Proceedings World Geothermal Congress 2020+1
Reykjavik, Iceland, April - October 2021

Unlocking the NCG Utilization Potential of Turkish Geothermal Fields: Criteria of Selection NCG Injection Well for GECO Project, Kizildere Geothermal Field

Erdinc Senturrk[1], Taylan Akin[2]

1-Zorlu Energy Group, Levent 199, Istanbul, Turkey

2-Pamukkale University, Geological Engineering Department, Denizli, Turkey

erdinc.senturk@zorlu.com, takin@pau.edu.tr

Keywords: GECO, Kizildere, non-condensable gases, co2, injection, well, selection, criteria

ABSTRACT

Turkey has become one of the most valuable player in European geothermal industry with their relentless efforts in last decade. As the Turkish geothermal industry grows, one topic of interest got great deal of attention from reservoir perspective, which is producing geothermal fluid with high concentration of NCG. The high NCG concentration in geothermal fluid has both advantages and disadvantages. The most important disadvantage is the obvious one, higher emission rates. Although there is not any regulation or penalty mechanism for higher emission rates from geothermal power plants, some of the leading Turkish companies already started to put an effort to solve this issue. With this purpose, Zorlu Energy who operates in Kizildere and Alasehir geothermal field with installed capacity of 305 MWe, has joined the GECO(Gas Emission Control) project, which is EU funded research project that started in 2018 as Turkish site leader. Within GECO project, one of the injection well in Kizildere Geothermal Field will be used for NCG injection in order to evaluate the carbon storage potential of Turkish geothermal reservoirs. In this study, selection criteria of injection well will be discussed from both surface and subsurface perspectives and selection algorithm will be created.

1. INTRODUCTION

Kizildere geothermal field is located at South-Eastern side of Aegean area between Denizli and Aydın provinces. As being the first explored geothermal field for electricity generation, Kizildere has a big part in Turkish geothermal industry. Since the first geological and geophysical studies started at the field in 1965, Kizildere becomes a living laboratory for geothermal development in Turkey. In 1984 the first geothermal power plant was installed, Kizildere-I which has installed capacity of 15 MWe . After 24 years in 2008, Kizildere geothermal field was acquired by Zorlu Enerji. From this date up to today, installed capacity of the field has raised up to 260 MWe with 2 new geothermal power plants. Addition to Kızıldere-I, Kızıldere-II which has installed capacity of 80 MWe was commissioned in 2013. In 2017 and 2018, two units of Kızıldere-III which is the largest power plant in Turkey with an installed capacity of 165 MWe, were commissioned.

Along the production history of the field, similar to many other Turkish geothermal fields one major topic attracts great attention from all members of the industry which is production of geothermal fluid having high non condensable gas content. Although this high gas content improves production performances of the wells, from environmental aspect it basically means higher emission rates.

In order to get the best of two worlds, there arises a need for a CCUS(carbon capture utilization and storage) application starting at field. For this purpose, Zorlu Enerji plans to capture NCG from GPP and inject into one of the existing injection wells with GECO project.

2. METHODOLOGY

The first injection strategy was taking CO2 from an outsource and injecting 300 tonnes pure CO2 through a tubing into a well in a 6 months(0.07 tonnes per hour) application period. After several discussions, injection strategy was changed. The reasoning for this, is that although there are commercial risks with the new injection strategy Zorlu Enerji has a great urge to come with a cost-effective solution for high CO2 emissions which is a major problem for the geothermal industry in Turkey. With this purpose, produced NCG from GPPs is decided to be used as CO2 source. In addition to this, since 0.07 tonnes per hour is almost negligble for decreasing GPP emissions regarding to total emission rate in Kizildere geothermal field, amount of the CO2 planned to inject was decided to be maximum amount inlined with the budgetary and technical limits of the project. With this change Zorlu made in injection strategy, for Turkish geothermal industry GECO is no longer an experiment for CO2 injection and interpretation of its results, it turns into a pilot application which will investigate solutions for lowering emission levels and utilizing NCG in Turkish geothermal fields. For this, Kizildere-III GPP Unit-1, 99.5 MWe which has the highest emission rates(nearly 66 tonnes per hour) amongst the others was decided to be used as NCG source. After GPP selection for the application, 38 wells which are still or recently used for injection purposes, were investigated. Candidates were investigated according to a selection algorithm which considers both surface and subsurface parameters. Lastly, one well from this list was selected as best candidate and NCG injection well for GECO project.

First, the requirements for every stage of the project were identified in order to create a selection algorithm. These are;

1. Results of injection are need to be observable/detectable,

2. Pilot application is need to be a cost effective solution for upscaling the project to industrial level,

3. Commercial risks due to outcomes of the projects are need to be minimized.

2.1 Observable Results

In order to observe any results of injection, firstly injection well should have interaction with the production wells. For this purpose, all activities which could relate to pressure/material interferences on wells are revised.

In Kizildere geothermal field, 4 different tracer tests have been conducted so far. Results of these studies are;

1. In 2002 tracer was injected from R-2 and observed at 7 wells, (Yeltekin and Akin, 2006)

2. In 2015 tracers were injected from KD-23C, KD-25A, KD-38C, KD-27A. (Akin et al., 2016). Tracer from KD-23C has been observed at 1 well, KD-27A observed at 3 wells, KD-25A at 5 wells, and tracer from KD-38C has not been observed at any production wells.

3. In 2018 tracers were injected from KDE-2, KDE-11, KD-93B, KDE-20B, R-2, KD-44A, KD-50. Tracers from KD-93B observed at 5 wells, R-2 observed at 5 wells. Other tracers were observed at several wells but at considerably low concentrations.

4. In 2018 tracer were injected from KDE-8 and observed at 4 wells.

According to these results main flow zone in the field located in the center which is a main fault zone called Gebeler. Since flow directions towards this fault zone, any injection well which is connected to this zone should be chosen as an injector. There are 8 injection wells meeting this criteria, namely KD-25A, KD-93A, KD-93B, KD-50, KD-50A, R-2, R-6, KD-27A(Figure 1 & 2).

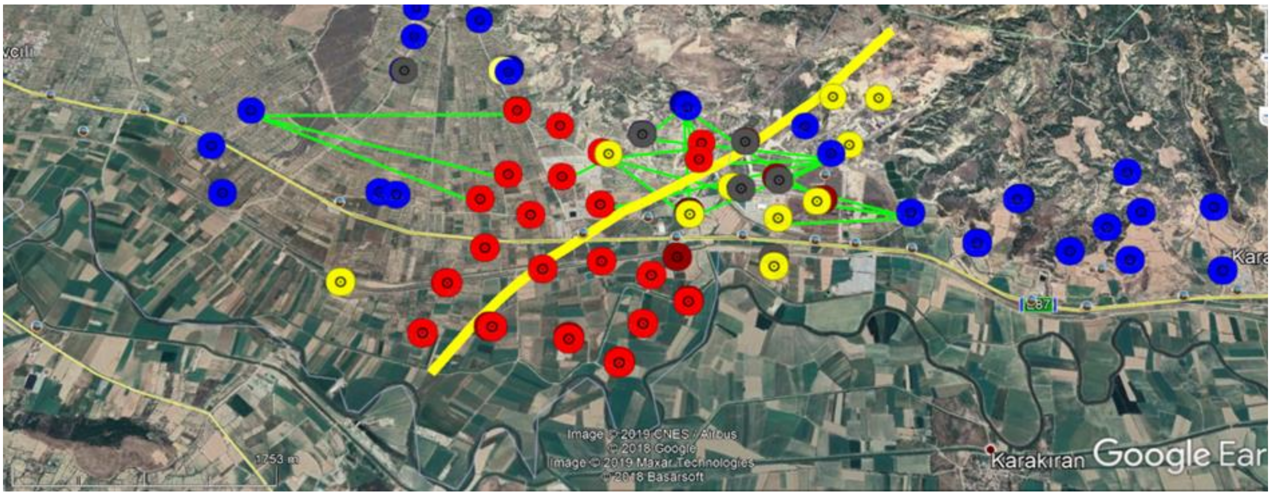

Figure 1: Kızıldere Geothermal Field Well Locations: Green Lines: Flowpaths Yellow Line: Gebeler Fault Trace at Menderes Metamorphics

Figure 2: Candidates for Injector: Locations

Other criteria needs to be in consideration for observable results is injection flow parameters. In Kizildere geothermal field average injection pressure is around 21 barg and flowrate is around 180 tph. But flowrates and wellhead pressures show great variety. For example, some injection wells has wellhead pressures around 36 and just 50 tph, on the other hand some wells are injecting over 400 tph in vacuum condition. This kind of wells are not qualified to be a NCG injector because of the vacuum conditions at wellhead, since it is not possible to solve NCG in brine at the vacuum condition. Flow parameters of 8 candidates can be seen in Table 1. According to data, KD-50 and R-6 were eliminated from the candidate list, since they are operating at vacuum conditions.

Table 1: Candidates for Injector: Flow Parameters

Well ID	WHP(barg)	Flowrate(tph)
KD-27A	18	80
R-2	20	170
R-6	0	190
KD-50	0	450
KD-50A	29	200
KD-93A	32	200
KD-93B	32	260
KD-25A	26	100

2.2 Cost Effective Solution

Regarding the possible upscale of the project to the industrial level, pilot application should be cost effective. For this purpose two main factor which directly affect installation budget identified. First one is injection line length which is directly related to distances between injection wells and NCG outlet of GPP. Second one is pump/compressor capacity which is directly related to flowrates and elevation difference between source and destination. For remaining 6 wells, these parameters are collected (Table 2). According the data, an injection line to R-2, KD-27A needs to be above 3.5 km. From remaining 4 wells, KD-93A and B elevation difference with GPP is around 82 m, which almost corresponds to 8 barg pressure loss for the pump. On the other KD-25A has 21 m and KD-50A 55 m differences with GPP NCG outlet.

Table 2: Candidates for Injector: Elevations and Injection Line

Well ID	Elevation(m)	Injection Line(m)
KD-27A	150	3907.4
R-2	161.6	3700.8
KD-50A	195.5	1020.0
KD-93A	222	2264.9
KD-93B	222	2264.9
KD-25A	161	784.6

2.3 Minimizing Commercial Risks

For the final evaluation, last criteria is commercial risks due to injection of NCG solution. Main risk is possible negative effects on production performance of wells nearby the injector, due to an early thermal breakthrough or degassing effect. The nearest production well to KD-25A, KD-50A is the same well, KD-25B which has started to produce in 2018. First well testing studies on this well, showed a great thermal effect due to injection activities on well KD-25A(Figure 3). Once this affect was explored, injection activities on KD-25A had to be stopped immediately. Because of this, KD-25A was eliminated from the list in order to not taking any risks on decreasing production performance of KD-25B.

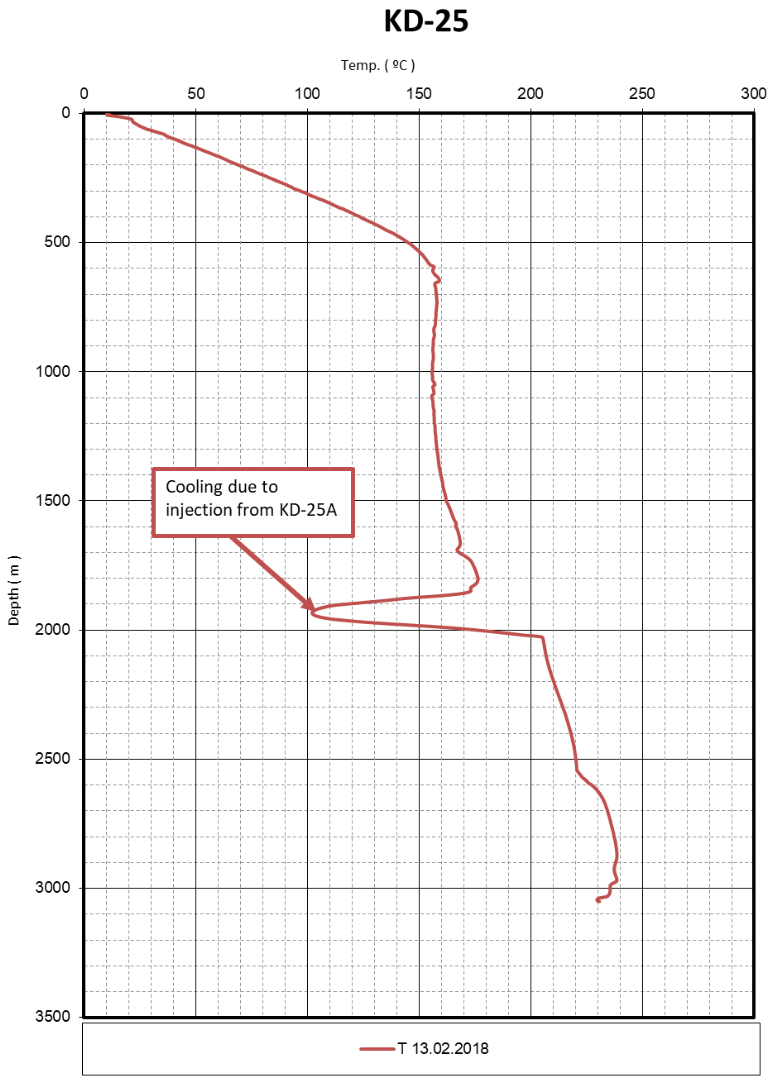

Figure 3: KD-25B Static Temperature Log

All selection criteria and candidate list for every step is summarized in Figure 4.

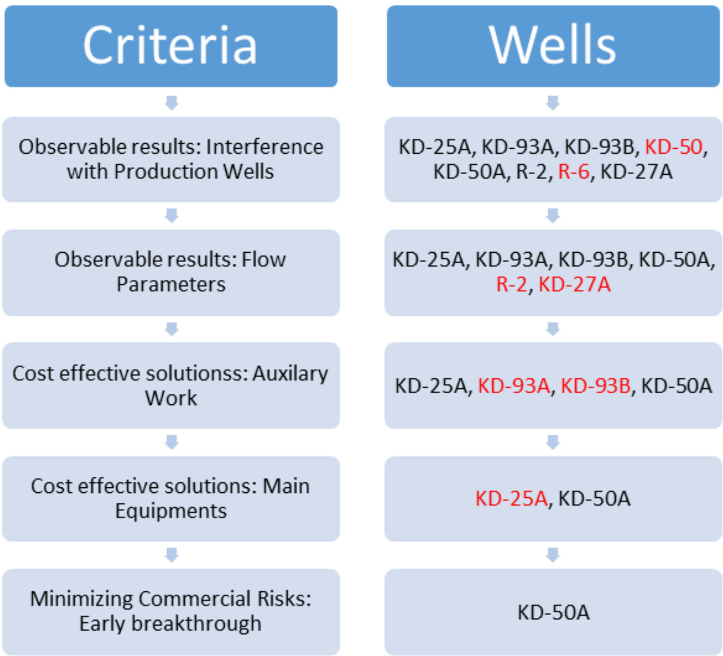

Figure 4: NCG Injector Selection Criteria

3. CONCLUSION

As a result, KD-50A well was selected as NCG injector regarding to all aforementioned criteria. NCG amount injected from this well, will be decided according to ongoing geochemical and wellbore modeling studies results. The selection algorithm used in this study could be applied on similar projects with some site specific modifications. At this point, most important aspect of creating a selection algorithm is defining the requirements of the project in every stage in order to identify limitation factors for the application.

ACKNOWLEDGEMENT

This project has received funding from the European Union's Horizon 2020 research and innovation programme Grant Agreement No.818169-GECO. This publication reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

REFERENCES

Yeltekin, K., and Akin, S. "Analysis of Long Term Tracer Test in Kizildere Geothermal Field Turkey" Proceedings, Thirty-First Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, California, January 30-February 1, (2006)

Akin, S, Güney A., Şentürk, E., Şengün R., Kılınçarslan S. "Tracer Testing at Kizildere Geothermal Field, Turkey, Using Naphtalene Sulfonates" Proceedings, Forty-First Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, California, February 22-24 (2016)