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PREVIEW

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## Water-driven geothermal heat extraction with simultaneous CO<sub>2</sub> injection: overview of concepts, benefits and challenges

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Geothermal energy production and CCS (Carbon Capture and Storage) represent promising technological solutions to help mitigate climate change and aid the current global energy crisis. In recent years, the number of concepts that propose to combine and mutualize these technologies has risen dramatically. While a number of concepts (notably CPG and CO<sub>2</sub>-EGS) use supercritical CO<sub>2</sub> as the heat vector, another promising route for hybridization is to inject dissolved CO<sub>2</sub> in the geothermal brine. This is the focus of our current work. An extensive literature review was carried out of the concepts, complemented by interviews of some of the developers.

A few concepts are still theoretical (only described in the literature), but most technological ones are on the way to pilot/demonstration projects at progressively increasing scale. The main projects and their associated sites are:

- CO<sub>2</sub>-DISSOLVED technology, with potential sites identified in the Paris basin (France);
- AAT-G / Cleag technology, with a site in Croatia;
- Related projects CarbFix, GECO and SUCCEED, with sites in Hellisheidi (Iceland), Nesjavellir (Iceland), Bochum (Germany), Kizildere (Turkey), Castelnuovo in Italy (as case study due to permitting issues);
- Reinjection of CO<sub>2</sub> from geothermal brines at Ngatamariki and Te Huka sites in New Zealand.

Despite similarities, these solutions are differentiated by their purpose:

- either to store CO<sub>2</sub> from an external industrial emitter (notably for the CO<sub>2</sub>-Dissolved concept), thus bringing a contribution to CCS,
- or to reinject CO<sub>2</sub> emitted by CO<sub>2</sub>-rich brine during geothermal exploitation, thus bringing geothermal to near-zero emissions.

Because of the CO<sub>2</sub> solubility limit in brine, the performance of heat extraction is generally higher than that of CO<sub>2</sub> storage. For instance the CO<sub>2</sub>-DISSOLVED technology is particularly well-suited to small CO<sub>2</sub> industrial emitters (ca. <150,000 t CO<sub>2</sub>/year). Unlike concepts using supercritical CO<sub>2</sub>, those using dissolved CO<sub>2</sub> can be deployed at much lower depths (no need to exceed the supercritical point). The concepts still need a tight caprock, but the high solubility trapping represents a lower risk of leakage. The geothermal system behaves mainly as a water-driven system, but the adjunction of dissolved CO<sub>2</sub> can in some cases increase thermo-hydrological

performance (pH decrease might avoid clogging and/or open porosity in carbonate reservoirs).

A number of challenges still need to be addressed, including complexity of regulations and validation of some technical aspects. Besides, considering the variety of underground configurations, there is no turnkey solution, which might hamper the economics of such small-scale projects.

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