Course guide
2400153 - 240MER58 - Solar Thermal Energy

Last modified: 29/04/2026

Unit in charge: Barcelona School of Industrial Engineering
Teaching unit: 724 - MMT - Department of Heat Engines.

Degree: MASTER'S DEGREE IN RENEWABLE ENERGY ENGINEERING (Syllabus 2025). (Optional subject).

Academic year: 2026 **ECTS Credits:** 5.0 **Languages:** English

LECTURER

Coordinating lecturer: Rodriguez Perez, Ivette Maria

Others:

PRIOR SKILLS

Fundamental aspects of thermodynamics, fluid mechanics and heat transfer required to understand the operation of solar thermal systems.

TEACHING METHODOLOGY

During the development of the course the following teaching methods will be used:
-Lecture or conferences (EXP): Lectures taught by the professors of the course as well as invited lectures.
-Interactive classes (parts): Resolution of exercises, collective discussions with both the teacher and the students. Presentation by the students of exercises carried out individually or in small groups.
-Oriented theoretical-practical works (TD): Completion of a classroom activity, theoretical or practical, carried out individually or in small groups with the teacher's guidance.
-Project, activity or work of reduced scope (PR): Self-learning based on accomplishing an activity of reduced scope, individually or in small groups, just applying the knowledge acquired.
-Project or work of broader scope (PA): Self-learning based on accomplishing an activity of broader scope, individually or in small groups, just applying the knowledge acquired.
-Assessment exam (EV).

LEARNING OBJECTIVES OF THE SUBJECT

Upon completion of the course, students will be able to:

-Differentiate the three modes of heat transfer (conduction, convection, radiation) and explain their role in the operation of solar thermal collectors and systems.
-Identify and select appropriate materials for solar thermal applications, including selective absorbers, phase change materials (PCMs), and transparent insulation materials, based on their thermophysical properties.
-Apply standard design and sizing methodologies for solar thermal systems (e.g., f-chart, utilizability methods) for domestic hot water, space heating, or industrial process heat.
-Develop own scripts (e.g., in Python, MATLAB, or similar) to model and simulate solar thermal system performance, and interpret the obtained results critically.
-Analyze advanced solar thermal applications, such as absorption/adsorption cooling systems and concentrated solar power (CSP) plants for electricity generation, identifying their main components and performance parameters.
-Evaluate the technical feasibility and energy performance of a solar thermal installation based on load profiles, local solar radiation data, and economic constraints.

STUDY LOAD

Type	Hours	Percentage
Hours large group	30,0	66.67
Hours small group	15,0	33.33

Total learning time: 45 h

CONTENTS

Solar radiation fundamentals and materials for solar thermal energy

Description:
1) Availability of solar energy: Introduction to basic solar radiation concepts (direct, diffuse, reflected). Methods to estimate solar resource based on geographical location, orientation, and tilt. Overview of a typical solar thermal installation and its main components (collectors, heat exchangers, storage tanks, piping, pump, control system).

2) Most common materials used in thermal solar energy and their properties: Classification into transparent materials (covers) and opaque materials (absorbers, insulation). Key thermal properties: thermal conductivity, specific heat, density, absorptance, emittance. Introduction to selective surfaces that combine high solar absorptance with low thermal emittance.

Specific objectives:
-Assess solar resource availability – Understand solar radiation concepts (direct, diffuse, reflected), evaluate the Sun's angular position, and estimate solar radiation on tilted surfaces for optimal system performance.
-Classify solar thermal installations – Identify different types of installations used to harness thermal energy, based on their operating temperature range and main components (collectors, storage, pipes, pump, control).
-Analyze material properties for solar collectors – Review radiant properties of opaque and transparent surfaces, evaluate spectral properties (absorptance, emittance), and calculate the energy gains of a solar absorber, with knowledge of the most common materials used in solar thermal collectors.

Full-or-part-time: 9h
Theory classes: 6h
Laboratory classes: 3h

Low-temperature applications

Description:
-Solar thermal collectors: Introduction to flat-plate and evacuated tube collectors. Main components (absorber, cover, insulation, casing) and operating principles. Efficiency curves and factors affecting performance.
-Solar thermal storage: Role of thermal storage in low-temperature systems. Sensible heat storage using water or other liquids. Basic sizing criteria (volume, temperature levels, heat losses).
-Solar thermal systems: Typical low-temperature systems (domestic hot water, space heating, swimming pool heating). Methods for sizing and evaluating system performance: load profile, solar fraction, f-chart method, and key indicators (efficiency, coverage, payback).

Specific objectives:
-Describe the working principle and efficiency curve of flat-plate and evacuated tube collectors.
-Explain the role of sensible thermal storage and basic sizing criteria (volume, temperature levels, heat losses) for low-temperature systems.
-Learn to size a solar thermal installation based on requirements (load profile, solar resource, desired solar fraction), and evaluate its performance (efficiency, coverage, energy savings).

Full-or-part-time: 24h
Theory classes: 16h
Laboratory classes: 8h

High-temperature applications - Concentrated Solar Power (CSP)

Description:
-Solar field: Most common technologies used. Parabolic trough. Linear Fresnel. Central tower. Parabolic dish. Principle of operation. Performance. Optical principles. Main losses.
-Storage: Role of thermal storage in CSP plants for dispatchability. Sensible storage using molten salts. Thermal losses evaluation.
-CSP plants: Most common technologies used in CSP plants. Parabolic trough. Linear Fresnel. Central tower. Parabolic dish. Comparison of operating temperature ranges. Concentration ratios.
-Future trends: Third generation CSP. Advanced supercritical cycles. Supercritical COâ□□. Supercritical steam. Hybridization of CSP with other energies.

Specific objectives:
-Describe the most common CSP solar field technologies, their principle of operation, optical principles, performance, and main losses.
-Explain the role of molten salt sensible storage for CSP dispatchability and evaluate thermal losses in storage tanks.
-Compare the most common CSP plant technologies and identify future trends, including third generation CSP, advanced supercritical cycles, and hybridization.

Full-or-part-time: 12h
Theory classes: 8h
Laboratory classes: 4h

GRADING SYSTEM

Final exam (PE): 50%
Assessment exercises (individually or in small groups) (TR): 50%.

There will be three assessment exercises to be developed along the course.
The final grade will be obtained from the continuous evaluation and the final exam following the formula:
FINAL mark=0.1×assessment1+0.15×assessment2+0.3×assessment3+0.5×final exam

BIBLIOGRAPHY

Basic:
- Kalogirou, Soteris. Solar energy engineering : processes and systems [on line]. 1st ed. Burlington, MA: Elsevier/Academic Press, c2009 [Consultation: 12/05/2026]. Available on: https://www-sciencedirect-com.recursos.biblioteca.upc.edu/book/monograph/9780123745019/solar-energy-engineering. ISBN 9786612285608.
- Duffie, John A; Beckman, William; Blair, Nathan. Solar engineering of thermal processes, photovoltaics and wind [on line]. Fifth edition. Hoboken: Wiley, 2020 [Consultation: 12/05/2026]. Available on: https://onlinelibrary-wiley-com.recursos.biblioteca.upc.edu/doi/book/10.1002/9781119540328. ISBN 9781119540304.
- Vogel, Werner; Kalb, Henry. Large-scale solar thermal power : technologies, costs and development [on line]. Weinheim: Wiley-VCH, cop. 2010 [Consultation: 12/05/2026]. Available on: https://onlinelibrary-wiley-com.recursos.biblioteca.upc.edu/doi/book/10.1002/9783527629992. ISBN 9783527405152.

Complementary:
- Winter, C.-J; Sizmann, Rudolf L; Vant-Hull, Lorin L. Solar power plants : fundamentals, technology, systems, economics. Berlin [etc.]: Springer-Verlag, cop. 1991. ISBN 9783642647598.
- Gordon, Jeffrey. Solar energy : the state of the art : ISES position papers [on line]. Oxon: James & James, 2013 [Consultation: 12/05/2026]. Available on: https://www-taylorfrancis-com.recursos.biblioteca.upc.edu/books/edit/10.4324/9781315074412/solar-energy-jeffrey-gordon. ISBN 9781315074412.

RESOURCES

Other resources:
Audiovisual material:
- Transparències. Resource
Computer material:
- Apunts i articles. Resource