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Underground Storage of Natural Gas and CO_2 Monitoring Applications

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Natural gas is one of the most widely used fossil fuels in the world and it represents an essential element for human activities. It can be stored in underground geological structures such as depleted oil/gas field, aquifers and salt caverns. Underground Gas Storage (UGS) application plays a key role for covering natural gas demand and supply fluctuations, e.g., methane, CH_4, by injecting gas in the summer season when the demand is lower, ready to be withdrawn and deployed into the network to meet increased consumer demand in the winter season. Unfortunately, constant human exploitation of fossil fuels causes climate change phenomenon, creating a potential risk of breaching environmental tipping points with negative consequences. In this regard, the carbon capture and storage (CCS) practice, which is different in methods and purpose from UGS, has been gaining popularity in the last decades. The latter strategy involves storing Carbon Dioxide (CO_2) before it enters in the atmosphere, by means of geological structures for centuries or thousands of years and it can support one of the most important challenges of the twenty-first century, helping the decrement of the global warming and to chase the goal of near-zero greenhouse gas emissions. Misuse of UGS and CCS activities or poor maintenance of injection and withdrawal wells can induce effects of considerable magnitude such as ground deformation, micro-seismic events, fault reactivation and gas leakage. The development of appropriate injection methods and long-term monitoring systems for leak detection is important to verify the integrity of the reservoir, the effectiveness of activities and the respect of safety conditions. In literature approximately a hundred scientific contribution of UGS and CCS monitoring applications were spanning in the world. All the scientific peer-reviewed books and articles, and congress proceedings about the reservoir monitoring in gas storage activities collected and critically analysed show an analytical and statistical overview of the most common use of UGS and CCS, detailing the different goals of these two applications. This research allows displaying the advantages and drawbacks of each monitoring technique involved in gas storage applications by analysing the main UGS and CCS projects. Further developments are required for the UGS monitoring, especially through multidisciplinary approaches useful for identifying possible effects on the surface and gas leaks at depth; meanwhile, CCS solutions are still at an experimental stage, due to the high costs for large-scale applications that require specific researches. The state of the art of these two very different practices can improve the further development of new monitoring approaches or additional methods. The next years will reveal if the CCS methods will be among the leading techniques in the race for energy transition.