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Simulations of Field Development Planning Help Improve Economics of Heavy-Oil Project

Dwight Teotico, SPE, Luke Schauerte, SPE, and James Griffith, SPE, Shell; Gary Schottle, SPE, and Ralph Mehl, SPE, Halliburton

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Abstract

When Shell began an ultraheavy-oil development in Alberta, Canada, the field plan was based on manual pad positioning without consideration for surface hazards, trajectory constraints, or injector/producer slot requirements arising from the prefabricated pad configuration.

Shell teams were challenged to investigate alternative field development plans to reduce the initial investment. The volume of wells, surface hazards, trajectory constraints, and pad slot configuration requirements for injector-to-producer ratios made this a formidable task. Shell leveraged the expertise of third-party consultants and powerful software to generate numerous development scenarios, which enabled the Shell staff to focus on the economics of each plan.

An aerial image that delineated surface hazards, an elevation grid, and injector/producer targets were loaded into the 3D subsurface visualization environment of the software to generate pad placement simulations, including trajectory designs. The software followed the Shell planning constraints and avoided all surface hazards.

The analyses were conducted for the highest, lowest, and median number of pads. From these three scenarios, a value analysis was plotted. This value analysis enabled the planning team to identify the optimal surface-to-reservoir configuration and to maximize the value of the field by delivering all of the reservoir targets, while minimizing the number of pads needed to drill. The output also yielded field cumulative values, including total and nominal well length, to support future economic analyses.

The analysis determined that 87 pads maximized the value of the field when 42-well pads were considered. Additional studies determined that when 50-well pads were considered, more than 99% of the planned reservoir targets could be drilled from 72 major and four or fewer minor pads. In either case, a significant reduction from the original 98 pads was realized. Through the combined efforts of Shell engineers and third-party consultants, as well as the use of state-of-the-art software, this optimization was completed in only eight worker-weeks.

This paper describes the software and processes used to reduce Shell's estimated field development costs and to minimize the environmental effect of the field by reducing the number of pads required.

Introduction

Carmon Creek field is a large unconventional oil field located near Peace River, Alberta, Canada. The proposed field exploitation method is for vertical steam drive EOR by means of approximately 450, seven-spot patterns (one injection well surrounded by six producing wells). Because of its scale and scope, pad positioning and well placement were crucial to maximize recovery and to minimize the environmental effect and pad construction costs. The pad locations were constrained by water hazards, surface facilities, roads, and government regulated areas. Within the surface facilities area, pre-fabricated surface equipment reduced costs by capturing economies of scale, but added another constraint to the positioning and number of wells on the pad.

From the subsurface perspective, the wells required an optimum spacing to adequately inject steam and produce the reserves. This requirement led to specific well geometries and target selections. The optimum distances were incorporated into the designs; however, varying this distance to meet surface constraints was difficult.

When combining all of the functional requirements from the surface (environmental, regulatory, and construction), subsurface (drilling, completions, production, reservoir, and geology), and surface facilities equipment constraints, the task of field planning was overwhelming. Too many options existed. The planning of the pads and corresponding wells was labor-intensive and could take more than two weeks to determine a single development plan. Multiple iterations would be required