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Technical and Economical Analysis of NCG Reinjection in Geothermal Power Plants

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INTRODUCTION

Reducing carbon dioxide emissions is a global priority, with increasing efforts in carbon capture, utilization, and storage (CCUS) technologies.

In geothermal power plants, extraction of hot water and steam releases naturally occurring gases from the reservoir, contributing to greenhouse gas emissions and causing pressure drops that can reduce plant efficiency and electricity generation.

The GECO (Geothermal Emission Control) project, funded by the EU Horizon2020 program, addresses these challenges by demonstrating the feasibility of reinjecting separated gases back into the geothermal reservoir. [1]

This study presents a simplified technical and economic analysis of the integrated system and discusses its potential scalability in relation to carbon markets.

METHODS

- Non-Condensable Gases (NCGs) are collected from the existing plant's cooling tower fan stacks through a dedicated piping branch with a separate valve, to be pressurized by compressor in GECO system and mixed with pressurized brine from Emergency Dump Pond (EDP).
- Water + gas mixture is then directed to existing active injection line and then injected into the well.
- Cooling water for heat transfer operations is drawn from nearby cooling tower basins, while electricity for compressors, pumps, and blowers is supplied via redundant switchgear connections with voltage adjusted to equipment requirements.
- This design ensures safe integration of the GECO system without affecting plant operation, maintaining reservoir sustainability, and enabling NCG reinjection for emission reduction.

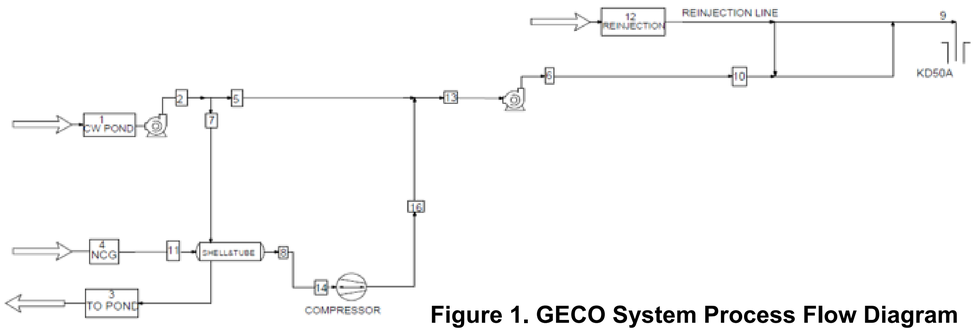


Figure 1. GECO System Process Flow Diagram

RESULTS

With the implementation of the studies described in the methodology, 980 tons of CO2 were reinjected into the reservoir during the 6-month pilot study period.

The annual CO_2 emissions of 186 people were offset through a pilot-scale study.*

This equals the amount of carbon that 166,000 trees would capture in one year.**



Figure 2. GECO Demonstration Area

Brine injection into the reinjection well selected for the project increased by 100% without any external intervention other than NCG reinjection. (Fig. 3)

The need for well conditioning has been virtually eliminated due to the increased acid concentration within the NCG.

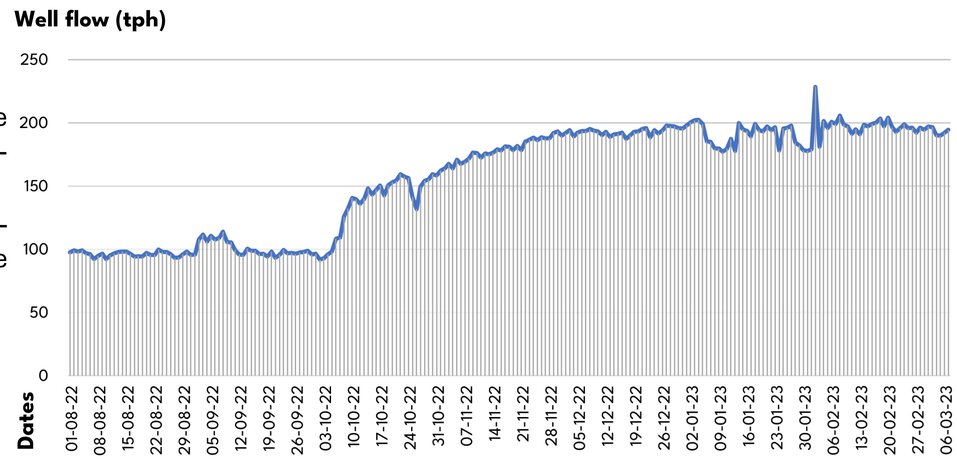


Figure 3. Well Reinjection Flow

186 people claim based on 2023 CO_2 per capita calculation. [2][3]

**Similarly, 166,000 trees assumption based on the younger trees that can capture 10 to 20 kg CO_2 per year. [4]*

DISCUSSION

At the Kızıldere-3 power plant, the amount of gas that can be reinjected must first be determined for scale-up. It has been calculated that 20 tons per hour can be injected . The annual emission reduction value resulting from 20 tons/h of NCG reinjection is given below:

Table 1. Yearly emission reduction value calculation

NCG Mass flow (ton/h)	NCG CO_2 rate adjustment (99%)	CO_2 rate conserved in reservoir adjustment (85%)	Yearly total (ton/year)
20	19.8	16.83	147,430

The equipment cost required for 20 tons/h of CO2 capture is assumed to be $12,660,000, and the electricity consumption is assumed to be 2.24 MWh. Maintenance costs, selected as 10% of the equipment investment cost. The annual cost of power for operating the system is estimated to be approximately $1.37 million/year. Accordingly, the total annual cost of the system is calculated to be approximately $2.64 million.

When calculating the carbon credit prices required to break even with only annual expenses, on a $2.64 million investment, this equates to a carbon price of approximately $18/ton. The payback periods for the investment according to different carbon pricing scenarios are shown in the table below.

Table 2. Payback Periods relative to Carbon Prices

Carbon Price	Return of Investment for 20 ton/h (year)
0	-
$10.00	-
$18.00	-
$20,00	41,0
$30,00	7,1
$40,00	3,9
$50,00	2,7
$60,00	2,0
$70,00	1,6
$80,00	1,4

The system was operated for 6 months as planned for demonstration period. Main power consumers were compressor (45 kW), re-injection pump (55 kW) and cooling water pump (5 kW). There was also minimal consumption from intermittent usage of air compressor for instrument air. Table 2 given on the left hand sideonly provides insight on break-even point of revenue and CAPEX for a large scale system, with inclusion of a blower and larger dual compressors to remove re-injection pump. OPEX and power consumption is also considered during this calculation as mentioned above, however it does not include detailed financial calculations.

As carbon prices approach the values expected to be reached between 2030 and 2050, the payback period for investments accelerates.

The increase in carbon prices ensures that the payback period for high-cost investments is faster than for low-capacity systems.

CONCLUSION

While preventing carbon emissions is vital to halting global warming, the primary cause of climate change, the results achieved through the GECO Project represent a significant opportunity for decarbonizing flash cycle geothermal power plants.

Over the past 30 years, efforts to reduce carbon emissions have been undertaken, starting with the Kyoto Protocol and reinforced by the EU Green Deal. Turkey has announced a net-zero emissions target by 2053 through the Paris Climate Agreement and Nationally Determined Contribution agreements. In line with these targets, projections indicate that if carbon emissions are commercialized in the coming years, carbon prices will accelerate as the agreement dates approach. [5][6]

It is predicted that the estimated value will stabilize between USD 80 and USD 120 after 2030.

With the reduction of carbon emissions becoming so important today, projects such as the GECO Project have gained considerable value.

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