Combined geothermal and dissolved CO$_2$ storage system -
Example of application to a geothermally heated greenhouse area in the Netherlands

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The CO2DISSOLVED concept, relying on CO$_2$ storage in dissolved phase, integrated with geothermal operations, is characterized by the increased storage security and safety compared to supercritical storage (Kervévan et al., 2014). Due to the absence of buoyancy as an upward migration force, leakage is much less likely. Because of this, a caprock is not required and therefore more storage sites become available. This is only true if degassing, both on the short- and the long-term, can be excluded. Since the solubility of CO$_2$ in water is highly dependent on pressure, temperature and composition of the water, a thorough assessment of the entire chain of a storage system is required to find the maximum co-injection rate per well based on the lowest solubility limit within the chain. Because of the solubility limit, much less CO$_2$ can be injected per well compared to conventional storage in the supercritical phase. This implies that more wells need to be drilled or longer injection needs to take place in order to inject similar quantities.

Figure 1. Location of the proposed pilot site in the Westland area in The Netherlands; inset: lay-out of the CO2DISSOLVED system. In the summertime, CO$_2$ from the sources in the Rotterdam area is provided to the greenhouses (A), whereas excess CO$_2$ can be co-injected in winter when less CO$_2$ is needed in the greenhouses (B).
The concept of a combined geothermal – CO$_2$ storage system is therefore well suited for small emitters, located far from large storage sites or transportation facilities, but close to (potential) geothermal systems (Kervévan et al., 2014). It uses an innovative and low-cost CO$_2$ capture technology developed and patented by Partnering in Innovation (USA), which can add dissolved CO$_2$ to the injected stream of a geothermal doublet.

Figure 1 shows an example layout, for an existing geothermal system delivering heat to greenhouses in the Westland area of The Netherlands. The carbon credits from co-injecting and storing CO$_2$ in the geothermal system would provide additional revenues to the geothermal operator, provided that small emitters are covered in the ETS in the future and that the value of carbon credits increase. The latter is especially important since adapting the wells and surface installations to be able to handle corrosive fluids is expensive. In addition, it needs to be demonstrated that the co-injection of CO$_2$ does not negatively impact the geothermal potential or interfere with neighboring systems.

For this system, a preliminary reservoir simulation study was performed to assess the impact of co-injected CO$_2$ on the geothermal production. In this case, 43 kg/s (~ 3500 m$^3$/hr) of brine is produced at reservoir temperature of 87.8 °C and re-injected at a temperature of approximately 40°C. Since solubility of CO$_2$ decreases with increasing temperature, the amount of CO$_2$ to be co-injected was calculated for the brine at reservoir temperature to prevent degassing during heating of the carbonized brine by in the reservoir. Using a safety margin by co-injecting 75% of the solubility limit resulted in a dissolved concentration of 0.73 mol/kg water. The simulations demonstrate that for various scenarios the injected CO$_2$ does not affect the thermal efficiency of the geothermal system by enhanced breakthrough of the cold front. In addition, a breakthrough of the dissolved CO$_2$, which was assumed to be unreactive and hence act as a tracer, was not predicted within 30 years of operations. This was primarily due to the large thickness of the reservoir (500 m). For smaller target formations or smaller distance between injection and production wells, earlier breakthrough might occur, as demonstrated by Hamm et al. (2014). Future simulations should also include the geochemical processes to evaluate potential effects on injectivity and breakthrough. Also the engineering components of the geothermal system should be evaluated in detail to assess corrosion and scaling potential in order to consider the efficiency and safety of the entire system.

The concept seems to be a promising option to reduce CO$_2$ emissions from small emitters located close to geothermal areas. The high costs for adapting the geothermal system to be resistant to the corrosive brine requires a higher European Emission Allowance (EUA) price than the current € 7/tCO$_2$ in order for the business case to be economic. Currently, the Dutch government focusses on demonstrating subsurface storage of CO$_2$ offshore. Therefore, onshore pilot projects of a combined geothermal CO$_2$ storage system in The Netherlands will only be possible on the longer term. Yet, the CO2DISSOLVED concept should be considered as a potential emission reduction option for small emitters in long-term roadmaps.

References


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1 See http://pi-innovation.com/.