



Monitoring Concept for CO₂ Storage at the Pilot Site Ketzin, Germany

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Between 2008 and 2013, the German Research Centre for Geosciences – GFZ has injected more than 67 kt of CO₂ at the Pilot Site in Ketzin, 25 km west of Berlin. The CO₂ was stored in porous sandstones of the Upper Triassic Stuttgart Formation at a depth of 630 to 650 m.

In more than a decade, GFZ has developed and tested an extraordinary multi-monitoring concept for onshore CO₂ storages which mainly comprises the following methods:

Time-lapse 3D seismic surveying is the most commonly used method for imaging and monitoring a CO₂-plume in the deep underground before, during and after the injection phase. Such campaigns require high logistical and financial efforts and can be realised only to a limited extent. At Ketzin, for instance, 3D-seismic repeat surveys were acquired using several thousand surface acquisition points and lasting over two or three months. Alternative approaches include permanently buried seismic receivers.

Geoelectric measurements in Ketzin are mainly applied by using a permanent downhole electrode installation (Vertical Electrical Resistivity Array = VERA) which has been implemented in three wells behind the well casings. Measurements between 590 m to 735 m are constantly carried out covering the vertical thickness of the entire CO₂ storage horizon. Valuable results were achieved by a combination of inhole, crosshole and surface downhole measurements which has been carried out with appropriate acquisition geometries. For focused areas around monitoring wells, geoelectric methods may support and supplement information from seismic surveys.

Borehole monitoring of pressure and temperature are generally indispensable for every underground gas storage type. In Ketzin, a remote monitoring system for all wells has been installed that constantly provides the operators with values for date, time, downhole and wellhead pressure, depth, and temperature. Moreover, all wellheads are checked weekly during onsite inspections. Samples for chemical analysis are taken in regular intervals from an observation well. With a total depth of 418 m, the well reaches the natural brine filled sandstones of the Triassic Exter Formation which represents the layer straight upon the caprock of the CO₂ reservoir. Fluid samples are being analysed for stable carbon isotopes $\delta^{13}\text{C}$, dissolved organic carbon (DIC) and pH. Any significant intrusion of CO₂ into this aquifer would cause distinct anomalies and trigger alarm conditions.

Another regularly applied monitoring method in Ketzin is the measurement of soil CO₂ flux. Natural CO₂ flux is generated by the respiration of roots and soil organisms and the decomposition of organic matter. Both processes very much depend on the seasons respectively on the soil temperature. Outliers of the natural background range could indicate a leakage in the reservoir.