

Innovative Unconventional EOR: An Unconventional Tertiary Recovery Approach to an Unconventional Reservoir

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Abstract

In 2011, Lightstream Resources initiated a dry gas injection enhanced oil recovery (EOR) pilot at their Creelman Bakken field. The Upper Devonian-Lower Mississippian Bakken formation is an extensive dolomitic siltstone unit containing a significant accumulation of oil reserves in Williston Basin. At 920 meters subsea (1540 meters TVD), this tight oil reservoir has a porosity of 10-12% and permeability under 1 md.

Primary recovery in the Bakken is traditionally low and is produced using hydraulic fracture stimulation. Low primary recovery factors necessitate the evaluation of EOR options to improve recovery rates and extend the economic life of the field. However, the tight reservoir matrix presents a challenge with waterflood design, as voidage is difficult to replace and maintain with limited injectivity. With compressibility, lower viscosity and significantly higher injection volumes, natural gas presents a more effective means of replacing voidage.

Lightstream's horizontal development of the Bakken in the Creelman area is at 160 acre spacing. The project is designed as a 1:8 toe-heel injection pattern, with a one mile horizontal in-fill well supporting eight perpendicular producers to the north and south. Gas injection rates within the pilot have varied between 10 and 25 e3m³/d, resulting in an instantaneous voidage replacement ratio of 0.7 to 1.3.

Low natural gas prices in Western Canada enhance the economics of using natural gas as an injection fluid. Injecting primarily C1 allows for effective EOR and long-term gas storage, allowing the injected natural gas to be sold at the end of the project's life. In addition, the potential vaporizing effect of injected dry gas picking-up NGL's may result in further reserves. Project results have been encouraging to date, as oil production in the pattern increased from an initial rate of 21 m³/d (132 bbl/d) to a peak rate of 46 m³/d (245 bbl/d) within 12 months of the start of injection. Current oil production is 24 m³/d. Natural gas injection EOR projects could result in significantly improved recovery factors and project economics.

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