Course guide
820745 - EGT - Geothermal Energy

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

Degree: MASTER'S DEGREE IN ENERGY ENGINEERING (Syllabus 2013). (Optional subject).
MASTER'S DEGREE IN INDUSTRIAL ENGINEERING (Syllabus 2014). (Optional subject).
MASTER'S DEGREE IN ENERGY ENGINEERING (Syllabus 2022). (Optional subject).

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

LECTURER

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

Others: Mas De Les Valls Ortiz, Elisabet
De Medina Iglesias, Vicente César
Péan, Thibault Quentin

PRIOR SKILLS

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

REQUIREMENTS

Thermal Equipment

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CEMT1. Understand, describe and analyse, in a clear and comprehensive manner, the entire energy conversion chain, from its status as an energy source to its use as an energy service. They will also be able to identify, describe and analyse the situation and characteristics of the various energy resources and end uses of energy, in their economic, social and environmental dimensions, and to make value judgments.
CEMT4. Efficiently collect data on renewable energy resources and their statistical treatment and apply knowledge and endpoint criteria in the design and evaluation of technology solutions for using renewable energy resources, for both isolated systems and those connected to networks. They will also be able to recognise and evaluate the newest technological applications in the use of renewable energy resources.
CEMT5. Employ technical and economic criteria to select the most appropriate thermal equipment for a given application, dimension thermal equipment and facilities, and recognise and evaluate the newest technological applications in the production, transportation, distribution, storage and use of thermal energy.
CEMT7. Analyse the performance of equipment and facilities in operation to carry out a diagnostic assessment of the use system and establish measures to improve their energy efficiency.

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, simulations and experts' conferences. The case studies and the design project are carried out in small teams. However, simulations are carried out individually with the continuous support of the teachers.
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 medium group	15,0	11.54
Self study	85,0	65.38
Hours large group	30,0	23.08

Total learning time: 130 h

CONTENTS

1. Introduction to geothermal energy

Description:
Basic concepts of geothermal energy will be introduced: internal structure of the Earth, origin of Earth heat, Heat fluxes, geothermal temperature gradients, geothermal singularities and main differences between deep and shallow geothermal applications.
A brief summary of history of geothermal energy use and current state. Potential of geothermal use at global, national and regional level.
Main players and sources in geothermal energy use.

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

Related activities:
i. First ideas quiz

Related competencies :
CEMT-1. Understand, describe and analyse, in a clear and comprehensive manner, the entire energy conversion chain, from its status as an energy source to its use as an energy service. They will also be able to identify, describe and analyse the situation and characteristics of the various energy resources and end uses of energy, in their economic, social and environmental dimensions, and to make value judgments.

Full-or-part-time: 11h
Theory classes: 5h
Self study : 6h

2. Soil geophysics

Description:
The main aspects of soil geophysics will be introduced always focusing on its relevance for the geothermal energy installation. These include aspects covering a wide range of knowledge areas, from tectonic plate theory to soil thermal and hydraulic properties. The types of subsoil water systems will be presented together with the requirements of the subsoil water to be used in open systems.
The hydraulic head concept and Darcy's law will be revised, and some simulations carried out to consolidate the concepts.
Overview of available drilling technologies and its use depending on soil type and depth.

Specific objectives:
• Review the fundamentals of the tectonic plate theory and how it determines the type of geothermal facility to be designed.
• Provide a summary of main soil thermal and hydraulic properties and its influence in the design of geothermal installations.
• Provide guidelines to assess the influence of an open geothermal facility in the quality of the subsoil water reservoirs.
• Provide experience in performing hydrogeological simulations with the tool Code Bright.
• Expose some real examples of studies related to subsoil water management.
• Provide an overview of available drilling technologies.

Related activities:
i.Short exercise to identify available aquifers in Catalonia using online open resources.
ii. Perform a hydrogeological simulation using the code Code_Bright.
iii. Written exam

Related competencies :
CEMT-4. Efficiently collect data on renewable energy resources and their statistical treatment and apply knowledge and endpoint criteria in the design and evaluation of technology solutions for using renewable energy resources, for both isolated systems and those connected to networks. They will also be able to recognise and evaluate the newest technological applications in the use of renewable energy resources.
CEMT-5. Employ technical and economic criteria to select the most appropriate thermal equipment for a given application, dimension thermal equipment and facilities, and recognise and evaluate the newest technological applications in the production, transportation, distribution, storage and use of thermal energy.

Full-or-part-time: 24h
Theory classes: 6h
Guided activities: 4h
Self study : 14h

3. Low, medium and high enthalpy

Description:
Main characteristics of low, medium and high enthalpy 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:
i. Team project about a geothermal electricity power plant and its country geothermal characteristics.
ii. Written exam

Related competencies :
CEMT-7. Analyse the performance of equipment and facilities in operation to carry out a diagnostic assessment of the use system and establish measures to improve their energy efficiency.
CEMT-4. Efficiently collect data on renewable energy resources and their statistical treatment and apply knowledge and endpoint criteria in the design and evaluation of technology solutions for using renewable energy resources, for both isolated systems and those connected to networks. They will also be able to recognise and evaluate the newest technological applications in the use of renewable energy resources.

Full-or-part-time: 28h 30m
Theory classes: 6h 30m
Guided activities: 3h
Self study : 19h

4. Very low enthalpy

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

Related competencies :
CEMT-7. Analyse the performance of equipment and facilities in operation to carry out a diagnostic assessment of the use system and establish measures to improve their energy efficiency.

Full-or-part-time: 61h
Theory classes: 10h
Guided activities: 10h
Self study : 41h

ACTIVITIES

2. Project of very low enthalpy geothermal energy

Description:
Develop a team project to implement very low temperature geothermal energy

Specific objectives:
Evaluation of the students' achievement of competencies CETM4, CTM6 and CETM7

Material:
Given data: location and the type of building.

Delivery:
Two presentations to be made during the development of the project. At the end of the project: project report and summary poster with presentation.

Related competencies :
CEMT-5. Employ technical and economic criteria to select the most appropriate thermal equipment for a given application, dimension thermal equipment and facilities, and recognise and evaluate the newest technological applications in the production, transportation, distribution, storage and use of thermal energy.
CEMT-4. Efficiently collect data on renewable energy resources and their statistical treatment and apply knowledge and endpoint criteria in the design and evaluation of technology solutions for using renewable energy resources, for both isolated systems and those connected to networks. They will also be able to recognise and evaluate the newest technological applications in the use of renewable energy resources.
CEMT-7. Analyse the performance of equipment and facilities in operation to carry out a diagnostic assessment of the use system and establish measures to improve their energy efficiency.

Full-or-part-time: 61h
Theory classes: 10h
Guided activities: 10h
Self study: 41h

3. Written test

Description:
Written test on all the concepts explained during the course

Specific objectives:
Evaluation of students' achievement of all the concepts explained during the course

Material:
Statement questions

Delivery:
Exam at the end of the course (according to the official calendar)

Related competencies :
CEMT-1. Understand, describe and analyse, in a clear and comprehensive manner, the entire energy conversion chain, from its status as an energy source to its use as an energy service. They will also be able to identify, describe and analyse the situation and characteristics of the various energy resources and end uses of energy, in their economic, social and environmental dimensions, and to make value judgments.
CEMT-5. Employ technical and economic criteria to select the most appropriate thermal equipment for a given application, dimension thermal equipment and facilities, and recognise and evaluate the newest technological applications in the production, transportation, distribution, storage and use of thermal energy.
CEMT-7. Analyse the performance of equipment and facilities in operation to carry out a diagnostic assessment of the use system and establish measures to improve their energy efficiency.
CEMT-4. Efficiently collect data on renewable energy resources and their statistical treatment and apply knowledge and endpoint criteria in the design and evaluation of technology solutions for using renewable energy resources, for both isolated systems and those connected to networks. They will also be able to recognise and evaluate the newest technological applications in the use of renewable energy resources.

Full-or-part-time: 2h
Theory classes: 2h

1. Project of very medium & high enthalpy geothermal energy

Description:
Develop a group project for the analysis of a medium & high temperature geothermal installation

Specific objectives:
Evaluation of the students' achievement of competencies CETM1, CETM4, CETM7

Material:
Data provided: country and type of power cycle of the geothermal power plant.

Delivery:
Presentation

Related competencies :
CEMT-4. Efficiently collect data on renewable energy resources and their statistical treatment and apply knowledge and endpoint criteria in the design and evaluation of technology solutions for using renewable energy resources, for both isolated systems and those connected to networks. They will also be able to recognise and evaluate the newest technological applications in the use of renewable energy resources.
CEMT-7. Analyse the performance of equipment and facilities in operation to carry out a diagnostic assessment of the use system and establish measures to improve their energy efficiency.
CEMT-1. Understand, describe and analyse, in a clear and comprehensive manner, the entire energy conversion chain, from its status as an energy source to its use as an energy service. They will also be able to identify, describe and analyse the situation and characteristics of the various energy resources and end uses of energy, in their economic, social and environmental dimensions, and to make value judgments.

Full-or-part-time: 28h 30m
Theory classes: 6h 30m
Guided activities: 3h
Self study: 19h

GRADING SYSTEM

Any academic fraud, plagiarism or use or possession of unauthorised means in an assessment activity leads to a mark of zero (0) for the affected test or assignment. Furthermore, in accordance with the University's regulations, if disciplinary proceedings are initiated the subject is recorded as "Pending Assessment" until a decision is reached. These incidents are managed in accordance with the **Action Framework for Academic Integrity in Assessment at the UPC**.

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 4.0:
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 4.0:
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 : principles, applications, case studies and enviromental impact [on line]. 4a ed. s.l.]: Butterworth-Heinemann, 2015 [Consultation: 11/05/2026]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=4188453. ISBN 9780081002902.
- Deutsche Gesellschaft für Geotechnik. Shallow geothermal systems: recommendations on design, construction, operation and monitoring [on line]. Berlin: Ernst & Sons, 2016 [Consultation: 12/05/2026]. Available on: https://discovery.upc.edu/discovery/fulldisplay?docid=alma991005326078206711&context=U&vid=34CSUC_UPC:VU1&lang=ca. ISBN 3433606676.
- Egg, Jay ; Cunnig, Greg ; Orio, Carl D. Modern Geothermal HVAC Engineering and Control Applications. New York: McGraw Hill, 2013. ISBN 9780071792684.

Complementary:
- Grant, Malcom A.; Bixley, Paul F. Geothermal reservoir engineering [on line]. 2a ed. Amsterdam ; Boston, MA: Academic Press, 2011 [Consultation: 12/05/2026]. 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, DL 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]. 1st ed. Amsterdam: Elsevier Science, 2007 [Consultation: 11/05/2026]. Available on: https://www-sciencedirect-com.recursos.biblioteca.upc.edu/book/monograph/9780444528759/geothermal-energy. ISBN 0080465641.

RESOURCES

Other resources:
Presentations and other documents in digital campus