf and on a dedicated website
- Slides and Pre-recorded videos, available on Moodle and on a SWITCHtube channel

Note that the course compendium and the slides/videos present the same content, the main difference lies in the addition of examples and further details in the coursebook in case of interest or need of explanations. This is done so that the interested student can choose the most suitable material and follow the course in case of conflict with other courses.

Websites

- http://moodle.epfl.ch
- http://www.energyscope.ch

Moodle Link

- https://go.epfl.ch/ME-409

Videos

- https://tube.switch.ch/channels/90cbb52f