Course guide
2400150 - 240MER55 - Geothermal Energy

Last modified: 05/05/2026

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: Capdevila Paramio, Roser
Mas De Les Valls Ortiz, Elisabet

Others: Capdevila Paramio, Roser
Péan, Thibault Quentin

PRIOR SKILLS

Fundamentals of Heat Transfer.
Fundamentals of Thermodynamics.
Fundamentals of Fluid Mechanics.

REQUIREMENTS

Thermal Equipment

TEACHING METHODOLOGY

The Geothermal Energy course is designed so as students acquire the geothermal fundamentals that enable them to propose adequate geothermal installation considering both technical, economical and sustainability aspects.
To reach so, theory is continuously combined with case studies, a design project and experts' conferences. The case studies and the design project are carried out in small teams.
In both the case studies and the design project, oral defences will be carried out, not only to show the final result, but the enable the follow up of each team.
There will be conferences by competent experts on the subject.
If possible, a visit to a geothermal installation will be scheduled. This attendance in this visit is mandatory.

LEARNING OBJECTIVES OF THE SUBJECT

- Provide an overview of the geothermal energy potential of the soil
- Provide information regarding the different types of geothermal facilities and their potentialities.
- Provide a comprehensible description of the different cycles used in each type of geothermal facility.
- Provide the state-of-the-art on existing deep geothermal facilities
- Provide the guidelines to design a very low enthalpy installation
- Increase the expertise in teamwork skills

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

1. Introduction to geothermal energy

Description:
Basic concepts of geothermal energy will be introduced: internal structure of the Earth, origin of terrestrial heat, heat flows, geothermal temperature gradients, geothermal singularities, fundamentals of solar geophysics, soil thermal and hydraulic properties, types of groundwater systems, and major differences between deep and shallow geothermal applications.
A brief summary of the history of the use of geothermal energy and the current state. Geothermal use potential at global, national and regional level.
Main actors and sources in the use of geothermal energy.
Integration of geothermal energy within heat and cold networks.

Specific objectives:
Understand the basic concepts of geothermal energy.
Understand the scope and potential use of geothermal energy.

Related activities:
First ideas quiz
Written exam

Full-or-part-time: 21h 30m
Theory classes: 10h 30m
Self study : 11h

2. Deep geothermal

Description:
Main characteristics of deep geothermal energy.
Analysis of different utilizations and technologies.
Geothermal electricity power plants.

Specific objectives:
Understand the different type of electricity production cycles depending on the thermal and geophysical characteristics of the terrain.
Know different application and technologies from geothermal sources a part from electricity production.
Have an overview of the current state and future perspectives of geothermal energy use in the World.

Related activities:
Team project about several geothermal electricity power plants and their country geothermal characteristics.
Written exam

Full-or-part-time: 36h
Theory classes: 8h
Laboratory classes: 4h
Self study : 24h

3. Shallow geothermal

Description:
The contents are provided following a Project Base Learning where students work in teams. Each team chose one of the given locations and the type of building to be built. Step by step, students will identify the demands, understand the heat pump fundamentals and choose the appropriate heat pump for their project, they will be able to choose the type of facility and calculate its dimensions. Also, an economical and environmental analysis will be performed.

Specific objectives:
- Provide an overview of the very low enthalpy systems including vertical boreholes, horizontal systems, thermal foundations and open systems.
- Provide guidelines to choose among the different geothermal systems according to the needs and the technical and socioeconomical opportunities.
- Provide a detailed description of the heat pump cycle and key components.
- Provide some indications regarding the most suitable heat pump for each scenario and how to assess its performance.
- Provide the algorithm to calculate the geothermal collector dimensions for a very low enthalpy geothermal project.
- Provide guidelines on how to perform a suitable economic analysis and a reasonable environmental study.

Related activities:
Team project. Along the team project some deliverables will be scheduled, and brief oral presentations carried out.
Written exam

Full-or-part-time: 67h 30m
Theory classes: 11h 30m
Laboratory classes: 11h
Self study : 45h

GRADING SYSTEM

Attendance at synchronous sessions is mandatory. In order to be eligible to be assessed for the subject, attendance at a minimum of 75% of these activities will be required.

If the final exam grade is greater than or equal to 3.5:
Final qualification FQ will be calculated as FQ = 0.15·CS + 0.35·DP + 0.10·AP + 0.40·FE, being:
• CS: case studies related to low, medium and high enthalpy geothermal projects.
• DP: design project concerning a very low enthalpy geothermal facility.
• AP: active participation in class. This includes expositive lessons, conferences, small exercises, simulations and the visit.
• FE: final exam regarding the contents of the whole course and activities.

If the final exam grade is less than to 3.5:
Final qualification FQ will be calculated as FQ = 0.10·CS + 0.10·DP + 0.10·AP + 0.70·FE, being:
• CS: case studies related to low, medium and high enthalpy geothermal projects.
• DP: design project concerning a very low enthalpy geothermal facility.
• AP: active participation in class. This includes expositive lessons, conferences, small exercises, simulations and the visit.
• FE: final exam regarding the contents of the whole course and activities.

To obtain an evaluation of the course activities and projects, students must validate their work. In that sense, group or individual defense sessions will be scheduled, if necessary.
The detection of copying or plagiarism in CS or DP will result in automatic suspension of the entire subject.

EXAMINATION RULES.

Unrealized activities are not evaluated

BIBLIOGRAPHY

Basic:
- DiPippo, Ronald. Geothermal power plants : primciples, applications, case studies and environmental impact [on line]. 4a ed. Butterworth-Heinemann, 2015 [Consultation: 14/05/2026]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=4188453. ISBN 9780081002902.
- Deutsche Gesellschaft f. Shallow geothermal systems - recommendations on design, construction, operation and monitoring [on line]. Berlin: Ernst & Sohn, 2016 [Consultation: 15/05/2026]. Available on: https://onlinelibrary-wiley-com.recursos.biblioteca.upc.edu/doi/book/10.1002/9783433606674. ISBN 3433606676.
- Egg, Jay ; Cunniff, Greg ; Orio, Carl D.. Modern geothermal HVAC : engineering and control applications. New York: McGraw Hill Education, 2013. ISBN 9780071792684.

Complementary:
- Grant, Malcom A.; Bixley, Paul F. Geothermal reservoir engineering [on line]. second edition. New York: Academic Press, 2011 [Consultation: 15/05/2026]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=667717. ISBN 9780123838810.
- Llopis Trillo, Guillermo; López Jimeno, Carlos; Franqueza Palacios, Juan. Guía técnica de sondeos geotérmicos superficiales. Madrid: Fundación de la Energía de la Comunidad de Madrid, 2009. ISBN 9788461291366.
- Conde Lázaro, Eduardo...et al. Guía técnica de bombas de calor geotérmicas. Madrid: Fundación de la Energía de la Comunidad de Madrid, 2009. ISBN 9788461291427.
- Gupta, Harsh ; Roy, Sukanta. Geothermal energy : an alternative resource for the 21st century [on line]. Amsterdam: Elseiver, 2007 [Consultation: 14/05/2026]. Available on: https://www-sciencedirect-com.recursos.biblioteca.upc.edu/book/monograph/9780444528759/geothermal-energy. ISBN 1280708018.

RESOURCES

Other resources:
Presentations and other documents in digital campus