

SUBJECT DATASHEET

| Course information | |
|---------------------------|---|
| Name | Energy Engineering |
| Code | DIM-MII-522 |
| Degree | Master on Industrial Engineering |
| Year | First |
| Semester | Second (Spring) |
| ECTS credits | 7.5 |
| Type | Compulsory |
| Department | Mechanical Engineering |
| Area | Energy |
| Coordinator | José Ignacio Linares Hurtado |

| Instructor information | |
|-------------------------------|---|
| Instructor | |
| Name | Luis López Álvarez |
| Department | Mechanical Engineering |
| Area | Energy |
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| Phone | |
| Office hours | To be defined at the term beginning. |

| Lab Instructors | |
|------------------------|------------------------------------|
| Nombre | Luis López Álvarez |
| Nombre | Bienvenido Martínez Pantoja |
| Nombre | Leopoldo Prieto Fernández |
| Nombre | José Rafael Rubio Caldera |

SPECIFIC SUBJECT DATASHEET

| Subject contextualization |
|---|
| Contribution to the professional profile of the Title |
| <p>In the professional profile of the Masters in Industrial Engineering this subject aims to equip students with the basic knowledge to understand both energy sources and systems to convert them into power, heating and cooling and to assess the technical and economic feasibility of energy systems.</p> <p>After completing the course students will be able to discuss energy policy scenarios with technical criteria to evaluate energy systems, analyzing the behavior of energy systems working at off-design point, knowing and proposing improvements in power plants of all types and determine the strengths and weaknesses of the different energy sources, both from production and from logistics and processing. In short, the knowledge acquired in this course will provide students with the technical criteria to contribute to the energy debate</p> |



seeking sustainability in a holistic sense (economic, social and environmental).

In addition, this course has a mixed theoretical and practical sense, so that the theoretical components are added the practical aimed at solving numerical issues where the concepts studied will be exercised, as well as conducting laboratory practice where they face real systems to scale.

Pre requirements

There are not any prerequisites needed to study the subject. However, as the subject is inserted in an engineering syllabus, it is supported on concepts previously seen in other subjects:

Thermodynamics

- Energy and mass balances

Heat transfer

- Heat exchangers

THEME SEGMENT AND CONTENTS

Contents – Theme segments

THEME 1: Systems

Unit 1: INTRODUCTION

- 1.1 Energy, classifications and types. Energy sources.
- 1.2 Macro-energy units.
- 1.3 Environmental implications of power generation.
- 1.4 Social and geostrategical aspects of energy sources.
- 1.5 Assessment of scenarios and energy policies.
- 1.6 Assessment of economic feasibility of energy projects.

Unit 8: ANALYSIS OF ENERGY SYSTEMS IN OFF-DESIGN WORKING

- 8.1 Introduction.
- 8.2 Heat exchangers and ducts.
- 8.3 Volumetric machines.
- 8.4 Turbomachines.
- 8.5 Systems integration.

THEME 2: Energy sources

Unit 2: COMBUSTION

- 2.1 Introduction.
- 2.2 Combustion reactions.
- 2.3 Mass balance.
- 2.4 Energy balance.

Unit 6: NUCLEAR ENERGY

- 6.1 Introduction
- 6.2 Nuclear reactions.
- 6.3 Systems and components of a nuclear reactor.
- 6.4 Nuclear fuel cycle.
- 6.5 Nuclear wastes.
- 6.6 Ionizing radiations.
- 6.7 Nuclear fusion.
- 6.8 Nuclear power plants: types and Generations
- 6.9 Current nuclear power plants: Generation II and III
- 6.10 Forthcoming nuclear power plants: Generation III+, IV and fusion

Unit 7: FOSSIL FUELS



- 7.1 Introduction
- 7.2 Oil and derivatives production and distribution.
- 7.3 Natural gas production and distribution.
- 7.4 Coal production and distribution.
- 7.5 Non-conventional hydrocarbons production.
- 7.6 CO₂ storage.

Unit 9: HYDROGEN AND FUEL CELLS

- 9.1 Introduction
- 9.2 Hydrogen generation.
- 9.3 Hydrogen storage.
- 9.4 Hydrogen direct combustion.
- 9.5 Fuel cells.

THEME 3: Energy conversion

Unit 3: FOSSIL FUEL POWER PLANTS

- 3.1 Introduction.
- 3.2 Coal power plants (steam cycle).
- 3.3 Combined cycle power plants.
- 3.4 Repowering of coal power plants.
- 3.5 Clean combustion in power plants.
- 3.6 CO₂ capture.

Unit 4: REFRIGERATION CYCLES AND HEAT PUMPS

- 4.1 Introduction.
- 4.2 Low temperature chillers.
- 4.3 Advanced heat pumps.
- 4.4 Non-conventional chillers.
- 4.5 Absorption chillers.

Unit 5: ADVANCED POWER PLANTS

- 5.1 Introduction.
- 5.2 Combined heat and power.
- 5.3 Organic Rankine cycles.
- 5.4 Supercritical CO₂ cycles.
- 5.5 Other power plants.
- 5.6 Electric generation from renewable sources
- 5.7 Massive energy storage.

Competences – Learning Outcomes

Competences

General competences

- CB2. Knowing how to apply and integrate their knowledge, understanding these, its scientific basis and troubleshooting capabilities in new and imprecisely defined environments, including multidisciplinary contexts both researchers and highly skilled professionals.
- CB7. Being able to take responsibility for their own professional development and specialization in one or more fields of study.
- CG1. To have appropriate knowledge about the scientific and technological aspects of: mathematical, analytical and numerical methods in engineering, electrical engineering, power engineering, chemical engineering, mechanical engineering, continuum mechanics, industrial electronics, automation, manufacturing, materials, quantitative methods management, industrial computing, planning, infrastructure, and so on.
- CG2. To project, to calculate and to design products, processes, facilities and plants.

Specific competences

- CMI4. Knowledge and skills to plan and design electrical and fluid facilities, lighting, air conditioning and ventilation, energy saving and efficiency, acoustics, communications, automation and smart buildings and security installations.
- CMT1. Knowledge and capabilities for the design and analysis of generation, transport and distribution of power systems.
- CMT5. Knowledge and capabilities for the design and analysis of thermal machines and engines, hydraulic machines and industrial heating and cooling facilities.
- CMT6. Knowledge and capabilities to understand, analyze, operate and manage the different energy sources.

Learning outcomes

At the end of the course students should be able to:

- LO1. To know the current energy scenario (national and international) with its mid and long term challenges.
- LO2. To know assessing the economic feasibility of an energy project.
- LO3. To calculate the energy and mass balance of a combustion.



- LO4. To know the capture and storage CO2 capture.
- LO5. To achieve the performances of complex energy systems so at its design point as off-design point.
- LO6. To know and analyse advanced systems of electricity generation.
- LO7. To calculate the mass and energy balance of chilling and air conditioning devices based on different technologies.
- LO8. To know the current technology challenges of fossil fuels.
- LO9. To understand the electricity generation technology from nuclear energy.
- LO10. To calculate the performance of renewable energy installations.
- LO11. To know the hydrogen energy technologies analysing their performances.

TEACHING METHODOLOGY

Subject methodological aspects

| In-class methodology: Activities | Competences |
|---|------------------------------------|
| 1. Lectures. The lecturer will explain basic concepts for every unit showing the more important aspects. Special attention to be paid with equations and how to use. Examples will be presented, discussed and solved to complete the understanding. (34 hours) . | CG1,CMT5, CMT6, CMI4 |
| 2. In-class case discussion and problem solving. Students will discuss the cases and problems proposed by the teacher. Cases will be open challenges that can be analyzed and solved by the use of the concepts already presented in class. (23 hours) . | CB2, CB7, CG2 |
| 3. Team Work presentations. The students, split in small teams, will expose in class a work about topics related with the subject. The topics will be able proposed by the lecturer or by the students with the approval by the former. (5 hours) . | CB2, CB7, CG2 |
| 4. Lab sessions. The students, split in small teams, will do lab sessions with different devices and simulation software in order to apply the acquired knowledge in the lectures to actual energy facilities. (8 hours) . | CB2, CB7, CG2 |
| 5. Assessment. In the mid term students will individually perform a written exam no longer than 1.5 hours. Such exam will be solved in the next session (1 hour). At the end of the course an individual written exam will be performed. This exam will last 3 hours. (5 hours) . | CB2, CG1, CG2, CMT05, CMT06 |

| Distance Methodology: Activities | Competences |
|---|------------------------------------|
| <p>1. Self-learning on the concepts presented in class. The student must make a personal work back to the lectures to understand and internalize the knowledge provided in the subject. It will be used for that the material presented on slides and notes (additional texts) on the subject (45 hours).</p> | CB2, CB7, CG2 |
| <p>2. Cases study. The student will analyze the resolution of the problems in class conducted primarily by the lecturer, and then turn to face the problems proposed (no solved) in class, whose solution will be available later, asking questions in the tutoring sessions. This activity shall also apply to previous years solved exams available for students in Moodle. (35 hours).</p> | CB2, CB7, CG2 |
| <p>3. Lab sessions. After the in-lab session a report will be written following a guide provided by the instructor. (24 hours).</p> | CB2, CB7, CG2 |
| <p>4. Team Works. Once the topic has been assigned the students, divided in small teams, will perform the information searching and the developing of the work and the presentation. The work will be controlled by partial deliveries at established milestones. (20 hours).</p> | CB2, CB7, CG2 |
| <p>5. Exams preparation. Students will prepare the exams based on the supplied material and the acquired knowledge. (26 hours).</p> | CB2, CG1, CG2, CMT05, CMT06 |

ASSESSMENT AND SCORING CRITERIA

| Assessment activities | Criteria | Weight |
|--|---|------------|
| <p><u>Exams performing:</u></p> <ul style="list-style-type: none"> • Mid term exam • End of term exam | <ul style="list-style-type: none"> - Concepts understanding. - Use of concepts to solve real cases. - Problem solving solution analysis and results interpretation. - Presentation and written communication. | 70% |
| <p><u>Continuous assessment:</u></p> <ul style="list-style-type: none"> • Team work | <ul style="list-style-type: none"> - Information searching. - Knowledge application to | |

Scoring

The score for the **ordinary summon** will be obtained by:

- 70% comes from the exams. End of term exam score will weight 50% in the overall score of the subject while the score in the mid term exam will weight 20%.
- 15% comes from team work.
- 15% comes from the lab sessions reports.

If the previous weighted average results higher than 5 the subject score will be such average; in the opposite case the score will be the minimum between such average and the end of term exam score.

Extraordinary summon

- 20% from the score obtained in continuous evaluation (team work and lab reports).
- 80% from the extraordinary summon exam.

If the previous weighted average results higher than 5 the subject score will be such average; in the opposite case the score will be the minimum between such average and the extraordinary summon exam score.

Rules

Attendance (see latter) and work team and lab reports performing is a necessary condition to pass the subject in both summons.

Neither programmable calculators nor formulae summary, books and notes are not allowed in the final exam of the ordinary summon and in the exam of the extraordinary summon a formulae summary covering economic parameters (unit 1) and cogeneration indexes (unit 6) will be included. A sample of such summary can be found in past exams available in Moodle.

Attendance: The absence of more than 15% of the total amount of classes can entail to fail the ordinary summon.

WORKING SCHEDULE

| In-class and distance activities | Do date | Delivery date |
|--|-----------------------------------|---------------|
| <ul style="list-style-type: none"> • Self-learning of concepts presented in class (slides and additional text if any) | After session | |
| <ul style="list-style-type: none"> • Problem solving | After the end of the unit | |
| <ul style="list-style-type: none"> • Mid term and end of term exam | Week 8 and ordinary summon period | |

| | | |
|-----------------------------------|------------------------------|--|
| • Mid term exam preparation | At least weeks 7 and 8 | |
| • End of term exam preparation | At least weeks 13, 14 and 15 | |
| • Lab sessions | Weeks 11, 12, 13 and 14 | |
| • Lab sessions reports performing | | Weeks 12, 13, 14 and 15 |
| • Team work performing | Weeks 3 to 15 | M1: week 7 M2: week 11 M3: week 13 to 15 |
| • Team work presentation | Weeks 13 to 15 | |

| STUDENT SCHEDULE SUMMARY (HOURS) | | | | |
|---|--------------------|------------------------|---------------------|--------------------------|
| LIVE | | | | |
| Lectures | Team work | Case discussion | Lab Sessions | Assessment |
| 34 | 5 | 23 | 8 | 5 |
| DISTANCE | | | | |
| Self-learning | Cases study | Team works | Lab Sessions | Exams preparation |
| 45 | 35 | 20 | 24 | 26 |
| ECTS:7,5 (225 hours) | | | | |

BIBLIOGRAPHY AND RESOURCES

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|---|
| Basic bibliography |
| Notes and Slides |
| <ul style="list-style-type: none"> • Slides of every unit (available at Moodle). • Additional texts of nearly all the units (available at Moodle). • Solved problems (available at Moodle). • Solved exams (available at Moodle). |
| Additional Bibliography |
| Text books |
| <ul style="list-style-type: none"> • E. Cassidy and P. Grossman, Introduction to Energy: Resources, Technology and Society. Cambridge University Press, 1998 • R.W. Haywood, Analysis of Engineering Cycles, 4th Edition. Pergamon Press, 1991. |