

The First Discovered High Enthalphy Geothermal Field in Büyük Menderes Graben : Kızıldere Geothermal Field with new 80 MWe Power Plant Investment in Western Anatolia, Turkey

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ABSTRACT

Kızıldere Geothermal Field was privatized in September, 2008 and in this scope the current power operation right was transferred to Zorlu Energy Group for 30 years. After the privatization, rehabilitation of Kızıldere-I geothermal power plant was performed by Zorlu Energy and after the additional geological, geophysical surveys and the company was decided to expand the geothermal power capacity and started to studies in the field in 2009.

Geothermal drilling studies was started in November 2009 and completed in December 2011 and at this period, 20 new wells were drilled, which depths reach to 2872 m and total 40.000 m drilling, by the company to establish new 80 MWe triple flash and bottoming cycle power plant in the license area.

The Commercial operation will be started by August 2013 and the total power production will be 95 MWe and 50 MWt in Kızıldere geothermal field. This will be the first combine system that 3000 residences and greenhouses will be heated by geothermal energy near the field.

1. INTRODUCTION

Kızıldere Geothermal Field is located at the eastern end of an east-west trend Büyük Menderes Graben in Western Anatolia, Turkey (Figure 1).



Figure 1: General View of Kızıldere Geothermal Field

Kızıldere Geothermal Field was discovered as high geothermal field at the end of 1960's when KD-1 well was encountered 198 °C geothermal fluid by General Directorate of Mineral Research and Exploration (MTA) (Figure 2). Geological, geochemical and geophysical investigations were completed to characterize and develop the resource for 25 wells during 1968-2008 in the field. In 1984, Kızıldere I geothermal power plant, which is the first geothermal power plant and has 15 MWe net power, single flash system was established in Denizli city.

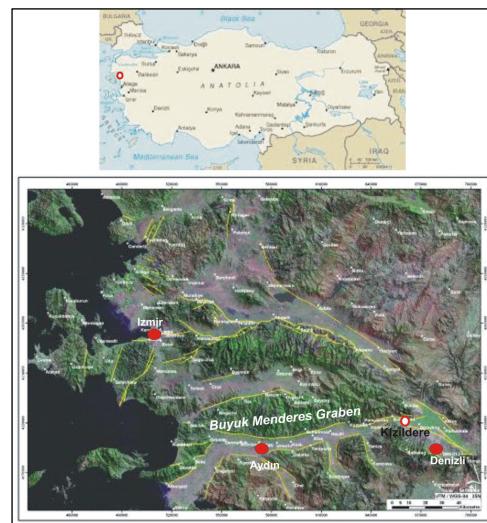


Figure 2: Kızıldere Geothermal Field

In 2008, Zorlu Energy acquired the Kızıldere field. End of the 2008, Zorlu began work over and power plant modifications and maintenance to restore Kızıldere I to capacity and resource investigations and drilling to supply a 80 MWe expansion (Kindap, Haklidir Tut, 2011, Kindap et. al, 2010).

2. DRILLING STUDIES FOR KIZILDERE 80 MW PROJECT

After the completion of the rehabilitation studies, investigation of field potential, evaluation of previous data and prepared the feasibility study, the capacity increase studies were started for Kizildere Geothermal Field. With this scope, detailed geophysical, geological investigations were performed and new production and reinjection drilling locations were determined by the Project Team (Figure 3).

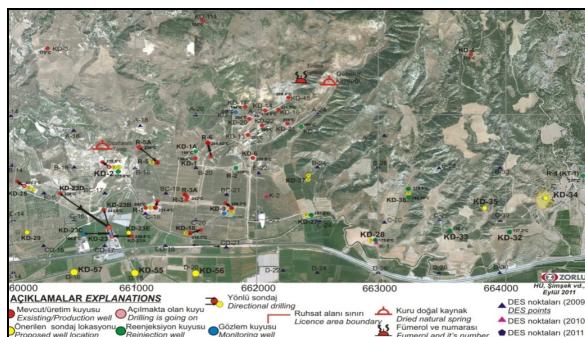


Figure 3: New Well Locations in Kizildere Geothermal Field (Şimşek, 2011)

Drilling studies were started in November 2009. Twenty new wells were drilled at 1100-2872 m depths between 2009-2012 years in the field. Reservoir characteristics of the wells were specified by well completion tests. Based on the results of reservoir tests and geochemical studies, it was decided to establish new 80 MWe triple flash system power plant in the field (Haklidir et al., 2011; Güney et al. 2011).

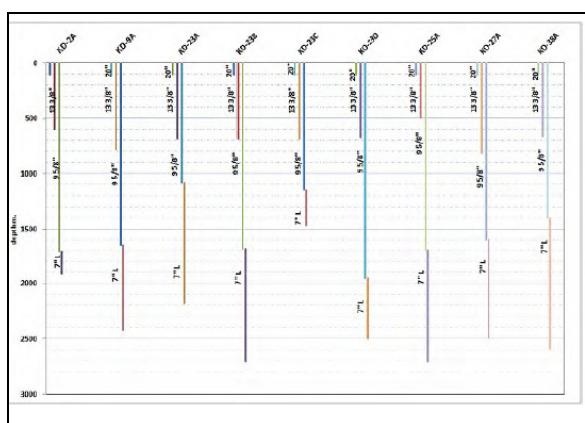


Figure 4: The well sketch of the new deep wells (Güney et al, 2011)

2. MAIN RESULTS OF THE RESERVOIR STUDIES

Three different reservoirs are discovered in the Kizildere Geothermal Field. The first and the second reservoirs mainly consist of limestones and marbles (Şimşek, 2003). The third reservoir consists of schists while lies under the second reservoir and indicate 40 °C higher temperature than the second one (Haklidir et al, 2011).

After completion of the each drilling, the short term well tests have been performed in each new well. The test procedure includes that static and dynamic temperature and pressure surveys, pressure transient tests and flow tests. Productivity and injectivity and interference test were also performed in the field after short term tests in the field.

In the static survey data shows that the near wellbore temperatures of the 5 wells are higher than 220 °C and the highest measured value is 245 °C in the KD-23B well (Figure 5). The flow rates of the deep wells vary from 200-470 t/h in the field.

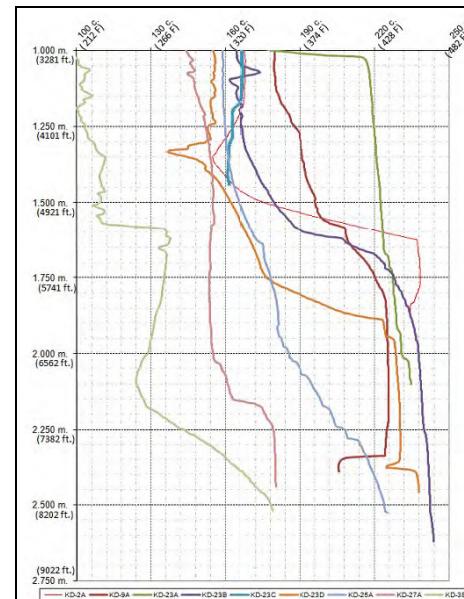


Figure 5: The Static Temperature Survey Data of Kizildere Geothermal Wells (Güney et al. 2011)

2.1 Geochemistry

Kizildere geothermal waters are characterized by Na-HCO₃ and it is understood that geothermal fluids have interacted with the metamorphic rocks long time at deep elevations (Haklidir et al, 2011).

While brine chemistry between the shallow and the deep reservoirs is almost identical, the average noncondensable gas concentration in the deep reservoir (0.03 kg NCG/kg brine) is approximately twice the shallow reservoir (0.015 kg NCG/kg) brine (Haizlip, et al, 2013). Gas composition is almost the same with 98 to 99% CO₂ (Haklidir et al, 2011 and 2012).

3. THE POWER PLANT STUDIES IN KIZILDERE GEOTHERMAL FIELD

The engineering design studies started in December 2010 for the new 80 MWe Power Plant. Based on the reservoir test results, the new plant was designed as combine cycle; 60 MWe triple flash and 20 MWe binary to increase energy efficiency. This combine system will be the first for the Turkey.

The construction study has been started in December 2011 in the field.

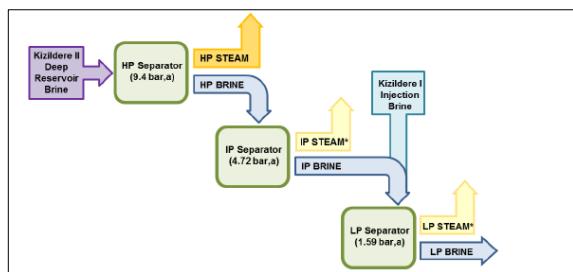


Figure 6: Basic design of the Kizildere New Triple Flash Geothermal Power Plant (Geologica, 2012)

All main equipments such as Fuji-Sumitomo steam turbine generator, condenser, NCG systems, cooling tower equipments, separator systems, hot well pump were transferred to the site last quarter of 2011.

The commercial operation will occur mid of 2013 for triple flash part and beginning of the autumn for binary part of the new power plant.

3. CONCLUSIONS

Kizildere Geothermal Field is located at the eastern end of the Büyük Menderes Graben in Western Anatolia, Turkey. It is the first explored geothermal field in Turkey having capacity able to generate energy.

Kizildere Geothermal Power Plant was operated by the government until privatization of the field. Kizildere Geothermal Field License including current 15 MWe power plant operation is transferred to Zorlu Energy at September 2008 by the government. After the privatization, the company started to work development of Kizildere new 80 MWe Geothermal Power Plant.

Within this scope, additional geological and geophysical studies performed in the field and twenty new wells were drilled for the new power plant. Reservoir temperatures change vary from 220-245 °C and based on the reservoir characteristics of the fluid, the combine cycle which consists of the triple flash and the binary systems are selected for power production in the field.

REFERENCES

Geologica, 2012. Kizildere Geothermal Power Expansion Project, Resource Design Criteria Report, CA, USA, P.16.

Güney, A. Haklidir, Tut, F.S., Akın, T., Alpagut, A.: Kizildere Short Term Flow Test, Impact of Deep Wells. *Proceedings of the 36th Stanford Workshop Geothermal Reservoir Engineering* (2013), CA, USA, p: 80-86.

Geothermal Reservoir Engineering (2011), CA, USA, p: 80-86.

Haizlip Robinson, J., Haklidir Tut, F., Garg, S.K.: Comparison of Reservoir Conditions in High Noncondensable Gas Geothermal Systems. *Proceedings of the 38th Stanford Workshop Geothermal Reservoir Engineering* (2013), CA, USA.

Haklidir Tut, F.S., Akin, T. Güney, A., Alpagut Büklmez, A.: Geochemistry of Fluids in New Wells of Kizildere Geothermal Field in Turkey. *Proceedings of the 36th Stanford Workshop Geothermal Reservoir Engineering* (2011), CA, USA, p: 869-877.

Haklidir Tut, F.S., Akın, T., Güney, A., Uzun, A.: Geochemical Evaluation of the New Wells, Completed in Deep Reservoir, in Kizildere Geothermal Field. *Proceedings of the 65th Turkey Geology Congress* (2012), Ankara-Turkey, in Turkish.

Kindap, A., Kaya, T., Tut Haklidir, F.S., Alpagut Büklmez, A.: Privatization of Kizildere Geothermal Power Plant and New Approaches for Field and Plant. *Proceedings of World Geothermal Congress* (2010), Bali, Indonesia p: 1-4.

Kindap, A., Haklidir Tut, F.S.: Geothermal Energy Investments On Power Production With An Example: New Geothermal Investments in Kizildere-Denizli. *Proceedings of 1st International %100 Renewable Energy Conference and Exhibition (IRENEC)* (2011), Istanbul, Turkey p: 344-348.

Simsek, S.: Kizildere Geothermal Field, R-3A Geothermal Production Well Geology & Hydrogeology Report. Hacettepe University (2011) in Turkish.

Simsek, S. :Hydrogeological and Isotopic Survey of Geothermal Fields in the Buyuk Menderes Graben, Turkey," *Geothermics*, Page: 32,669-678.

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