UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Laboratory of Renewable Energy Technologies

2627-1-F7603Q021

Aims

This laboratory course in Renewable Energy Technologies represents an interdisciplinary program that integrates physics and economics to analyze the feasibility and sustainability of modern energy systems.

The laboratory course is structured into two integrated modules: *Physical Bases of Modern Energies* and *Economic Principles of Modern Energies*. These will deal with, respectively:
• A fundamental understanding of the physics behind energy sources, energy conversion, and energy storage technologies.
• A comprehensive overview of the economic principles that govern investment in energy sources, market-based models for production and sale of energy, and long-term sustainability strategies.
By the end of the course, students will have a multidisciplinary perspective on global energy systems, their physical limitations, and their economic management, allowing them to critically assess energy challenges and evaluate sustainable solutions.

Knowledge and understanding
At the end of the course the student will have a fundamental understanding of:
• the physics behind energy sources;
• renewable energy technologies;
• energy conversion principles;
• the economic and environmental aspects.

Applying knowledge and understanding
At the end of the course the student will be able to:
• deal with energy aspects in a multidisciplinary perspective;
• critically assess energy challenges;
• evaluate sustainable solutions.

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

• apply the acquired knowledge in various contexts;
• transfer the concepts and approaches introduced in a certain context to connected fields;
• elaborate the concepts of sustainable and green energy concepts discussed in the course.

Communication skills
At the end of the course the student should be able to
• analyse problems in the ares covered by the course in a clear and concise way.
• explain orally with a suitable language the objectives, the procedures and the results of the elaborations carried out.

Learning skills
At the end of the course the student should be able to different from those presented during the course, and to understand the topics covered in the scientific literature concerning the sustainability issue.

Contents

Physical Foundations
• energy principles & measurement;
• classical energy sources;
• renewable energy technologies;
• energy storage & conservation;
• sustainability & policy implications.

Economic Aspects
• electricity markets & economic integration;
• renewable energy and market dynamics;
• investment & financing for renewable energy;
• market reforms & long-term planning.

Detailed program

• Fundamentals of energy: forms, measurement, and transformations.
• Conventional energy sources: fossil fuels, combustion, and thermodynamic efficiency.
• Renewable energy: solar (photovoltaic effect), wind (aerodynamics of turbines), hydropower, and geothermal energy.
• Energy storage technologies: electrochemical storage (batteries, supercapacitors), thermal storage (phase-change materials, molten salts), mechanical storage (flywheels, pumped hydro), hydrogen as an energy carrier.
• energy systems and sustainability: integration of renewable energy into national grids, energy efficiency strategies, and climate change mitigation.
• Introduction to electricity markets: market liberalization, privatization, and electricity trading mechanisms.
• Renewable energy in the electricity market: priority of dispatch, variability, and price effects.
• Investment and profitability: investment under uncertainty, internal rate of return, business plan development, financing mechanisms.
• Market challenges and long-term policies: electricity market reform, power purchase agreements (PPAs), contracts for differences.

Prerequisites

• Classical mechanics, electricity and magnetism.
• Basic principles of general and solid-state chemistry.
• Single and multivariable calculus.
• Basic principles of consumer behavior and firm profit maximization.

Teaching form

6 CFUs of theoretical lessons in the classroom (60 hours):
• 20 two-hour lectures, in person, Delivered Didactics;
• 10 two-hour activities, in person, reading and discussing case studies, discussions on sustainable energy projects, data analysis of energy markets and pricing trends, possible guest lectures from experts in physics, economics, and policy-making, and joint discussions between physical and economic aspects of renewable energy, Interactive Teaching.

Attendance to lectures and interactive exercises is highly recommended.

Textbook and teaching resource

• J. Tester et al., Sustainable Energy: Choosing Among Options.
• D. MacKay, Sustainable Energy – Without the Hot Air.
• C. B. Vining, Thermoelectric: Basic Principles and New Materials Developments.
• P. Zweifel, A. Praktiknjo, G. Erdmann, Energy Economics - Theory and Applications, Springer, 2017.
• Slides, notes, and research papers available on the e-learning platform.

Semester

II semester (March - June)

Assessment method

The final examination consists of a single oral exam at the end of the course. The exam will evaluate the student's ability to discuss various topics covered in the course, with an emphasis on theoretical understanding, interdisciplinary connections, and critical evaluation of sustainable energy technologies.

The final score will be between 18/30 and 30/30 *cum laude*, based on the overall assessment considering the following criteria:
(1) knowledge and understanding;
(2) ability to connect different concepts;
(3) autonomy of analysis and judgment;
(4) ability to correctly use scientific language.

Office hours

Students are asked to refer to the indications provided in the syllabi of the modules.

Sustainable Development Goals

QUALITY EDUCATION | AFFORDABLE AND CLEAN ENERGY | INDUSTRY, INNOVATION AND INFRASTRUCTURE | SUSTAINABLE CITIES AND COMMUNITIES | CLIMATE ACTION