UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Applied Technologies in Energy Storage and Energy Generation

2627-2-F7603Q010-F7603Q01001

Aims

The course aims to provide the students with knowledge related to the electrochemical systems for energy storage and conversion such as fuel cells, water electrolyzers, power to gas technologies, batteries and other technologies. The course will include a brief overview of the materials used, the composition and structure of these technologies, their integration into the existing network of renewable energies and their operations. Other storage technologies such as flywheels and hydroelectric and other emerging technologies will be presented. The needs of each technology including pro and cons, advantages and disadvantages to balance the peaks of renewable output for conversion and storage will be analyzed. Environmental-Techno-Economical analysis will be carried out with specific examples related to transportation, industrial sector, buildings and agriculture. Water and its quality are directly connected to energy storage and conversion and will be crucial for sustaining the green energy revolution. Electrochemical devices and their integration into the existing energy network or with hard-to-abate sectors is cardinal for reaching the EU goal of the full carbon-neutrality by 2050.

Contents

• Greenhouse gases, concept and consequences;
• Mass and energy balance;
• Hydrogen economy;
• Decarbonize hard to abate industries;
• Electrochemical conversion and production through fuel cells and electrolyzers;
• Electrochemical storage through batteries;
• Other energy storage;
• Environmental Analysis;
• Techno economic analysis.

Detailed program

• Greenhouse gases and manmade global warming: discussion using the IPCC;
• The transition from fossil fuels to renewable energy through the Green Deal;
• Concepts of mass flow and energy flow to introduce energy storage and utilization;
• Hydrogen economy, concepts and integration into the existing industrial context;
• Concept of hydrogen colours and hydrogen production;
• Hard to abate industries: the case of ammonia production;
• Hard to abate industries: the case of steel production;
• Hard to abate industries: the case of cement production;
• Decarbonize transportation through hydrogen technologies for automotive;
• Electrolyzers types and operations;
• Economics on utilization of water;
• Economics on water electrolyzers considering critical raw materials;
• Fuel cells types and operations;
• Economics on fuel cells considering critical raw materials;
• Power-to-gas: converting electrochemically carbon dioxide into valuable products;
• Batteries types and operations;
• Economics on utilization of primary and secondary batteries;
• Hydraulic energy type and operations;
• Economics on hydraulic energy;
• Flywheels and their implications;
• Environmental implications;
• Life cycle assessment over examples of electrochemical technologies;
• Cases studies.

Prerequisites

• Basic knowledge of chemistry.
• Basic notions of thermodynamics.

Teaching form

• 6 CFUs in total, 4 CFU of theoretical lessons in the classroom (32 hours), 2 CFU of exercises (20 hours):
-> 16 two-hour lectures (32 hours total), in person, Delivered Didactics.
-> 10 two-hour lectures (20 hours), online, Mixed Didactics / Seminar, exercises.

Attendance to lectures and interactive exercises is highly recommended.

Textbook and teaching resource

• slides
• notes shown during lectures and additional material on selected topics, *i.e.*, scientific articles, made available on the e-learning website of the course.

Semester

I semester (October - January)

Assessment method

The final exam consists of a single written exam at the end of the course, with a score between 18-30 / 30, which comprises the discussion of various topics covered in the course, with an emphasis also on the connections between concepts and processes.

Assessment will be based on 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* e-mail.

Sustainable Development Goals

CLEAN WATER AND SANITATION | AFFORDABLE AND CLEAN ENERGY | INDUSTRY, INNOVATION AND INFRASTRUCTURE | RESPONSIBLE CONSUMPTION AND PRODUCTION | CLIMATE ACTION