The course will offer an introduction to different Geo-energy technologies for subsurface extraction of energy and secure sequestration and storage of byproducts of energy production. Different subsurface energy extraction systems including shallow and deep geothermal energy systems, enhanced oil recovery systems, shale gas extraction, and various subsurface systems for storage of carbon dioxide and nuclear wastes will be discussed in this course.

References:
Several references are used including:
- Reservoir geomechanics; by Mark Zoback; Cambridge; 2007
- Petroleum related rock mechanics; 2nd Edition; by Erling Fjaer; Elsevier; 2008
- Geological Sequestration of Carbon Dioxide: Thermodynamics, Kinetics, and Reaction Path Modeling; by Luigi Marini; Elsevier, 2007
- Frontiers in Geochemistry; by Russel Harmon and Andrew Parker; Wiley-Blackwell; 2011

Tentative Grading:
Mid-term test 20%
Homework 15%
Design Project 20%
Case Study 10%
Class Presentation 10%
Final Exam 25%

Schedule:
Lectures: T/R (8:30 - 9:45 am)
Location: PERKIN 101
Learning Objectives:

- Recognize different types of geothermal energy extraction systems
- Understand and be able to design energy piles
- Evaluate the potential of enhanced geothermal systems, analyze the design components, and identify its environmental impacts
- Distinguish enhanced oil recovery systems and understand the principles of two phase flow in porous media applied to enhanced oil recovery
- Analyze different aspects of shale energy, particularly the geomechanics and environmental aspects of shale gas extraction
- Assess the potential of geological storage of energy byproducts and be able to evaluate the underground transport of these byproducts
- Enhance inquiry-based, research-based learning
- Practice open-ended problem solving and design skills
- Practice oral presentation and interpersonal skills

Course Outline

A. Review

   I. Stresses, Strains, and Elastic Deformation
   II. Mohr-Coulomb's strength theory
   III. Shear Stresses

   I. Stresses, Strains, and Elastic Deformation
   II. Fluid transport in rocks

B. Geothermal Energy

3. Shallow geothermal energy (energy piles) [4]
   I. Development of energy piles
   II. Heat transfer in porous media and Ground Source Heat Pumps (GSHP)
   III. Thermo-mechanical properties of soils
   IV. Advances in the geotechnical design of energy pile foundations
   V. Case studies and design consideration of energy piles

   I. Development of EGS
   II. Rock-fluid interactions
   III. Hydro-shearing and fracture mechanism
   IV. Case studies and design consideration of EGS

MID TERM EXAM                              Date: October 12
C. Enhanced oil and gas recovery

5. Enhanced oil recovery (EOR) [3]
   I. Development of two phase flow in porous media
   II. Petroleum related rock mechanics
   III. Environmental concerns associated with EOR

   I. Development of shale gas extraction
   II. Mechanics of hydraulic fracturing
   III. Environmental impacts:
      a. Erosion and sedimentation
      b. Spills and leaks
      c. Groundwater contamination risks
      d. Water resources management and waste water disposal
      e. Induced seismic events

D. Subsurface systems for storage of energy byproducts

7. Carbon capture and sequestration (CCS) [3]
   I. Development of carbon sequestration and storage
   II. Geochemistry of CO₂ storage
   III. Environmental issues of CCS

8. Nuclear and chemical waste disposal [2]
   I. Development of underground waste disposal
   II. Fate, transport, and leakage of nuclear wastes

FINAL EXAM Date: December 12

Computer Usage:
COMSOL software and some MATLAB programming will be used.

Design Component:
There will be a design project on energy pile. Specifics of the project will be discussed in class.

Code of Academic Integrity:
Offence against the Code of Academic Integrity are deemed serious and insult the integrity of the entire academic community. Any suspected violations of the Code are taken very seriously and will be forwarded to the Center for Student Ethics & Standards for further intervention. To read the Code of Academic Integrity and learn more about the Center for Student Ethics and Standards, visit their website at: http://www.uvm.edu/cses