Abstract

Geothermal energy is used in more than 20 countries worldwide and is a clean, reliable, and relatively available energy source. Nevertheless, to make geothermal energy available anywhere in the world, technical and economic challenges need to be addressed. Drilling especially is a technical challenge and comprises a significant part of the geothermal development cost.

An enhanced geothermal system (EGS) is a commercially viable thermal reservoir where two wells are interconnected by some form of hydraulic stimulation. In a commercial setting, fluid is injected into this hot rock and passes between wells through a network of natural and induced fractures to transport heat to the surface system for electricity generation. To construct EGS wells, vertical and directional drilling is necessary with purpose-built drilling and steering equipment. This is an application where oil-and-gas drilling tools and techniques can be applied.

A recent well, 16A(78)-32, drilled as part of the US Department of Energy’s (DOE’s) Utah Frontier Observatory for Research in Geothermal Energy (FORGE) program, highlights some of the technical challenges, which include drilling an accurate vertical section, a curve section, and a 5300-ft 65° tangent section in a hard granitic formation at temperatures up to 450°F (232°C). Extensive downhole temperature simulations were performed to select fit-for-purpose drilling equipment such as purely mechanical vertical drilling tools, instrumented steerable downhole motors, measurement-while-drilling (MWD) tools, and embedded high-frequency drilling dynamics recorders. Downhole and surface drilling dynamics data were used to fine-tune bit design and motor power section selection and continuously improve the durability of equipment, drilling efficiency, and footage drilled.

Drilling optimization techniques used in oil and gas settings were successfully applied to this well, including analysis of data from drilling dynamics sensors embedded in the steerable motors and vertical drilling tools, surface surveillance of mechanical specific energy (MSE), and adopting a drilling parameter roadmap to improve drilling efficiency to minimize drilling dysfunctions and equipment damages. Through drilling optimization practices, the instrumented steerable motors with proper bit selections were able to drill more than 40 ft/hr on average, doubling the rate of penetration (ROP), footage, and run length experienced in previous granite wells. This paper presents a case study in which cutting-edge oil-and-gas drilling technologies were successfully applied to reduce the geothermal well drilling time by approximately half.

Introduction

Geothermal energy is possibly the largest potential renewable energy source on earth. The thermal energy is created at the earth’s core by the decay of radioactive elements and moves upward through the crust (Turcotte and Schubert 2002). Humans have taken advantage of this energy resource for thousands of years. Romans and Greeks used hot springs for bathing and natural heating (Roman Bath 2021). The oldest geothermal plant in the world that produces electricity is located in Lardarello, Italy, and geothermal energy generation was first demonstrated in 1904 (ENEL 2018). The first commercial use of geothermal power-generation technology occurred there in 1913 with the construction of a plant that produced 250 kilowatts (kW). The main advantages of geothermal energy used for power generation are that it is clean and reliable and supplies baseload (“always-on”) electricity, independent of weather conditions (United States Department of Energy 2019).