Title: **Modeling CO2 injectivity**
Subtitle: **CO2 injection as a tool for increased HC production on the NCS**

**Introduction**
Technology related to carbon dioxide capture and storage (CCS) is gaining ground, as a short to medium term solution, for reducing atmospheric emission and expected global warming. From a capacity point of view, deep saline aquifers offer the greatest potential for CO2 storage, while from an economical and enhanced hydrocarbon recovery standpoint, partly depleted oil and possibly gas – and gas condensate reservoir, seem to be more attractive.

Experimental research carried out during the last decades, indicate that pressure – and temperature gradients that exist under normal reservoir injection processes, in part may lead to dissolution and precipitation of porous grains in the near well region, with possibly loss of injectivity as a result. Well injectivity is therefore considered a key issue, both technically as well as economically, where rock – fluid interaction, dissolution and precipitation of minerals, in particular in carbonates, but also in sandstones, are recognized to be of principal importance for near well-bore injectivity losses.

**Project idea**
Even though injection and production wells today are all inclined or horizontal, we may consider modeling CO2 injection, based on a field injection prospect where a vertical well is drilled through a reasonable thick reservoir segment with seemingly homogenous and isotropic reservoir characteristics. This pancake model will serve as the field case, of which further analysis and experimental work is referenced to.

The kind of fluid expansion (and changing pressure gradient) experienced in the pancake model is preserved in a laboratory model which should be able to handle pressures up to 100 bar or more and temperatures up to about 100 C. Some deliberations on such a mechanical stable laboratory model (physical model) have already been carried out at IPT/UiS and a reasonable sound way to tackle the mechanical challenges have been found.

The laboratory model will be filled with unconsolidated grains of different granular size and mineral content, in order to mimic a field case reservoir with respect to porosity, permeability and lithology. The laboratory model is constructed such as allowing pressure, temperature and possibly saturations (density) to be measured along the fluid flow direction. Additionally, the laboratory model should be constructed such as to allow for varying reservoir temperature.

Injection of CO2 is maintained at a constant flow rate while pressure -, temperature - and possibly density measurements are recorded. Various experimental alternations of the above flow situation would be considered, such as; varying fluid composition (impurities), varying flow rate (WAG, discontinuities), varying injection pressure and temperature (reservoir), varying initial or connate saturation (water/oil/gas).

Loss of injectivity in CO2 injection field cases is believed to be related to chemical changes in the fluid as well as in the rock where dissolution of rock material and precipitation of material grains
finally will reduce both porosity and permeability in the reservoir. Free particle generation and matrix migration are therefore important issues in understanding the CO2 injection loss process. In this context deep bed filtration theory and other statistical methods have to be evaluated. (A MSc thesis is presently underway at IPT/UiS, where some of these questions are under investigation).

As part of modeling deep particle filtration and matrix migration, a subclass of laboratory experiments is suggested on the core sample scale. These experiments should be directed towards answering the questions related to the effect of chemical changes and mechanical particle migration.

**Scope of thesis work**
The chosen PhD candidate should preferably have a comprehensive understanding of mathematics, physics including thermodynamics and chemistry. After an introductory period of literature survey and scientific preparation, the candidate shall:

1. Research the area of deep particle filtration and matrix migration modeling and simulation.
2. Initiate laboratory experiments on the core sample scale in validating the above mentioned models.
3. Take part, and in part be responsible for planning and the practical build-up and implementation of the laboratory field model.
4. Be the main resource person in carrying out the experiments on the laboratory field model.
5. Take initiative to formulate and in a great part document and write up experimental and theoretical results and seek to publish these through preferably referenced publication channels.
6. Take part in supervising students on inferior levels (MSc and BSc).

As we are presently trying to build up a new MSc degree specialization at IPT in Natural Gas Engineering, in partnership with internal and external good forces, - the PhD candidate is cordially invited to take part in this work on a voluntary basis.

**Cooperation**
The project described above is part of a triangular cooperation between AGH (Krakow), PGNiG Norway and IPT/UiS, where PGNiG is facilitating and financing the project between the two academic institutions.

It is therefore our (IPT/UiS) expressed intention to create a situation of mutual cooperation on the issues described above. In particular, agreed contact has been made with Prof. Jerzy M. Stopa, AGH, as the AGH project coordinator and contact person. It is believed the contributions administrated by Dr. Stopa will be in the field of mathematical modeling and simulation related to the problems listed above and after closer consultations.

At IPT/UiS Prof. Aly Hamouda will in addition to the undersigned be responsible for project supervisory and advisory activities.

Jann Rune Ursin

Project leader and spokesperson for the Natural Gas Engineering initiative at IPT/UiS