UNICUSANO
ROME

**Code: ING-IND/09** **Credits: 9**
**Matter: Sustainable Energy Technologies**
**Main language of instruction:** Italian
**Other language of instruction:** English

**Teaching Staff**

**Head instructor**
**Prof. _Raffaello Cozzolino__ - raffaello.cozzolino@unicusano.it**

## Introduction

1. *Objective of the course:*

The course aims to critically illustrate the possibilities of developing energy conversion systems capable of ensuring "sustainable development", through the use of renewable sources and the improvement of energy efficiency and environmental compatibility of conversion systems of innovative and advanced primary energy for residential, civil and industrial uses.
The following topics will be analyzed:
- "zero emission" or "near-zero emission" technologies that can be used to convert energy from fossil sources;
- energy conversion technologies from renewable sources, discussing their potential and the technical and economic problems of design and management;
- the potential of hydrogen as an energy carrier.

## Objectives

2. *Course Structure:*

The course of Sustainable Energy Technologies has the following educational objectives:

1. Illustrate the analysis of renewable, solar, wind and hydroelectric plants
2. Explain the analysis of technologies for the clean use of coal
3. Explain the analysis of technologies for CO2 capture and storage
4. Explain the analysis of hydrogen and cogeneration technologies
5. Illustrate the implementation of the Homer Energy software for the study of polygeneration platforms

The course is delivered through pre-recorded video lessons which, together with slides and lecture notes, constitute the study material available on the platform.
The interactive teaching is carried out in the "virtual class" forum and includes 4 Etivity which apply the knowledge acquired in the theory lessons, in particular two numerical calculation Etivity and two models of polygeneration platforms developed with the Homer Energy software.The course provides 9 credits. The total study load for this teaching module is around 215 hours, divided as follows: about 100 hours for viewing and studying the video recorded materials; about 115 hours of Interactive Teaching for the elaboration of 4 E-tivity and for the execution of self-assessment tests.
We suggest to uniformly distribute the course study over a period of 11 weeks, devoting 20-30 hours of study a week.

**Competencies:**

Knowledge and understanding
At the end of the course the student will demonstrate knowledge of the topics of renewable and innovative energy systems, and will have acquired the ability to analyze them.
The student will acquire knowledge of the functioning of the main hydrogen production systems from fossil sources: steam reforming, autothermal reforming, and partial oxidation. The student will acquire knowledge and analysis of integrated gasification systems with combined cycles, fuel cells and CCS systems (carbon capture system). Moreover, through the Etivity the student will acquire the ability to formulate numerical problems and simulation models within the Homer Energy software.
Application of knowledge
The student will be able to use the knowledge of innovative energy systems for their analysis and optimization; furthermore will be able to solve numerical problems and simulation models of polygeneration platforms based on fossil and alternative sources. The Etivity plans to apply theoretical knowledge to optimization problems to be solved with the Homer Energy software.
Ability to draw conclusions
Through the Etivity the student will be able to perform technical analyzes of single and integrated energy systems, acquiring the ability to compare different system solutions.
Communication skills
Through the Etivity the student will be able to describe and support conversations on innovative and advanced energy system solutions, correctly identifying the

optimization and performance improvement points, and using appropriate terminology.

Ability to learn

At the end of the course the student will have knowledge of the fundamental notions necessary for the analysis of innovative and advanced energy systems. All this will allow to complete his engineering studies with greater scientific maturity and will provide the basis for a better integration into the working world.

**Syllabus**

3. *Programme of the course:*

**Subject 0. THE ENERGETIC PROBLEM** (3 videotaped theory lessons for a commitment of 10.5 hours - 1 self-evaluation test for a commitment of 0.5 hours - week 1) where the following topics are addressed:
The energetic problem: conventional and renewable energy sources, sustainable development, the Italian scenario.

**Subject 1. SOLAR ENERGY** (4 videotaped theory lessons for a commitment of 14 hours - 1 self-evaluation test for a commitment of 0.5 hours - week 2) where the following topics are addressed:
Solar energy: General considerations, Calculation of incident solar radiation on the earth, Effect of the atmosphere on ground radiation, Calculation of flat and fixed surface radiation, Solar thermodynamic systems, Photovoltaic plants.

Etivity 1 - Calculation of solar radiation (for a commitment of 15 hours - week 2)

**Subject 2. WIND ENERGY** (3 videotaped theory lessons for a commitment of 10.5 hours - 1 self-evaluation test for a commitment of 0.5 hours - week 3) where the following topics are addressed:
Wind energy: wind energy, wind speed measurement, wind speed variation and distribution, power and energy calculation, array yield, wind turbine characteristics, application fields

**Subject 3. HYDROELECTRIC ENERGY** (3 videotaped theory lessons for a commitment of 10.5 hours - 1 self-evaluation test for a commitment of 0.5 hours - week 4) where the following topics are addressed:
Hydroelectric energy: Hydraulic energy, Geodetic leap, total and useful motor jump, Net power of the plants, Classification of the plants, Construction elements,

Evaluation of hydraulic resources, Flow rate diagram, Hydrogram of durations, Sizing of the plant, The hydraulic turbines.

**Subject 4. HYDROGEN PRODUCTION** (4 videotaped theory lessons for a commitment of 14 hours - 1 self-evaluation test for a commitment of 0.5 hours - week 5) where the following topics are addressed:
Hydrogen production: Reforming systems, Steam reforming, Partial oxidation, Autothermal, Operating parameters, Case study, Carbon deposition, Influence of operating parameters, Influence of indirect parameters, Efficiency of the reforming unit.

**Subject 4. INTEGRATED GASIFICATION WITH COMBINED CYCLE** (3 videotaped theory lessons for a commitment of 10.5 hours - 3 self-evaluation test for a 1.5 hour commitment - week 6) where the following topics are addressed:
"Clean" use of coal: coal gasification and related technologies, fixed-bed gasifier, fluidized-bed gasification, trailed bed gasification, Syngas cooler, purification technologies, IGCC plants.

**Subject 6. CARBON CAPTURE SYSTEM** (3 videotaped theory lessons for a commitment of 10.5 hours - 1 self-evaluation test for a commitment of 0.5 hours - week 7) where the following topics are addressed:
CO2 capture and sequestration: CCS systems and technologies, CO2 capture downstream of combustion, CO2 capture upstream of combustion, Oxygen combustion, CO2 separation and capture, Chemical absorption, Physical absorption, Adsorption, Membranes, Transport and confinement.

**Subject 7. FUEL CELL** (3 videotaped theory lessons for a commitment of 10.5 hours - 1 self-evaluation test for a commitment of 0.5 hours - week 8) where the following topics are addressed:
Fuel Cells: General Considerations, Operating Principle, Real Operation and Losses, Cell Classification and Types, Performance and Fields of Application.

**Subject 8. POLYGENERATION PLANT**
Introduction and presentation of the Homer Energy design software (1 videotaped theory lesson for a 7 - week 9 commitment)
Approach and confidence with the Homer Energy design software (23 hours of study load - week 9)

Etivity 3 - Model of a polygeneration plant integrated with the network (25 hours of study load - week 10)

Etivity 4 - Model of an island polygeneration plant (25 hours of study load - week 11)

**Evaluation system and criteria**

The exam consists of a test aimed at ascertaining the abilities to analyze and re-elaborate the concepts acquired and a series of activities (Etivity) carried out during the course in virtual classes.
The test, consists of 4 open-ended theory questions that may concern the entire program carried out.
The first Etivity is worth 1 point, the second 2 points, the third and fourth 1.5 points each, therefore they will be evaluated for a score ranging from 0 to 6 points on the final grade. The evaluation of Etivity from 0 to 6 points, is carried out, during the course, during the duration of the course. The test exam is evaluated for the remaining ones from 0 to 24.
The expected learning outcomes regarding the knowledge of the subject and the ability to apply them are assessed by the written test and the Etivity, while the communication skills, the ability to draw conclusions and the capacity for self-learning are evaluated in itinere through the Etivity alone.

**Bibliography and resources**

4. *Materials to consult:*
   *The teaching material on the platform is divided into 8 modules. They completely cover the program and each of them contains lecture notes, slides and video lessons. This material contains all the elements necessary to study the course subjects.*

5. *Recommended bibliography:*
   - *Tecnologie delle energie rinnovabili di Daniele Cocco, Chiara Palomba, Pierpaolo Puddu*