MSc projects are available in the fields of environmental technology, geothermal energy and CO2 capture and storage. Projects 1-4 are relevant for students in chemistry, chemical engineering, geochemistry, industrial engineering, process engineering, physics or materials science. Projects 5-7 are relevant for students with a background in physics, geology, mathematics, mathematical earth sciences, numerical simulation, computation or mechanics.

Materials, chemical engineering and process simulations:

1. Development of mechanically stable solid sorbent agglomerates for high-temperature CO_2 capture.
2. Development of new hybrid ceramic material: catalyst/sorbent for hydrogen production and high-temperature CO_2capture.
3. Chemical process simulation.
4. Development of multi-functional soil amendments based on mafic minerals for GHG emissions mitigation in agriculture.

Geology and numerical simulations:

5. Developments of new numerical codes and experimental setups for coupled deformation, reaction and flow in tight rocks.
6. Basin modeling with metamorphic phase changes.
7. Linking geomechanics, fluid flow and seismic wave propagation.

Project descriptions

Project proposal 1: Development of mechanically stable solid sorbent agglomerates for high-temperature CO_2capture.

The aim of the project is to develop a novel agglomeration technique to produce spherical ceramic beads of mixed CaO/calcium aluminate ceramic for high-temperature CO_2capture application. Several agglomeration techniques will be tested and evaluated to determine the most suitable technique for preparation of medium size agglomerate batches.

The influence of process parameters on the final microstructure of the sorbent (density, porosity) and the capture properties (reaction kinetic, absorption capacity, chemical durability) will be evaluated.

The mechanical properties of the produced agglomerates/granules will be fully characterized by crushing strength and attrition measurements. Mechanical and chemical properties of the developed agglomerates will be compared to the properties of the natural sorbents and to literature data available for other sorbents.

Contacts: Julien Meyer and Luca Di Felice. (Julien.Meyer (at) ife.no / Luca.Di.Felice (at) ife.no)

Project proposal 2: Development of new hybrid ceramic material: catalyst/sorbent for hydrogen production and high-temperature CO_2 capture.

Preliminary studies have shown it is possible to integrate catalytically active nano-particles of Nickel or Rhodium within the microstructure of the sorbent particles to create an “all-in-one” particle: hybrid CO_2-sorbent particle with an active layer of Ni-particles.
This project will focus mainly on the development of stable “all-in-one” particles with special emphasis on the long-term chemical properties of the sorbent particles and the long-term activity of the catalytic particles.

The work will include the synthesis method optimization (impregnation/doping methods evaluation, catalyst loading, etc.) and the chemical and mechanical properties evaluation of the obtained materials. The development of such novel hybrid material would be a key step towards the commercialization of a sorption-enhanced reforming process.

Contacts: Julien Meyer and Luca Di Felice. (Julien.Meyer (at) ife.no / Luca.Di.Felice (at) ife.no

Available facilities
Available experimental apparatus at IFE for those two projects are: Thermogravimetric analysis (TGA) for the performance of studies on the CO_2 sorbents, a laser scattering particle size distribution instrument, scanning electron microscope (SEM), X-ray diffraction (XRD), fluid bed agglomerator/coater, an instrument for measuring particle hardness and a bench-scale fixed bed reactor, coupled with a micro-GC, for testing high-temperature reactions.

Project proposal 3: Chemical process simulation.

The Environmental Technologies Department has a licence for AspenTech's University Package for Process Engineering, which offers an integrated suite of software for research and educational purposes.

This set of software allows the modelling and simulation of industrial plants and chemical processes, covering areas ranging from equipment design to energy and mass balances, steady-state and dynamic process simulation, process optimization and economics evaluation, among others.

In our department we work on a range of research topics including chemical processes for mineral industry, CO_2 capture, hydrogen production, development of environment-friendly solutions for industry and evaluation of innovative energy-efficient concepts.
In all those areas, simulation tools can provide robust, fast, low cost and low risk, reliable calculations that help us to:

- Evaluate the viability of processes (energy and economy wise)
- Optimize process configurations
- Develop innovative alternatives

We are open to discuss the most suitable application for your Master Thesis, among the several topics we work with.

Background: Chemical engineering, industrial engineering, chemistry, basic to advance previous knowledge on Aspen or Aspen Hysys software (recommendable), programming skills (positive).
Contact: Julien Meyer and Luca Di Felice. (Julien.Meyer (at) ife.no / Luca.Di.Felice (at) ife.no

Project proposal 4: Development of multi-functional soil amendments based on mafic minerals for GHG emissions mitigation in agriculture.

Greenhouse gas emissions mitigation, crop-soil's long-term productivity, widening of resources and improving products at fertilizer producing companies, optimized use of available natural resources and environmentally friendly management of tailings from mining industry are some of the present challenges regarding environment and sustainability.

At IFE, we identify synergies between those topics, and this Master Thesis project will be focused on the experimental exploration of integrated solutions.
Based on the knowledge obtained on soils amendments and GHG emissions reduction, we will evaluate the potential of innovative alternatives to achieve positive global effects towards agriculture sustainability and climate change mitigation.
Task 1. State of the art review
Task 2. Exploratory experiments and characterization
(The evaluation of the material's impact on soils will be tackled later on, in different research activities comprised in the wider Research Project, where this Master Thesis is framed).

Objectives: Perform an experimental study on advance products preparation and identify opportunities and technical limitations
Suitable background: Chemistry, chemical engineering, materials science.
Contacts: Julien Meyer and Luca Di Felice. (Julien.Meyer (at) ife.no / Luca.Di.Felice (at) ife.no

Project proposal 5 A and B: Developments of new numerical codes and experimental setups for coupled deformation, reaction and flow in tight rocks.

Observation from nature and experiments show that periodic, focused and fast flow of fluids frequently occurs through seemingly impermeable rocks. Understanding what governs such phenomena is crucial for understanding geological processes such extraction of magma from the mantle, metamorphic dehydration, expulsion of hydrocarbons from source rocks, but also for activities with economic, social and climate implications such as mining of deep geothermal energy, safe long-term underground storage of $CO_2$and venting of climate gases such as methane from the ground.
The main objective of the project is to derived constraints for the conditions under which tight rocks become permeable and allow for discharge of fluids. The work in project A mainly consist of further development, testing and running numerical codes on fluid flow through a reacting and deforming porous matrix. Project B consists of designing and carrying out experiments in a transparent cell using analogue materials. Analogue systems allow carrying out experiments on processes that in nature occur on time and length scales outside the laboratory scale. These experiments are complementary to the theoretical models and may be used to benchmark the new codes.

Project 5A could be carried out in collaboration with UiB or UiO, project 5B will be co-supervised by UiO. Project 5A includes travel to UNIL (Lausanne, Switzerland) to attend a short course on the method.

Contact: Viktoriya Yarushina (viktoriya.yarushina (at) ife.no)

Project proposal 6: Basin modeling with metamorphic phase changes.

Rocks that are buried at depth and experience changes in pressure and temperature conditions undergo metamorphic phase changes that alter their physical properties. The property that controls isostatic subsidence and uplift in sedimentary basins is density. Density may change dramatically as a consequence of metamorphism, especially in crustal rocks.

The aim of project 6 is to develop simple, mass conservative 1-D basin models including reactions in the crust and compare the resulting subsidence curves for some end-member scenarios with those without phase changes. Of particular interest is the difference in thermal maturation of hydrocarbons predicted with the different models.

Project 6 is in collaboration with UiO or UiB.

Contact: Viktoriya Yarushina (viktoriya.yarushina (at) ife.no)

Project proposal 7: Linking geomechanics, fluid flow and seismic wave propagation

Master Project in CEED

The modern exploration and energy technologies, such as production of unconventional oil and gas, geothermal operations, carbon capture, wastewater management and others, involve underground fluid injection. In many cases such fluid injections are accompanied by induced seismicity. While potentially hazardous, induced seismicity might be used for monitoring purposes during fluid injection operations. For instance, micro-earthquakes during hydraulic fracturing might indicate the extent of the induced fracture. The natural analogs are related to volcanic systems: earthquake swarms and volcanic tremor. The better understanding these processes has a vital role both for the risk assessment linked to seismic activity and for revealing why and how the Earth's lithosphere eventually deforms in response to tectonic stresses.

The project will address these questions through numerical mechanical modeling of rock deformation coupled to fluid flow and wave propagation.

Learning outcomes:
The student will get theoretical and practical basis for solving advanced problems that arise in geophysics, geo-energy technologies and during geotechnical operations.

Potential background:
The potential student is expected to have a good physics/mathematics background and developed programming skills
Supervisors: Alexander Minakov (CEED), Viktroiya Yarushina (IFE)
For more details, please contact Viktoriya Yarushina (viktoriya.yarushina (at) ife.no)