UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Physical Bases for Modern Energies

2627-1-F7603Q021-F7603Q02101

Aims

This module is part of the Laboratory of Renewable Energy Technologies, an interdisciplinary program that integrates physics and economics to analyze the feasibility and sustainability of modern energy systems.
The course provides students with a fundamental understanding of the physics behind energy sources, focusing on renewable energy technologies, energy conversion principles, and the economic and environmental aspects of the energy landscape.

A key focus will be on:
• The physical principles governing energy production and utilization.
• The fundamentals of renewable energy sources, including solar, wind, hydro, and geothermal energy.
• Energy storage technologies and their role in sustainable energy systems.
• The relationship between physics and sustainability, examining how energy choices impact the environment.
• The economic and policy-related factors that influence energy decisions.

By the end of the course, students will have a multidisciplinary perspective on global energy systems and will be able to critically assess energy challenges and evaluate sustainable solutions.

Students are invited to consult the syllabus of the entire course for details regarding learning- and skill-related objectives.

Contents

• Fundamentals of Energy: definition, forms, and measurement of energy.
• Physical Forces and Energy: gravitational, electromagnetic, nuclear forces and their role in energy interactions.
• Conventional Energy Sources: physics of fossil fuels, their potentialities, and limitations.
• Renewable Energy: solar, wind, hydropower, and geothermal energy principles.
• Nuclear Energy: fundamentals and comparison with other energy sources.

• Energy Systems and Integration: interplay between different energy sources and their role in the global energy landscape.
• Climate Change and Sustainability: impact of energy use on climate and sustainability considerations.
• Energy Storage and Conservation: technologies for energy storage and strategies for energy efficiency.

Detailed program

Introduction to Energy Systems
• definition and classification of energy forms;
• energy transformations and the conservation of energy principle;
• units of measurement and energy scales.

Classical Energy Sources and Their Physical Principles
• fossil fuels: chemical energy conversion and thermodynamic efficiency;
• the physics of combustion and power plants;
• environmental impact of non-renewable energy sources.

Physics of Renewable Energy Sources
• solar energy: photovoltaic effect, solar spectrum, and efficiency of solar cells;
• wind energy: aerodynamics of wind turbines, power extraction from wind;
• hydropower: conversion of gravitational potential energy, efficiency of hydroelectric plants;
• geothermal energy: heat transfer in the Earth's crust, power generation potential.

Energy Storage and Conservation
• electrochemical energy storage: batteries and supercapacitors;
• thermal storage: phase-change materials, molten salts;
• mechanical storage: flywheels, pumped hydro storage;
• hydrogen as an energy carrier.

Energy Systems and Sustainability
• the role of energy systems in climate change;
• carbon footprint of different energy sources;
• energy efficiency and conservation strategies;
• the integration of renewable energy into national grids.

Prerequisites

• Classical mechanics, electricity and magnetism.
• Single and multivariable calculus.
• Basic principles of general and solid-state chemistry.

Teaching form

3 CFUs of theoretical lessons in the classroom (30 hours):
• 10 two-hour lectures, in person, Delivered Didactics;
• 5 two-hour , 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, 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
• Slides, notes, and additional scientific articles provided 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

Always, after scheduling an appointment *via* phone or e-mail.

Sustainable Development Goals

QUALITY EDUCATION | INDUSTRY, INNOVATION AND INFRASTRUCTURE | SUSTAINABLE CITIES AND COMMUNITIES | RESPONSIBLE CONSUMPTION AND PRODUCTION