UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Energy Sustainability

2526-1-F1703Q050

Aims

Knowledge and understanding

- Understand issues related to the use of energy resources, including environmental impacts, from the physical principles underlying energy transformation processes.
- Delve into the concepts of energy saving and energy efficiency, analyzing strategies and technologies to optimize energy use in different sectors.
- Gain knowledge of the potential and limitations of techniques that can be used to promote energy sustainability, framing them in the context of the global energy system.

Applying knowledge and understanding

- Apply rigorous and quantitative analytical methodologies to assess the potential and limitations of energy sustainability techniques.
- Apply analytical and quantitative methods to evaluate the energy efficiency of thermal cycles and refrigeration machines.

Making judgements

- Make independent judgments about the sustainability and energy efficiency of various processes based on experimental data, models, and scenario analyses published in scientific literature.

Communication skills

- Communicate energy analysis results clearly and rigorously, using technical reports, graphs, and oral presentations.

Learning skills

- Independently investigate specific topics such as renewable energy sources, energy storage techniques, and efficiency strategies by selecting reliable scientific sources.

Contents

- Introduction to energy sustainability
- Thermodynamics
- Thermal machines
- Refrigeration machines
- Energy saving
- Potential and limits of renewable energy sources
- World energy system
- Effects of energy consumption on the environment

Detailed program

Introduction to energy sustainability

- Definition of sustainable development
- Introduction to the energy problem
- Correlation between energy consumption and population growth
- Definition of energy and description of different forms of energy
- Energy conversion processes
- Definition of primary, secondary, and end-use energy

Thermodynamics

- Concept of thermodynamic system and temperature
- First principle of thermodynamics and conservation of energy
- Enthalpy and its application in reactions
- Second principle of thermodynamics: reversibility and irreversibility
- Entropy function and its evolution
- Thermodynamic efficiency

Thermal machines

- Internal combustion engines: Otto cycle (internal combustion engine), Diesel cycle (compression ignition engine), Brayton cycle (turbine engine)
- External combustion engines: Rankine cycle
- Combined gas-steam cycles
- Combined heat and power systems
- Optimization of thermal machines

Refrigeration machines

- Definition of refrigeration machines and heat pumps
- Coefficients of performance
- Vapor compression refrigeration cycles
- Refrigerant fluids

- Absorption refrigeration cycles and trigeneration systems
- Renewable energy from heat pumps
- Energy comparison of heat pumps, fuel-fired boilers and cogeneration systems
- Performance of aerothermal heat pumps
- Geothermal application of heat pumps

Energy saving

- Energy saving and sustainability
- Energy consumption estimation and efficiency evaluation in various sectors
- Energy saving in the transportation sector
- Techniques for reducing heat loss
- Electricity savings
- Comparison of various energy-saving techniques

Potential and limits of low-emission energy sources

- Analysis of the potential of major low-emission energy sources (solar, wind, hydro, geothermal, biomass, nuclear)
- Comparison of different energy sources in terms of EROI (energy return on energy invested), capacity factor, land occupancy, life cycle, critical raw materials, and Levelized Cost of Energy (LCOE)
- The problem of discontinuity in electricity generation from intrinsically variable sources
- Notes on the main energy storage techniques
- Analysis of some low-emission energy scenarios

World energy system

- Data on primary energy consumption in the world
- Temporal trends in the use of different energy sources
- Geographic distribution of primary energy consumption (integral and per capita)
- Electricity: world-scale production and breakdown by sources
- Energy in end uses: breakdown by energy sources and by sectors/applications
- Analysis of past trends and future projections of energy demand
- Peculiar aspects of energy consumption in Italy
- Use of renewable energy sources in Italy and targets for the future

Effects of energy consumption on the environment

- The temperature on Earth
- The atmosphere and the greenhouse effect
- The Earth's radiative budget
- Global warming and climate change
- Earth's temperature in the past
- Radiative forcings
- Impacts and effects on climate
- Greenhouse gas emissions and future scenarios

Prerequisites

Basic knowledge of bachelor's degree in physics

Teaching form

All lectures are given in-presence in delivery mode:

- 21 lectures (2 hours each).

Also part of the course program are some supplementary seminars that will be delivered in-presence during the lecture hours.

Textbook and teaching resource

Egbert Boeker and Rienk Van Grondelle - Environmental Physics: Sustainable Energy and Climate Change (3rd edition)

Y. A. Çengel – Introduction to thermodynamics and heat transfer – McGraw-Hill

David JC MacKay - Sustainable Energy — without the hot air (2008) -

Additional literature references will be provided during the course and some lecture notes will be available.

Semester

Second semester

Assessment method

Oral Examination - There are no intermediate tests.

- Questions on topics covered in the course to check preparation on the examination program
- Questions to check the ability to reflect autonomously on some aspects related to energy production and use and possible approaches related to energy sustainability
- Optional colloquium on additional topics not covered in the course

Erasmus students may request to take the exam in English.

Office hours

Monday - Friday by appointment by e-mail (davide.chiesa@unimib.it)

Sustainable Development Goals

AFFORDABLE AND CLEAN ENERGY | SUSTAINABLE CITIES AND COMMUNITIES | RESPONSIBLE CONSUMPTION AND PRODUCTION | CLIMATE ACTION