

Energy and Geotechnics (250MEG014)

General Information

School	ETSECCPB
Departments	Departament d'Enginyeria Civil i Ambiental (DECA)
Credits	5.0 ECTS
Programs	MÀSTER UNIVERSITARI EN ENGINYERIA GEOTÈCNICA (pla 2025)
Course	2025/26

Main teaching language at each group

- Group 10Q1 Spanish (Q1)

Faculty

Responsible Faculty: Jean Vaunat

Faculty: Marcos Arroyo Alvarez De Toledo, Laura González Blanco, Núria Sau Valenzuela, Jean Vaunat

Objectives of Education

The course has seven main objectives:

- To introduce students to the main geotechnical issues that are emerging in relation to the energy transition and energy in general.
- To open students' minds to the need to adapt traditional geotechnical concepts to new problems and, to this end, to reflect on the basis of current geotechnical practice.
- To introduce students to the fundamental mechanisms involved in geotechnical problems related to energy, as well as the theoretical chemo-thermo-hydro(gas)-mechanical concepts that control these mechanisms.
- To prepare students to apply these concepts to address unconventional problems.
- To prepare students to work in groups to analyze and propose solutions to unconventional problems.
- To introduce students to the design rules that are being consolidated for designing energy-related solutions.
- To prepare students to present a solution to an unconventional problem in public.

Total hours of student work

		Hours	Percentage
Supervised Learning	Large group	45.0 h	100.00 %
	Medium group	0.0 h	0.00 %
	Laboratory classes	0.0 h	0.00 %
	Guided Activities	0.0 h	0.00 %
Self Study		80.0 h	

Contents

Introduction

Course presentation, teaching methodology, assessment methods, and student presentations. General presentation of the new geotechnical issues emerging along the entire energy production-transport-storage pipeline:

- extraction of fossil fuels, gas (including hydrates), minerals (mines), and heat (geothermal energy),
- electricity generation by wind turbines,
- construction and maintenance of transmission lines (oil pipelines, hydro pipelines),
- storage of gas and heat in the ground and waste management, whether mining or nuclear energy products

Contingut Lab

In-class workshop-debate on the elements that should be added to geotechnical practice to address energy-related problems. Home autonomous search for a case study to be presented at the end of the course.

Specific Objectives

Identify the specificity of geotechnical problems in energy-related issues.

Offshore platform foundations and mining tailings

Two issues of great current relevance and relatively close to traditional geotechnical practice will be addressed. These are:

- 1) the sizing of foundations for onshore and offshore wind farms,
- 2) the sizing of tailings dams and mine tailings.

From a materials behavior perspective, these two issues are characterized by the involvement of coupled hydromechanical processes in saturated/unsaturated soils and cyclical stresses.

Contingut Lab

Class presentations Presentation by a professional from an offshore company Supervised numerical calculations. Workshop on capillary barriers

Specific Objectives

Understand the processes operating in soft soils subjected to cyclic loading.
Use numerical tools to analyze the response of wind tower foundations and mine tailings ponds.

Underground gas storage

Issues related to gas injection into the ground will be addressed.

Contingut Lab

In-class presentations Hand's on sessions using numerical calculation programs Case study

Specific Objectives

- Understand the processes that control gas flow in the ground.
- Numerically model gas injection and flow problems in the ground.
- Understand existing gas injection solutions. Design improvements to existing solutions.

Solutions for thermal energy

Some issues related to the extraction, injection, and storage of heat in the ground will be addressed:

- Thermal geostructures
- Storage of exothermic waste

Contingut Lab

Numerical Modeling Workshop Group exercise on thermal geostructure design Discussion on the contributions of geotechnics to problems involving heat propagation.

Specific Objectives

Understand heat propagation processes in the soil.
Model boundary problems involving heat propagation in the soil.
Calculate solutions for heat storage and return to the soil.
Analyze the safety of underground exothermic waste storage solutions.

Final workshop

The class will be dedicated to a 3-hour workshop where students will present a case study and perform a role-playing game around a social/environmental issue related to energy.

Contingut Lab

Self learning Public presentation Role-playing game at a meeting

Specific Objectives

Integrate diverse information to analyze a real-life problem and develop solutions.
Present the information to an audience.
Discuss the solution in a group.

Teaching Methodology

The course consists of 3 hours per week of classroom activity.

During the course, 20 hours are devoted to theoretical lectures, in which the teacher presents the basic concepts and topics of the subject, shows examples and solves exercises.

15 hours are devoted to solving practical problems with greater interaction with the students. The objective of these practical exercises is to consolidate the general and specific learning objectives.

Support material is provided using the virtual campus ATENEA: detailed teaching plan, content, learning advance plan, evaluation activities and literature.

Although most of the sessions will be given in the language indicated, sessions supported by other occasional guest experts may be held in other languages.

Grading Rules

() The evaluation calendar and grading rules will be approved before the start of the course.*

Course mark is computed from the ratings obtained during continuous evaluation activities and evaluation tests.

Continuous evaluation consists in several additive and training activities carried out during the year in and out of the classroom. They are realized individually or in group.

Evaluation tests consist of questions on concepts associated with knowledge/understanding learning objectives, completed by several application exercises.

Test Rules

Any continuous evaluation activity not presented in the scheduled period will be granted with a null mark.

Office Hours

Out-of-room meetings are scheduled by agreement with the teacher

Bibliography

Basic

- Laloui L.; Loria A. F. [Analysis and Design of Energy Geostructures: Theoretical Essentials and Practical Application](#). 1st ed. London: Academic Press, 2020. ISBN 9780128165980.
- Olivella, S., Vaunat, J. & Rodríguez Dono, A. [CODE_BRIGHT 2025 USER'S GUIDE](#). Barcelona: CIMNE, 2025.
- Finke Morrison, K. Tailings Management Handbook: A LifeCycle Approach. Society for Mining, Metallurgy, and Exploration, 2022. ISBN 9780873354905.
- Gens, A. "Soil–environment interactions in geotechnical engineering". Géotechnique [en línia]. 60 (1): 3-74 [Consulta: 16/09/2025]. Disponible a: <https://www-emerald-com.recursos.biblioteca.upc.edu/geot/article/60/1/3/401022/Soil-environment-interactions-in-geotechnical>.

