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# GEOTHERMAL WORKING FLUIDS AND ITS PROPERTIES – RESEARCH ON THE DEVELOPMENT OF ENHANCED GEOTHERMAL SYSTEMS TECHNOLOGY

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## ABSTRACT

Climate change is being more and more noticeable throughout the world. Burning fossil fuels emits greenhouse gases, including $CO_2$, into the atmosphere, which has a negative impact on climate change. The solution to reducing global emissions is to use renewable energy sources such as geothermal energy. Enhanced Geothermal Systems enable the use of geothermal energy stored in hot dry rocks. The energy stored in deep reservoirs can be extracted using a proper geothermal fluid. The most common is water, but $CO_2$ is increasing in popularity. Its features such as lower viscosity and higher density allows to penetrate deeper into a rock mass and reduce power consumption for circulating pumps. What is more, utilization of $CO_2$ has the advantage of geological storage in situ, which reduces the global emissions. There are also a few analysis of nitrogen utilization, but heat extraction is predicted to be similar as for $CO_2$. A new research of supercritical $CO_2$ utilization in EGS is being investigated in EnerGizerS project. The Vapor-Liquid Equilibrium of $CO_2$ and water at high pressure and temperature (up to 1000 bar and 200°C) is a subject of experimental campaign conducted in cooperation with SINTEF Energy Research.

## METHODOLOGY

The High Pressure and Complex – Phase Equilibrium facility is employing an analytical isothermal technique to measure phase equilibria. It allows to accurately measure a variety of fluids at a wide pressure and temperature range. A mixture, which accurate total composition may not be known, is brought into a Vapor-Liquid Equilibrium cell with carefully controlled temperature and pressure. When phase equilibrium is reached, the fluid phases present in the cell are sampled from. Composition of the mixture is analysed in Gas Chromatograph.

## CURRENT RESULTS

Consistency of the results allows for accurate interpretation and fitting to other research

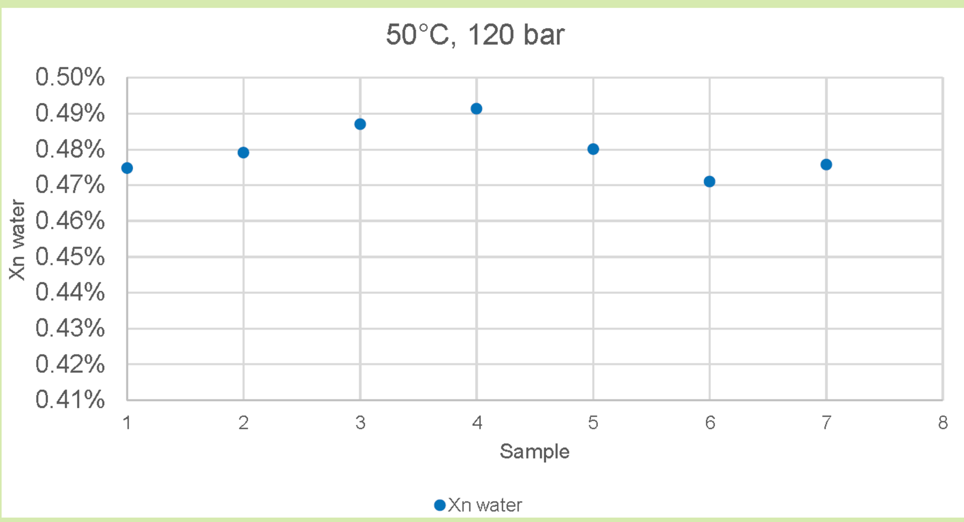
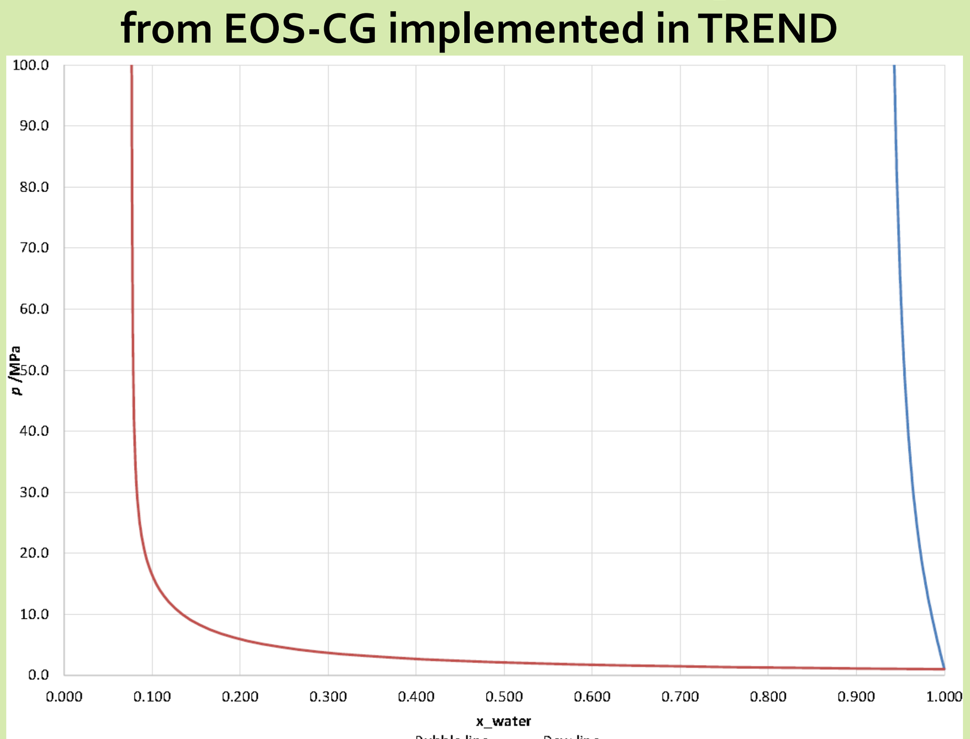



Table of base statistics – consistency of the results for measurement point at 50°C, 120 bar

| 50°C, 120 bar | Average | Standard deviation | Variance |
|---|---|---|---|
| All data | 0.47985% | 0.007% | 1.4877% |
| Excl. min and max | 0.47933% | 0.00485% | 1.01248% |

Phase equilibrium of water and $CO_2$ at 200°C, from EOS-CG implemented in TREND




Source: Løvseth, 2021, SINTEF, EnerGizerS

## THEORY

| Fluid properties | $CO_2$ | $H_2O$ |
|---|---|---|
| Chemical | **No mineral dissolution, scaling or precipitation problems.** A poor solvent for rock minerals, with no potentially strong chemical reactions. | **Serious problems of mineral dissolution, scaling and/or precipitation.** A good solvent for rock minerals that could have potentially strong chemical reactions between the rock and aquifers. |
| Fluid circulationin wells | **Highly compressible and expandable**. A larger wellbore diameter is needed to inject $CO_2$ (costly). | Low compressibility and expandability. **A smaller wellbore diameter is needed to inject $H_2O$**. |
| Ease of flow in the geothermal reservoir | Due to its **lower viscosity** - high flow capacity, high mobility, high mass rate and larger flow velocities for a given pressure gradient. **High density.** The much higher thermal expansivity of $CO_2$ would generate large Density differences between the cold $CO_2$ in the injection well and the hot $CO_2$ in the production well, and would provide a buoyancy force that **would reduce the power consumption of the fluid circulation system.** | Due to its **higher viscosity**-low flow capacity, low mobility, low mass rate and shorter flow velocities for a given pressure gradient. **Low density.** The much lower thermal expansivity of $H_2O$ would generate small density differences between the cold $H_2O$ in the injection well and the hot $H_2O$ in the production well, and would not provide a buoyancy effect that would reduce the power consumption of the fluid circulation system. |
| Heat transmission | Low specific heat level and low mass heat capacity. The outlet temperature at the production wellhead is much lower than for water. $CO_2$ is considerably more mobile than water, so for a given pressure gradient it would flow at higher mass rates than water. This effect offsets the lower specific heat of $CO_2$ and produces higher extraction rates for $CO_2$ than for water. | **High specific heat level and high mass heat capacity. The outlet temperature at the production wellhead is much higher than $CO_2$.** $H_2O$ is considerably less mobile than $CO_2$, so for a given pressure gradient it would flow at lower mass rates than $CO_2$. This effect offsets the higher specific heat of $H_2O$ and produces lower extraction rates for $H_2O$ than for $CO_2$. |
| Fluid losses | **Could result in beneficial geological storage of $CO_2$.** | A hindrance for the development of geothermal reservoirs (costly). |

Source: Olasolo et al. 2018

Maciej Szymanek, PhD student at AGH UST, working with HPC-PE facility during reserach stay in SINTEF Energy Research

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EnerGizerS
$CO_2$-Enhanced Geothermal Systems for Climate Neutral Energy Supply

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