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Advanced Cement Systems Used to Improve Geothermal Well Reliability in Java

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Abstract

An operator developing a geothermal field to generate and provide electricity in Indonesia focused on minimizing the potential for failure of planned wells throughout the expected field life. One of the main areas where this effort was directed was in the design and execution of primary cementing jobs during well construction. Wells drilled and completed earlier in Phase 1 were found to suffer from various wellbore integrity issues. Inspection log data and cement job records from existing wells suggest the zonal isolation problems experienced on earlier wells may have been related to (1) structural failure of the conventional cement sheaths used and/or (2) ineffective cement slurry placement caused by poor hole cleaning of the drilling fluid and/or (3) ineffective removal of drill cuttings from the well during the hole cleaning.

Structural damage to the cement sheath can sometimes be in the form of debonding at the casing, formation interfaces, cement sheath, cracking, and/or compressive shear. The damage can be caused by stresses on the cement sheath brought on by well events such as cement hydration, well completion, and steam production. These events change the temperature and pressure under which the cement slurry is placed and cured. If these changes are severe, the cement sheath may be damaged, leading to zonal isolation failure.

After detailed analysis, and by using an integrated design approach to effectively address the challenges identified, it was decided to use innovative elastic cement systems incorporating various mechanical property enhancement additives expected to withstand the predicted well operations with less possibility of failure than conventional cements.

These advanced cement systems were placed in the planned development using conventional cementing equipment. Industry-recognized best practices were also used to maximize mud displacement and enhance hole-cleaning. These wells were steamed, and no wellbore integrity issues have been reported. Additional benefits observed while using the advanced cement systems in these applications include a reduction in lost circulation and significantly reduced wellhead growth.

The Wayang Windu Power Project

Located 40 km south of Bandung, in West Java, the Wayang Windu power-generation project is operated by Magma Nusantara Limited (MNL), a wholly owned subsidiary of Star Energy. It is managed under a joint operation contract (JOC) with Pertamina to develop geothermal resources within the 12,960 hectare contract area (**Fig. 1**). An energy sales agreement between MNL, Pertamina, and PLN (a state-owned utility company) gives Star Energy the exclusive right to develop up to 400 MW of electricity-generating capacity over a period of 42 years—with each generating unit being scheduled to operate for at least 30 years. The JOC has the potential to ultimately deliver more than 650 MW of base-load electricity.

Phase I of the Wayang Windu has been producing power since June of 2000. The Phase I power plant has the biggest single geothermal turbine in the world, and is currently delivering 110 MW of electricity into the Indonesian national grid. Geothermal fluids are gathered from three wellpads where 10 production wells are located. This geothermal fluid is transported to a centralized separator station. From there, the separated steam is delivered to the power station by two main steam pipelines (approximately 0.5 km) through two scrubbers located at the station boundary. Brine plus any excess condensate is then reinserted into the ground.

At this time, development of Phase II (a second 110 MW unit) is well underway. Drilling of Phase II wells was completed in 2007 (**Fig. 2**) and the Phase II power plant is expected to be operational by early 2009.

Potential for significant field expansion was observed during the development drilling for Phase II with some wells testing at more than 40 MW_e.

A significant factor in the decision to invest in Phase II at Wayang Windu was the potential revenue from CO₂ emission credits that will be generated by the project. Geothermal electricity generation has much lower greenhouse gas emissions than