UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Geoenergy

2324-2-F7401Q078

Aims

To provide a knowledge framework that makes a geologist capable of addressing emerging issues in geoenergy and sustainability. The course starts with an analysis of energy sources and consumption, resource distribution, and includes treatment of both fossil and conventional as well as renewable and unconventional sources. From the perspective of sustainability, maximum emphasis is given to renewable resources.

Contents

Energy sources are one of the most important factors for human activities, and the consumption of these sources has an immediate impact on living conditions but also on the balance of our planet.
All renewable resources are mentioned as well as methods of possible immegazzinamento of energy, of transformation.
Geothermal energy, geoexchange techniques are analyzed in detail. The course makes full use of hydrogeological knowledge gained by students in other courses.

The course will cover the basic aspects regarding the problems of research and exploitation of energy resources with hints about the associated risks.

List of contents:
Introduction to Geoenergy:

- Definition and overview of geoenergy
- Importance and role of geoenergy in the energy sector
- Distinction between conventional and unconventional energy sources

Geothermal Energy:

- Geothermal heat sources and geothermal gradient
- Types of geothermal systems (e.g., hydrothermal, enhanced geothermal systems)
- Geothermal resource assessment and exploration techniques
- Geothermal power generation technologies
- Geothermal heat pumps and direct use applications

Petroleum Geology and Reservoir Engineering:

- Formation and accumulation of petroleum
- Petroleum exploration and production techniques
- Reservoir characterization and modeling
- Enhanced oil recovery (EOR) methods
- Unconventional oil and gas resources (e.g., shale gas, tight oil)

Coal and Coalbed Methane:

- Formation and types of coal deposits
- Coal mining techniques and environmental impacts
- Coal-to-liquids (CTL) and coal gasification technologies
- Coalbed methane extraction and utilization

Underground Storage of Energy:

- Underground gas storage for natural gas
- Compressed air energy storage (CAES)
- Pumped hydro energy storage (PHES)
- Thermal energy storage (TES) in subsurface formations
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Environmental Considerations and Sustainability:

- Environmental impacts of geoenergy extraction and utilization
- Carbon capture, utilization, and storage (CCUS)
- Life cycle assessment and greenhouse gas emissions
- Policy and regulatory aspects of geoenergy development
- Integration of renewable energy and geoenergy systems

Emerging Technologies and Future Trends:

- Methane hydrates and gas hydrate production
- Deep geothermal energy and hot dry rock (HDR) systems
- Geothermal energy from abandoned oil and gas wells
- Energy geostructures and geothermal pile foundations
- Geoenergy in the context of a transitioning energy landscape

Detailed program

Main contents of this course are:

- General introduction to energy resources

- Energy demand

Conceptual models of reservoir rocks

Conceptual models of oil and gas reservoirs

- Geometric, physical and mechanical properties of reservoir rocks

- Geological key-factors

- Tools and techniques for characterization

- Stratification of fluids in a reservoir

- Multi-fluid circulation in oil and gas deposits in porous rocks and fractured rock masses

- Geomechanics applied to the extraction of hydrocarbons (drilling, stability, stresses in a reservoir, improvement techniques)

- Unconventional resources

Introduction to geothermal resources, geothermal systems in low, medium and high enthalpy

- The thermal field of the Earth. A brief history of geothermal energy. Sources of thermal energy within the Earth. The geothermal gradient. Conductivity contrasts. Effects of non-uniform temperatures to the surface on temperature profiles. Temperature distribution within the Earth and the Geothermal maps.

- Thermal properties of the rocks and fluids (conductivity, capacity, diffusivity). The impact of high temperature and pressure on fluids. Measurement of the thermal field, instrumentation, methods. Temperature anomalies and association with natural phenomena (hot springs, geysers, volcanoes, mud volcanoes). Interpretation of thermal measurements.

- Concepts, classification and chemistry of geothermal systems. Development of a geothermal model. Analysis of geothermal systems. Thermal surveys in oil exploration. Thermal analysis in hydrology.

- Systems of heat pumps in open and closed loops. Impacts on water quality. Legislation. Water flow and heat transport Storage heat, specific capacity and thermal, heat transport by advection, conduction, convection.

- Heat exchangers. Estimation of the potential heat of a shallow unconfined aquifer.

- Analytical solutions for closed and open systems.

- Numerical solutions.

- Operation in the short and long term.

- Methods of investigation.

- EGS: enhanced geothermal systems, hot dry rocks, techniques for improving the performance of reservoir rocks

CO? storage and natural gas

- Characterization of material properties

- Modeling Methods

- Tests in the laboratory, and on-site monitoring

- Micro-induced seismicity

- Techniques of Geophysical Research

Evaluation of radioactive waste repositories

Prerequisites

none

Teaching form

Lessons

Textbook and teaching resource

all the lectures material can be downloaded from the elearning site

Semester

Second

Assessment method

Written

Office hours

Sustainable Development Goals

AFFORDABLE AND CLEAN ENERGY