# Course guides
# 220211 - 220211 - Energy Technology

**Last modified:** 12/06/2020

**Unit in charge:** Terrassa School of Industrial, Aerospace and Audiovisual Engineering
**Teaching unit:** 724 - MMT - Department of Heat Engines.

**Degree:** MASTER'S DEGREE IN INDUSTRIAL ENGINEERING (Syllabus 2013). (Compulsory subject).

**Academic year:** 2020 **ECTS Credits:** 5.0 **Languages:** Catalan, Spanish

## LECTURER

**Coordinating lecturer:** Yolanda Calventus

**Others:** Gustavo Rausch, Ivette Rodríguez, Joaquim Rigola
Torrent Gelma, Miguel

## PRIOR SKILLS

Knowledge of thermodynamics. Knowledge of heat engines: cycles with steam turbine, gas turbine and reciprocating internal combustion engines. Elementary knowledge of the different energy sources and energy transformations.

## DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

**Specific:**
1. Knowledge and skills for the design and analysis of heat engines and machines, hydraulic machines and installations of heating and cooling industry.
3. Have adequate knowledge of the scientific and technological aspects of: mathematical methods, analytical and numerical engineering, electrical engineering, energy engineering, chemical engineering, mechanical engineering, continuum mechanics, electronics, industrial automation, manufacturing, materials, quantitative methods management, industrial computing, urban planning, infrastructure, etc..
4. Student capacity to use their knowledge in new and multidisciplinary situations.
5. Knowledge and skills to plan and design electrical and fluid, lighting, air conditioning and ventilation, energy saving and efficiency, acoustics, communications, home automation, intelligent buildings and facilities security.
6. Extension of some specific technology areas such as Materials Science and Metallurgical Engineering, Construction Engineering, Systems Engineering, Automation and Computer Engineering, Electrical Engineering, Electronics Engineering, Mechanical Engineering, Chemical Engineering, Textile and Paper, Statistics and Operations Research, Graphic Expression in Engineering, Physics and Nuclear Engineering, Language and Systems, Heat Engines, Applied Mathematics, Fluid Mechanics and Turbo machines, Business Administration, Engineering Design, Strength of Materials and Structures, Aerospace Engineering.
7. Knowledge and skills for understanding, analyzing, managing and exploiting different sources of energy.

## TEACHING METHODOLOGY

The course is organized :
1 - Classes in large groups . These classes in the theory classes , some classes of problems develop and assessments for the first and second exams. Expository method is that the teacher considers more suitable to achieve the objectives in the course. Problems were also solved.
2 - Classes in medium groups : In these classes will carry out laboratory classes and also sessions for solving problems that the teacher proposed to the students for their resolution and they are a part of autonomous learning .
ATENEA support platform is used in the two types of classes as described . It will be used as transmitter and communicator with students.
a) Teacher to students :
1 - Scheduling activities and information
2 - Learning Material
3 - Assesment activities
b ) Student to teachers :
1 - Questions and comments
c ) Between Students
1 - Use the FORUM as a place for information and discussion

## LEARNING OBJECTIVES OF THE SUBJECT

- Acquire in-dept knowledge of the different sources of renewable and non-renewable energy.
- Ability to obtain usable energy with maximum energy efficiency and minimum environmental impact possible.
- Acquire the ability to work with methods and technologies for the efficient use of energy based on thermodynamic criteria.

## STUDY LOAD

| Type | Hours | Percentage |
|---|---|---|
| Self study | 80,0 | 64.00 |
| Hours large group | 30,0 | 24.00 |
| Hours medium group | 15,0 | 12.00 |

**Total learning time:** 125 h

## CONTENTS

### Content 1: Energy efficiency in industry

**Description:**
1.1 Introduction
1.2 Review of the CHP concept
1.3 Parameters of efficiency cogeneration
1.4 Energy savings
1.5 Plants matched to power and heat demands
1.6 Cogeneration Technologies

**Specific objectives:**
- Give an overview of the energy efficiency in industry
energy and primary energy saving
- Define cogeneration and its main applications in the secondary and tertiary sectors
- Apply to practical problems and evaluate the different efficienct criteria in cogeneration and discern what plant will be the most suitable to install.
- Calculate for each type of plant the energy saving, according to the different electrical or thermal adjustings.

**Related activities:**
Theory/large sessions and exercises/medium sessions
Report of the subject

**Full-or-part-time:** 18h
Theory classes: 6h
Practical classes: 2h
Self study : 10h

### Content 2: Exergy and Thermoeconomical Analysis of power plants

**Description:**
2.1 Introduction: exergy analysis
2.2 Flow exergy
2.3 Exergy rate balance for control volumes at steady state. Determining exergy destruction
2.4 Fuel chemical exergy
2.5 Exergy parameters for evaluating plants: Exergetic efficiency. Exergy analysis diagrams
2.6 Destroyed exergy Percentage
2.7 Availability efficiency criteria in CHP plants
2.8 Thermoeconomical analysis

**Specific objectives:**
- Apply the exergy analysis for improving the power plants
- Evaluating criteria

**Related activities:**
Theory/large sessions and exercises/medium sessions

**Full-or-part-time:** 26h
Theory classes: 6h
Practical classes: 3h
Self study : 17h

**Content 3: Biomass**

**Description:**
3.1 What is Biomass
3.2 Sources of Biomass
3.3 Classification of Biomass
3.4 Biomass transformation processes

**Specific objectives:**
Learn the fundamental characteristics of biomass and its transformation processes

**Related activities:**
Theory classes
Report of the subject

**Full-or-part-time:** 7h
Theory classes: 2h
Self study : 5h

**Content 4: Solar energy**

**Description:**
4.1 Introduction to solar thermal energy. Theoretical background. Solar-energy concepts.
4.2 Solar thermal systems in buildings and their equipment.
4.3 Flat-plate collectors. Efficiency of a flat-plate collector.
4.4 Thermal energy storage for solar thermal systems.
4.5 Characterisation and performance of a low-temperature solar thermal system.
4.6 CTE. Passive systems in buildings. Energy-efficiency techniques for reducing heating and cooling loads in buildings.

**Specific objectives:**
- To know the main techniques used in solar thermal energy and their role in energy efficiency in buildings.

**Related activities:**
Theory/large sessions and exercises/medium sessions.
Report of the subject

**Full-or-part-time:** 18h
Theory classes: 4h
Practical classes: 2h
Self study : 12h

**Content 5: Thermal energy storage**

**Description:**
5.1 Introduction to thermal energy storage (TES) in buildings. Role of TES.
5.2 Main techniques and characteristics. Integration of TES in buildings: seasonal heat storage, massive storage, cood storage. Performance and evaluation of TES.

**Specific objectives:**
Introduction to thermal storage techniques and their integration in buildings

**Related activities:**
Theory/large sessions and exercises/medium sessions
Report of the subject

**Full-or-part-time:** 13h
Theory classes: 3h
Practical classes: 2h
Self study : 8h

**Content 6: Solar thermal electricity**

**Description:**
6.1 Introduction to concentrated solar power (CSP).
6.2 Main advantages of CSP plants. Main technologies and characteristics.
6.3 Examples of CSP plants.
6.4 Performance and evaluation of a CSP plant.

**Specific objectives:**
To know the main techniques for solar thermal electricity and how it works.

**Related activities:**
Theory/large sessions and exercises/medium sessions
Report of the subject

**Full-or-part-time:** 13h
Theory classes: 3h
Practical classes: 2h
Self study : 8h

**Content 7: Hydroelectric and wind energy**

**Description:**
7. Hydroelectric and wind generation
7.1 Hydroelectric generation
7.1.1 Introduction. Hydropower potential.
7.1.2 Fundamentals of Hydraulic Engineering. Flow in pipes and open channels.
7.1.3 Water resources. Discharge measurements. Runoff coefficient .
7.1.4 Hydraulic Structures. Dams.
7.1.5 Electromechanical equipment. Hydraulic turbines.
7.1.6 Environmental impact.

1.2 Wind energy
1.2.1 Introduction.
1.2.1.1 Advantages of wind power.
1.2 .1.2 History of wind power use.

1.2.2 Wind power exploitation
1.2.2.1 Nature and types of wind.
1.2.2.2 Wind power (and power of a wind turbine)
1.2.2.3 Performance. Betz Limit
1.2.2.4 Variability of the wind speed
1.2.2.5 Power curve of a wind turbine

**Specific objectives:**
- Ability to analyze the behavior of a hydroelectric plant and evaluate the variables involved in the calculation thereof potnecia
- Ability to perform a fluid dynamic and energetic study of a wind system

**Related activities:**
Theroy/large group sessions and practical/medium group sessions.
Laboratory experiment

**Full-or-part-time:** 15h
Theory classes: 3h
Practical classes: 2h
Self study : 10h

**Content 8: Geothermal Energy**

**Description:**
8.1 Geothermal Energy.
8.1.1. The Earth's crust .
8.1.2 . Evolution of the Earth's crust .
8.1.3. Source of heat .
8.1.4 . Energy transport in geothermal systems

8.2 Geothermal systems : general characteristics
8.2.1. Geothermal and Hydrothermal Systems .
8.2.2 . Geochemistry of geothermal fluids .
8.2.3 . Geothermometers .

8.3 Exploitation of geothermal systems
8.3.1. Features of the exploited geothermal systems .
8.3.2 . Exploitation of Geothermal Energy .
8.3.3. Types of Geothermal Power Plants .
8.3.4. Environmental impact of geothermal exploitation .

**Specific objectives:**
- Ability to analyze the behavior of a geothermal system
- Ability to evaluate the behavior of a fossil fuel power station and its environmental impact

**Related activities:**
Theory/large sessions and practical/medium sessions.
Laboratory experiment

**Full-or-part-time:** 15h
Theory classes: 3h
Practical classes: 2h
Self study : 10h

## ACTIVITIES

### ACTIVITY 1: THEORY CLASSES

**Description:**
Large group methodology
Expository and participatory classes
The subject is organized in 8 different contents
Exercises will be solve with the large group

**Specific objectives:**
At the end of this activity, the student should be able to master the skills worked, consolidate and correctly apply them to problems involving real situations.

**Material:**
Basic bibliography
Lecture notes (available in ATENEA)
List of proposed exercises (ATENEA)

**Delivery:**
Activity 1 and activity 2 will be both evaluated in first and second partial exams.

**Full-or-part-time:** 61h
Theory classes: 26h
Self study: 35h

### ACTIVITY 2: EXERCISES CLASSES

**Description:**
Medium group methodology
For each content, problems will be solved in class for students to acquire the necessary guidelines to carry out this resolution

**Specific objectives:**
After completing this activity, students should be able to apply theoretical knowledge to solving real technical problems.

**Material:**
Basic bibliography
Teacher notes (ATENEA)
List of proposed exercises (ATENEA)

**Delivery:**
Activity 1 and activity 2 will be both evaluated in first and second partial exams.

**Full-or-part-time:** 29h
Practical classes: 11h
Self study: 18h

### ACTIVITY 3: PRACTICAL CLASSES

**Description:**
Medium group methodology
For contents 7 and 8, laboratory experiments or computational practice will be carried out

**Specific objectives:**
Upon completion of this activity students should be able to:
- Deal with experimental data and draw conclusions
- Prepare a report of the work done

**Material:**
Basic Bibliography
Lecture Notes (ATENEA)
Statement of activity

**Delivery:**
A report of this activity will be given to evaluate
The rating practices (NL) will be 15% of the overall course grade

**Full-or-part-time:** 5h
Practical classes: 4h
Self study: 1h

### ACTIVITY 4: FIRST PARTIAL EXAM

**Description:**
Development of the partial examination of the subject of contents explained during this period
It includes theoretical and practical aspects
The students who pass this exam can remove theses contents

**Specific objectives:**
The exam must demonstrate that the student has acquired and assimilated the concepts and fundamentals related to the corresponding contents

**Material:**
Statement papers

**Delivery:**
The hand-in will be the result of the exam.
It represents 30% of the final course grade

**Full-or-part-time:** 9h
Theory classes: 2h
Self study: 7h

**ACTIVITY 5: SECOND PARTIAL EXAM**

**Description:**
Individual and writing assessment about the contents explained during the corresponding period
The exam is theoretical and practical (solving exercises)
In this exam it will be established the mechanism to redirect students who have not passed the first partial exam.

**Specific objectives:**
The exam must demonstrate that the student has acquired and assimilated the concepts and fundamentals related to evaluated contents

**Material:**
Statement papers

**Delivery:**
The hand-in will be the result of the exam.
It represents 40% of the final course grade

**Full-or-part-time:** 12h
Theory classes: 2h
Self study: 10h

**ACTIVITY 6: Report of the subject**

**Description:**
Students in groups of 3 or 4 will select, in agreement with professors, a report title that should develop from a list proposed by professors. This report must follow an scheme which will be discussed and fixed conveniently by professors.

It represents 15% of the final course grade

**Specific objectives:**
The aim of this activity is students delve into a topic of the subject that has a special interest for them. It also seeks to promote discussion among members of the group, to learn how to structure and develop the report and how to manage the information resources.

**Material:**
Bibliography recommended

**Delivery:**
Each group must upload the report in Athena in pdf format.

**Full-or-part-time:** 9h
Self study: 9h

## GRADING SYSTEM

## EXAMINATION RULES.

1 -. First partial exam will be made without using books, notes or other
teaching material except Book of Tables and Charts, and occasionally made a form that each student will do if the teacher says.
2 -. Concerning practices report students will deliver a report to the teacher

## BIBLIOGRAPHY

**Basic:**
- Duffie, J.A.; Beckman, W.A. Solar engineering of thermal processes [on line]. 3rd ed. Hoboken: John Wiley & Sons, 2006 [Consultation: 21/05/2014]. Available on: http://onlinelibrary.wiley.com/book/10.1002/9781118671603. ISBN 9780471698678.
- Kalogirou, Soteris A. Solar energy engineering: processes and systems [on line]. Burlington: Elsevier/Academic Press, 2009 [Consultation: 05/03/2014]. Available on: http://www.sciencedirect.com/science/book/9780123745019. ISBN 9780123745019.
- Sala Lizarraga, J.M. Cogeneración: aspectos termodinámicos, tecnológicos y económicos. 3ª ed. Bilbao: Universidad del País Vasco, 1999. ISBN 8475855717.
- Madrid Vicente, A. Energías renovables: fundamentos, tecnologías y aplicaciones. Madrid: AMV Ediciones, 2009. ISBN 9788496709102.
- Bermúdez, Vicente. Tecnología energética. Valencia: Servicio de Publicaciones UPV, 2000. ISBN 8477218684.
- Calventus, Y. [et al.]. Tecnologia energètica y medio ambiente, vol. 1 [on line]. Barcelona: Edicions UPC, 2006 [Consultation: 05/03/2014]. Available on: http://hdl.handle.net/2099.3/36818. ISBN 8483018489.
- Çengel, Y. A.; Cimbala, J. M. Mecánica de fluidos: fundamentos y aplicaciones [on line]. México: McGraw-Hill, 2006 [Consultation: 04/11/2020]. Available on: http://www.ingebook.com/ib/NPcd/IB_BooksVis?cod_primaria=1000187&codigo_libro=5644. ISBN 9789701056127.
- Calventus, Y. [et al.]. Tecnología energética y medio ambiente, vol. 2 [on line]. Barcelona: Edicions UPC, 2006 [Consultation: 05/03/2014]. Available on: http://hdl.handle.net/2099.3/36819. ISBN 8483018497.
- Beck, A.E.; Garven, G.; Stegena, L. Hydrogeological regimes and their subsurface thermal effects. Washington D.C: American Geophysical Union, 1991. ISBN 0875904513.
- Bear, Jacob. Dynamics of fluids in porous media. New York: Dover, 1988. ISBN 9780486656755.
- Custodio, E.; Llamas M.R. Hidrología subterránea, vol. 2. 2 ed. corregida. Barcelona: Omega, 1983. ISBN 9788428204460.
- DiPippo, Ronald. Geothermal power plants: principles, applications, case studies and environmental impact. 4th ed. [s.l.]: Butterworth-Heinemann, 2015. ISBN 9780081002902.
- Dickson, M.H.; Fanelli, M. What is geothermal energy? [on line]. Pisa: Istituto di Geoscienze e Georisorse, 2004 [Consultation: 05/03/2014]. Available on: http://www.geothermal-energy.org/geothermal_energy/what_is_geothermal_energy.html.
- Pous Jaume; Jutglar, Lluís. Energía geotérmica. Barcelona: CEAC, 2004. ISBN 9788432910616.
- Guía para el desarrollo de una pequeña central hidroeléctrica, vol. 2 [on line]. European Small Hydropower Association, 2006 [Consultation: 05/03/2014]. Available on: http://www.esha.be/fileadmin/esha_files/documents/publications/GUIDES/GUIDE_SHP/GUIDE_SHP_ES_02.pdf.
- Instituto de la Ingeniería de España. Energía geotérmica. Madrid: Instituto Geológico y Minero de España, 1985. ISBN 8474743230.
- Kaviany, Massoud. Principles of heat transfer in porous media. 2nd ed. New York: Springer-Verlag, 1995. ISBN 9781461287100.
- Minicentrales hidroeléctricas [on line]. Madrid: IDAE, 2006 [Consultation: 05/03/2014]. Available on: http://idae.electura.es/libros/438/.
- Energía Eólica [on line]. Madrid: IDAE, 2006 [Consultation: 05/03/2014]. Available on: http://idae.electura.es/libros/439/.

## RESOURCES

**Computer material:**
- Apunts de l'assignatura Tecnologia Energètica, mòdul d'Energia Solar Tèrmica

**Hyperlink:**
- www.energiza.org
- www.acogen.es
- www.gencat.cat/icaen/