Using Horizontal Wells to Sequester CO2 and Enhance Coalbed Methane Recovery: A Simulation Study of Operating Procedures

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Abstract

Because of increased concern about anthropogenic carbon dioxide emissions, a pilot project is being implemented in northwest West Virginia to study the technical feasibility of carbon dioxide sequestration in unmineable coal seams. The project consists of four 3000 ft horizontal wellbores forming the exterior of a square with four horizontal wellbores at its center. Methane production occurs from all wellbores until the reservoir is sufficiently depleted, then the central wellbores are converted to carbon dioxide injectors while production continues from the exterior wellbores. In our simulations for this project, injection and production continue until the mole fraction of carbon dioxide in the produced gas reaches 0.1.

The design factors studied were the lengths and orientations of the central wells, while the operational factors studied were the pressures in the injection wells. We examined both cases where the injectors are oriented perpendicular to the exterior wellbores and cases where the injectors are oriented toward the corners of the squre formed by the outer horizontal wells. The performance of a pilot project is also compared with that of a pattern in a fully-developed field. This comparison clarifies the role of methane produced from outside the isolated pattern, and how this methane must be accounted for in reaching an optimum design for a fully developed field on the basis of the results for the single, isolated-pattern pilot.

For a pilot project, operating parameters that give the longest project life also yield the greatest methane production. On the other hand, for a developed field the main factor controlling methane production is sweep. Although the longest injectors have poor sweep efficiency, short injectors represent little improvement over the performance of intermediate length injectors, but they significantly lower production rates. Injection pressure has only a weak effect on total methane production in a developed field. Higher injection pressures result in slightly more methane left in place in unswept areas of the reservoir, but also result in a higher production rate. The sequestration performance for either case is controlled by a combination of sweep efficiency and average pressure in the swept area. The interaction of sweep and reservoir pressure on performance results in a maximum in performance for intermediate length injectors. For low permeability anisotropy the diagonal injectors yield better sequestration performance, but for high anisotropy the perpendicular injectors with unequal lengths perform better. In all cases a long diffusion time constant places an upper limit on injection rates that also yield good performance.

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