Feasibility of combining natural gas recovery and CO_2-based geothermal in deep natural gas reservoirs

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Keywords: CO_2-enhanced gas recovery, CO_2-plume geothermal, CO_2 geological storage, reservoir simulation, wellbore heat-transfer model.

ABSTRACT

There is potential for utilizing supercritical CO_2 ($scCO_2$) for improving and maintaining the reservoir pressure during the production of natural gas, so as to increase natural gas recovery. This is conventionally referred to CO_2-enhanced gas recovery (EGR). It has also been proposed that $scCO_2$, due to its high expansivity and low kinematic viscosity, can be utilized as a working fluid for heat recovery from sedimentary reservoirs, referred to as CO_2-plume geothermal (CPG) systems. In both systems, the storage of CO_2 in the reservoirs is a favourable by-product. In deep, and hot, natural gas reservoirs, there are clear synergy effects in combining these two systems (CO_2-EGR and CPG) – including shared infrastructure and working fluid – which can be exploited. In this study, we investigate the feasibility, in terms of energy co-production and associated CO_2 geological storage, of integrating these two systems in deep, porous and permeable natural gas reservoirs. A summary of some existing hot natural gas reservoirs worldwide and their respective reservoir properties has been investigated and are presented in this study. Using key information obtained from the different examples of these natural gas reservoirs, an anticlinal natural gas reservoir model is set up. Using this model, a reservoir simulation study is carried out, using TOUGH2, to evaluate the natural gas recovery and heat-mining performance of the system. Two stages of development are considered: when there is only natural gas production (Stage 1), and during simultaneous $scCO_2$ injection and production stage (Stage 2). Stage 2 includes the processes of CO_2-EGR, pressure recovery and CPG. Results show a high heat-mining potential for both stages, with Stage 1 having a better heat-mining rate than Stage 2. The results also show that a significant part of the natural gas reservoir could be used for CO_2 storage. Coupling the reservoir model with a wellbore heat-transfer model is also important in order to find the temperature and pressure of the produced fluid at the wellhead. Hence, at any given time, the temperature and pressure of the produced fluid are numerically calculated as it rises through the production well. The obtained results confirm that the combined system can improve energy production and sustain the useful life of the gas field, for a longer period of time, as compared to the conventional CO_2-EGR or CPG systems when operated in isolation. In general, the additional energy produced and CO_2 sequestered in the gas reservoir can increase the gas field's overall system efficiency and have a positive effect on the final costs of electricity generation.