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A geothermal site combined with CO2-storage

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Introduction: Following two geothermal projects in Bleiswijk (for glashouses,1700 m depth) and the Hague (6000 houses), students of Delft University, Department of Applied Earth Sciences, started a feasibility study where casing drilling with composite pipe and CO_2-injection are combined with the production of geothermal energy. An anticlinal structure is present below the campus, which holds the Jurassic aged Rijswijk and Delft highly permeable sandstone members at a depth between 1.8 and 2.4 km. This member can produce about 150 m^3 of water per hour at 75°C. In urban environments, small operational footprints are essential for drilling a production- and a CO_2- injection well (Fig.1a). By using new light-weight composite materials for wells with casing drilling technology, only small drilling rigs are required. The composite material is less susceptible to corrosion and enables co-injection of CO_2 with the returning water (Wolf et al. 2007).

Geology: Several hydrocarbon exploration wells have been drilled around Delft, of which one on the University Campus. 2D and 3D seismic have been shot to primarily explore the regionally oil bearing Rijswijk formation above the Delft sandstones. The sands are part of the Upper Delfland formation and of Upper Jurassic (Kimmeridge) age. The overburden (1650 m) consists of mainly Cretaceous, Tertiary and Quaternary chalks, limestones, claystones, clays, siltstones, and sandstones. The target Delft sandstone for heat production and CO_2 storage is composed of sheets of amalgamated transgressive and coastal-barrier sands, rapidly alternating with clays, which were deposited on a Late-Kimmeridgian discordance. The 3D seismic shows an anticlinal structure of the Rijswijk sandstone member (fig 1b) covered by the mentioned sediments. No major structural phenomena, like faults, block faulting, erosion planes, etc., do cross the Delft sandstone in the area of interest. First studies by Smits (2008), de Boer (2008) and Eldert (2008) show promising reservoir qualities for the sandstone member; high permeability and porosity. Based on the petrophysics of the neighboring wells, the geothermal prognosis and reservoir properties for the area have been reconstructed: 1) At a depth of 2300 m, it is expected to produce water with a temperature of about 75°C. 2) A production- and injection rate over 150 m^3/hr should be feasible. 3) With carefully planned production- and injection wells, the original warm water and colder CO_2-saturated re-injected water will not interfere for at least 30 years (fig. 1c). The local geology of small oilfields shows that geothermal heat production and CO_2-storage options in the sandstone members are positive; i.e. a potential large reservoir volume with high permeabilities and a proper seal.

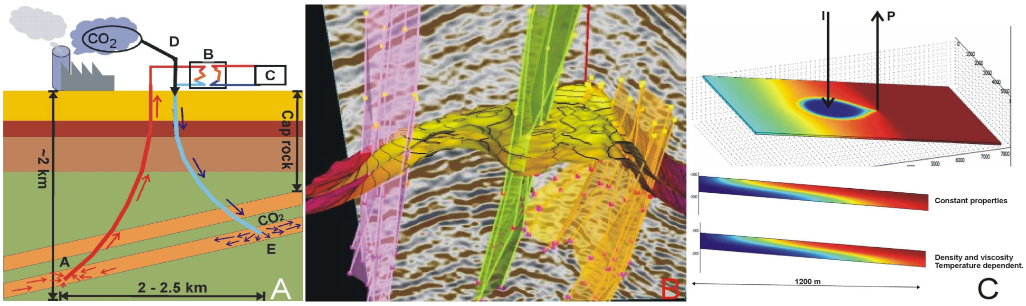
Surface Infrastructure and implementation of geothermal energy: The University Campus has an on-site79 MW power plant with two cogeneration units for base-load and three gas boilers for peak demand. The geothermal heat will contribute up to 5 MW continuously (95000 GJ), cutting CO_2 emission with 5000 tons annually, while reducing costs for base-load heat production. For optimal heat gain, the production- and injection well should be co-located with the power-plant. This gives spatial constrains on operations and the drilling of 2.5 km deep large-diameter holes with heavy equipment should be avoided.

Unconventional Drilling: The casing drilling with composite pipe here introduced finds its origin at Delft University and is further developed by an industrial consortium (Acquit BV). It resulted in a light weight concept where a composite casing pipe is combined with the casing drilling methodology. This almost buoyant casing pipe needs considerably less working space and existing civil pile drilling units can be used to drill wells (Leijnse, 2008). The composite casing pipe has a better insulation, improved skin and a better endurance for corrosion (CO_2-rich return water). Further, for monitoring, it is possible to implement P,T-sensors. Overall construction and operation costs can be significantly reduced, but the composite casing will be more expensive.

Second phase CO_2-Injection

Delft University has applied for the geothermal exploration license under and around its campus grounds. The "first phase" exploration is focusing on the construction of a normal geothermal system. In the second phase, a research program for CO_2 capture and storage will be realized. For removing the CO_2 from the power plants' flue gas, several capture techniques are studied. One of the options is adding CO_2 at low pressure (about 20 bar) as being 10% of the re-injected water volume (Smits, 2008). Gas can diffuse into the water achieving undersaturated conditions before it reaches the target member. The injected water is heavier

then the original water and migrates downward; annually ca. 5 ktons yearly. The studies show sufficient storage volume at P,T conditions. The favorable overburden rock of about 2 km prevents upward migration.
Conclusion: We propose several technical novelties for drilling and CO_2-injection. The first study shows that the concept is feasible. Nevertheless, long term injection and reservoir questions have to be investigated; the time effect of CO_2 on the tubing, reservoir rock, and overburden, optimal well configuration, Joule-Thomson effect, seasonal injection, pumping equipment and (surface) infra structure. Up to now, the major benefit is the innovation cooperation between Delft University, Industry, energy utilities and authorities.



References
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