Universidad Zaragoza

Academic Year/course: 2022/23

66361 - Solar Energy

Syllabus Information

Academic Year: 2022/23
Subject: 66361 - Solar Energy
Faculty / School: 110 - Escuela de Ingeniería y Arquitectura
Degree: 636 - Master's in Renewable Energies and Energy Efficiency
ECTS: 6.0
Year: 1
Semester: First semester
Subject Type: Compulsory
Module:

1. General information

1.1. Aims of the course

The **teaching objectives** of the subject are the following:

The student must be able to:

SOLAR THERMAL

- Identify the characteristics of solar radiation with repercussions on the design of solar installations, evaluating said radiation and its components.
- Identify the different forms of energy use of solar energy: passive and active systems of low enthalpy and active systems of high enthalpy.
- Know the range of application, the main characteristics, and the advantages and disadvantages of the different thermal solar technologies, clearly distinguishing between systems with and without solar concentration.
- Understand and critically analyze the criteria for selecting the type and model of collector that best suits the weather conditions, characteristics and peculiarities of a given installation.
- Know and understand the different concentrating solar thermal systems.

SOLAR PHOTOVOLTAIC

- Carry out the basic dimensioning of photovoltaic solar installations, both isolated and connected to the network.
- Identify and select with technical criteria the equipment that is part of a photovoltaic solar installation

These approaches and objectives are aligned with some of the **Sustainable Development Goals, SDG**, of the 2030 Agenda (https://www.un.org/sustainabledevelopment/es/) and certain specific goals, in such a way that the acquisition of learning outcomes of the subject provides training and competence to the student to contribute to some extent to their achievement:

Goal 7: Affordable and clean energy

- Target 7.1 By 2030, ensure universal access to affordable, reliable and modern energy services
- Target 7.2 By 2030, considerably increase the proportion of renewable energy in all energy sources
- Target 7.3 By 2030, double the global rate of improvement in energy efficiency

Goal 8: Promote inclusive and sustainable economic growth, employment and decent work for all

- Target 8.4. Progressively improve, by 2030, the efficient production and consumption of global resources and seek to decouple economic growth from environmental degradation, in accordance with the 10-Year Framework of Programs on Sustainable Consumption and Production Patterns, starting with developed countries

Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation.

- Target 9.1. Develop reliable, sustainable, resilient and quality infrastructure, including regional and cross-border infrastructure, to support economic development and human well-being, with a particular focus on affordable and equitable access for all
- Target 9.4. By 2030, modernize infrastructure and convert industries to be sustainable, using resources more

efficiently and promoting the adoption of clean and environmentally sound technologies and industrial processes, and ensuring that all countries take action according to their capabilities respective.

- Target 9.5. Increase scientific research and improve the technological capacity of industrial sectors in all countries, in particular developing countries, including by promoting innovation and substantially increasing, by 2030, the number of people working in research and development per million inhabitants and public and private sector expenditures on research and development

Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable.

- Target 11.2. By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all and improve road safety, in particular by expanding public transport, paying special attention to the needs of people in vulnerable situations, women, children, people with disabilities and people.
- Target 11.6. By 2030, reduce the per capita negative environmental impact of cities, including by paying special attention to air quality and municipal and other waste management
- Target 11.b. By 2020, substantially increase the number of cities and human settlements that adopt and implement integrated policies and plans to promote inclusion, resource efficiency, climate change mitigation and adaptation, and disaster resilience, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, comprehensive disaster risk management at all levels.

Goal 12: Ensure sustainable consumption and production patterns.

- Target 12.2. By 2030, achieve sustainable management and efficient use of natural resources
- Target 12.4 By 2020, achieve the environmentally sound management of chemicals and all waste throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to the atmosphere, water and the soil in order to minimize its effects adverse to human health and the environment

Goal 13. Take urgent action to combat climate change and its effects

- Target 13.3 Improve education, awareness and human and institutional capacity regarding climate change mitigation, adaptation, reduction of its effects and early warning

1.2. Context and importance of this course in the degree

Basic training in renewable energies and, in particular, in solar energy is fundamental in the Master's degree in Renewable Energies and Energy Efficiency.

The only way to understand and advance in the knowledge of technological applications is to study the theoretical foundations and the basic practical application of the renewable energies that are sought to be implemented.

1.3. Recommendations to take this course

It is a technical subject.

To successfully complete it, the following prerequisites are needed:

- Understanding and management of thermodynamic and thermophysical properties of substances. Material and energy balances and combustion.
- Basic concepts of heat transfer.
- Basic concepts of electrical circuit analysis
- Investment profitability analysis.
- Sufficient knowledge of English to handle documentation

2. Learning goals

2.1. Competences

Upon passing the subject, the student will be more competent to...

Specific skills:

- CE2.- Develop and execute renewable energy projects.
- CE10.- Design and analyze solar exploitation systems (thermal and electrical).

General skills:

- CG2.- Carry out research, development and innovation in products, processes and methods in relation to renewable energies.
- CG4.- Follow the technological evolution of renewable energies and have prospective knowledge of this evolution.
- CG7.-Assess the application of emerging technologies in the field of energy and the environment.
- CG8.- Develop the ability to advise and guide on the best way or channel to optimize energy resources in relation to renewable energies

2.2. Learning goals

To pass this subject, the student must demonstrate the following results:

SOLAR THERMAL

Be able to:

- Identify the characteristics of solar radiation with repercussions on the design of solar installations, evaluating said radiation and its components.
- Understand solar diagrams and their use.
- Evaluate the shadow factor that can occur in a group of collectors. Characterization of shadows and blockages.
- Analyze the characteristics of the solar spectrum and the value of radiation at each moment and location.
- Identify the different forms of energy use of thermal solar energy.
- Know the range of application, the main characteristics, and the advantages and disadvantages of the different solar technologies, clearly distinguishing between systems with or without solar concentration.
- Understand and critically analyze the criteria for selecting the type and model of collector that best suits the weather conditions, characteristics and peculiarities of a given installation.
- Know the technical and operational aspects of the different concentrating solar thermal systems.

SOLAR PHOTOVOLTAIC

Be able to:

- Know the current state of development of each technology, as well as the main countries and companies in the sector.
- Knowledge of the different subsystems of a photovoltaic solar installation, the different types of photovoltaic materials and their electrical behaviour.
- Knowledge of the current state of the implementation of photovoltaic electrical systems, and future prospects, as well as the applicable regulations in the case of Spain.
- Ability to use the necessary tools and techniques for the sizing, commissioning and maintenance of photovoltaic solar installations.

2.3. Importance of learning goals

Given the importance that energy systems based on solar energy (thermal and photovoltaic) have and will have in the future of thermal and electrical energy supply, it is of interest to know their typology, operation and sizing methods.

3. Assessment (1st and 2nd call)

3.1. Assessment tasks (description of tasks, marking system and assessment criteria)

The proposed procedure consists of a set of tests that allow students to pass the subject with a global mark equal to or greater than 5 points out of 10.

For evaluation purposes, the course is divided into two parts, with the following weights on the final grade:

- Solar thermal: 50%
- Solar photovoltaic: 50%

For each of these parts, both the practical activities and the exams will be computed.

The final grade will be calculated by weighting the grades obtained in each of the following activities:

- **Process evaluation (50%):** formative and summative evaluation throughout the process by carrying out tutored work with continuous evaluation and practical activities with the delivery of the corresponding script.
- **Final exam (50%):** summative evaluation, to assess the final learning result. It is necessary to obtain a minimum score of 5 points in the exams to pass the course.

Both in the first and in the second call, if the student does not opt for the evaluation procedure described above or has not passed it during the course, they may opt for the **global evaluation** of the subject. These tests will be scheduled within the examination period of the corresponding call.

4. Methodology, learning tasks, syllabus and resources

4.1. Methodological overview

The learning process that has been designed for this subject is based on the following:

- In the **theory sessions** the basic concepts are explained and they are related to the technical characteristics of the processes using short exercises that are solved on the blackboard, serving as support to establish the understanding of the concepts. In both cases the methodology is master classes.
- In the **practical sessions**, laboratory experiments are combined with computer sessions in which more complex practical cases than those presented on the blackboard are studied, where certain calculation power is necessary for their resolution. Visits to facilities in the area could also be made.

It also includes the possibility of several subject assignments: by carrying out a task guided by the teacher, students apply the concepts seen in class in a concrete and practical way.

4.2. Learning tasks

In order for students to achieve the learning outcomes described above and acquire the skills designed for this subject, the following training activities are proposed:

- A01. Master class: presentation of content by teachers or external experts to all students of the subject.
- A02. Resolution of problems and cases: carrying out practical exercises with all the students of the subject.
- A03. On-site laboratory practices carrying out practical exercises in small groups of students of the subject.
- A04.-Special practices or visits
- A05. Practical application or research work.
- A06.-Personalized guardianship
- A07. Autonomous study.
- A08. Evaluation tests.

Teaching hours will be adjusted depending on the academic calendar of the course.

At the beginning of the course, the calendar of practical sessions will be informed, which will be set according to the progress of the program and the availability of laboratories and computer rooms.

4.3. Syllabus

1. The solar resource
    1.1. Characteristics and spectral distribution of solar radiation.
    1.2. Geometry of the Earth-Sun movement.
    1.3. Solar cards. Calculation of shadows.
2. Solar Thermal Energy
    2.1. Solar thermal systems without concentration
        2.1.1. Low temperature solar thermal collectors
        2.1.2. solar towers
    2.2. Concentrating solar thermal systems (CSP)
        2.2.1. Parabolic Trough Collector Plants (CCP)
        2.2.2. Fresnel power stations
        2.2.3. Solar Furnace
        2.2.4. parabolic dishes
        2.2.5. CRS central receiver systems
3. Photovoltaic Solar Energy
    3.1. Introduction to photovoltaic energy. Present, future, applications.
    3.2. Fundamentals of photovoltaic conversion. The solar cell.
    3.3. The photovoltaic module

3.4. The inverter and other BOS subsystems.
3.5. Sizing methods. Grid-connected photovoltaic systems.
3.6. Sizing methods. Autonomous photovoltaic systems.
3.7. Photovoltaic self-consumption.
3.8. Economic and legislative aspects.

4.4. Course planning and calendar

Calendar of sessions and presentation of works

The planning and calendar of activities will be explained on the first day of class and will be available on the subject website within the UZ Digital Teaching Ring: https://moodle.unizar.es/

This subject will be taught in the First Semester.

Course start dates and exam calls can be found on the web: https://eina.unizar.es

4.5. Bibliography and recommended resources

http://psfunizar10.unizar.es/br13/egAsignaturas.php?codigo=66361