UNICUSANO
ROME

Code: ING-IND/09 **Credits: 9**
Matter: Systems for energy and environment
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 development possibilities of conventional energy conversion systems based on fossil fuels.
With a view to the diversification of fossil fuels and energy saving, the course also presents technologies for the "clean" exploitation of coal and cogeneration systems, respectively.
Finally, to complete the discussion on energy systems, innovative hydrogen technologies, such as fuel cells, are presented.

Objectives

2. *Course Structure:*

The course of Systems for energy and environment has the following educational objectives:

1. Analyze the national and international energy scenario
2. The analysis and optimization of steam plants, gas turbine plants and combined cycle plants.
3. Analysis of technologies for the clean exploitation of coal
4. The analysis of hydrogen fuel cells and cogeneration
5. Illustrate the use and implementation of Thermoflex software for the study of energy systems

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 Etivities which apply the knowledge acquired in the theory lessons, through numerical analyzes conducted by the student with the Thermoflex software, in order to study energy conversion systems.
In particular, the Systems for energy and environment course includes 9 training credits. The total study load for this teaching module is between 220 and 240 hours divided as follows: approximately 154 hours for viewing and studying the video-recorded material; approximately 70 hours of Interactive Teaching for the elaboration of 4 E-tivity; approximately 10 hours of Interactive Teaching for carrying out self-evaluation tests.
It is advisable to 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 have demonstrated knowledge of the topics of energy systems, and will have acquired the ability to analyze them. The student will acquire knowledge of the functioning of the main energy conversion systems: steam plants, gas plants, combined cycles, integrated gasifiers with combined cycles, fuel cells and cogenerators. Finally, the student will acquire methods for the analysis and optimization of energy systems. Furthermore, through Etivities students will acquire the ability to formulate problems within the Thermoflex software.
Application of knowledge
The student will be able to use the knowledge of energy conversion systems for the analysis and optimization of the same; will also be able to implement simple calculation codes for the solution of problems related to the energy optimization of the proposed systems. Etivities involve the application of theoretical knowledge to practical problems to be solved with the aid of calculation software
Ability to draw conclusions
Through the Etivities, the student will be able to perform technical analyzes of single and integrated energy systems, acquiring the ability to compare different plant 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 energy systems. All this will allow to continue his engineering studies with greater maturity and will provide him with the basis to be able to learn what will be proposed in the specialized mechanics courses, with particular reference to the "hot mechanics" topics

Syllabus

3. *Programme of the course:*

Subject 0. FUNDAMENTALS OF THERMODYNAMICS (6 video-recorded theory lessons for a commitment of 21 hours - 6 self-evaluation tests for a commitment of 1.5 hours - week 1) where the following topics are addressed:
Thermodynamics: state functions, perfect gases, first and second law, cycles, T-s and p-v plane, real ideal transformations and efficiency.

Subject 1. ENERGY PROBLEM & THERMOFLEX SOFTWARE (3 video-recorded theory lessons for a commitment of 10.5 hours - 1 self-assessment test for a commitment of 0.5 hours - week 2) where the following topics are addressed:
The energy problem: conventional and renewable energy sources, sustainable development, Italian scenario.

Introduction and approach to the Thermoflex thermodynamic software (14 hours of study load - week 2)

Subject 2. STEAM TURBINE ENGINE SYSTEMS (8 video-recorded theory lessons for a commitment of 28 hours - 5 self-assessment tests for a commitment of 2.5 hours - week 3-4) where the following topics are addressed:
Steam Turbine Engine Systems (IMTV): Thermodynamic considerations, Reheating and regeneration, Optimization of internal efficiency, Evolution and development prospects, Repowering systems for existing IMTVs.

Etivity 1 - Basic IMTV simulation model (for a 15 hours commitment - week 3-4)
Etivity 2 - IMTV simulation model with reheat and tapping (for a 20 hours commitment - week 5-6)

Subject 3. GAS TURBINE ENGINE SYSTEMS (10 video-recorded theory lessons for a commitment of 35 hours - 4 self-assessment tests for a commitment of 2 hours - week 5-6-7) where the following topics are addressed:

Engine systems with gas turbines (IMTG): General information on the evolution of industrial and aeronautical TG, Development trends of industrial and aeronautical TG, Ideal, limit and real cycle, Blade refrigeration, Performance analysis, Interventions on the cycle and regeneration thermal and interrefrigeration.

Etivity 3 - Basic IMTG simulation model (for a 15 hours commitment - week 7-8)
Etivity 4 - Remanufactured and Intercooled IMTG Simulation Model (for a 20 hours commitment - week 9-10)

Subject 4. COMBINED CYCLE SYSTEMS (4 video-recorded theory lessons for a commitment of 14 hours - 4 self-evaluation tests for a commitment of 2 hours - week 8-9) where the following topics are addressed:
Combined gas-steam cycle plants: thermodynamic considerations, design methodologies, cycle efficiency, recovery boiler and construction characteristics, recovery cycle arrangements, CC development prospects.

Subject 5. INTEGRATED GASIFICATION WITH COMBINED CYCLE (3 video-recorded theory lessons for a commitment of 10.5 hours - 3 self-assessment tests for a commitment of 1.5 hours - week 10) where the following topics are addressed:
"Clean" use of coal: Coal gasification and related technologies, fixed bed gasifier, fluidized bed gasifier, entrained bed gasifier, Syngas cooler, purification technologies, IGCC plants.

Subject 6. FUEL CELLS AND COGENERATION (3 video-recorded theory lessons for a commitment of 10.5 hours - 1 self-assessment test for a commitment of 1 hour - week 11) where the following topics are addressed:
Fuel Cells: General considerations, Operating principle, Real operation and losses, Classification, Performance and fields of application. Cogeneration: General considerations, Italian and European regulatory framework, Technologies for cogeneration, Choice and sizing criteria

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 and third Etivities are worth 1 point each while the second and fourth are worth 2 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 6 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:*
   - *Turbine a gas e cicli combinati, G. Lozza, Ed. Progetto Leonardo*