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Enhancing Geothermal Affordability through Advanced Chemical Technologies

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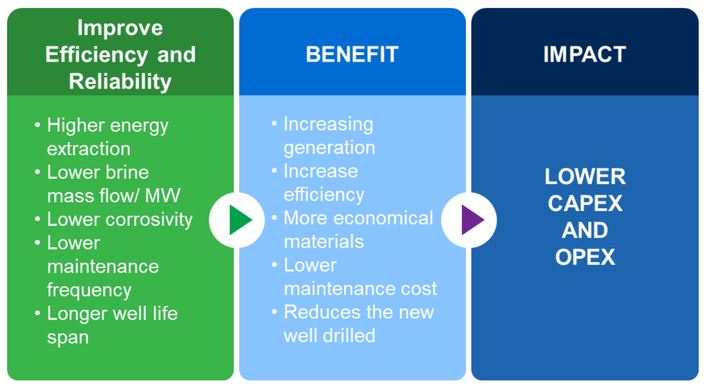
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INTRODUCTION

Geothermal energy is a reliable and renewable source capable of providing stable baseload power, yet its operational growth is often hindered by financial challenges, particularly those related to mineral scaling and corrosion. These issues lead to **increased capital and operational expenditures** due to the need for specialized materials and costly maintenance. Based on Stefannson (2002), investment cost for 40 MW are 44.9-79.1 million USD. Consequently, occurrences of those issues can lead to increase cost of geothermal power plants. Recent advances in chemical technology now offer practical solutions, delivering significant cost reductions and performance improvements through innovative chemical formulations. This breakthrough makes geothermal energy more affordable and efficient, supporting its wider adoption as a sustainable energy solution.

CHEMICAL TECHNOLOGY FOR GEOTHERMAL

The implementation of chemical technologies will contribute to improvements in various areas, particularly enhancing the reliability of the plant. Below are some improvement, benefit and impact that chemical technology can offer :



QUANTIFIED AFFORDABILITY GAINS

Objective, Advantage, Benefit and Impact

- Comparative assessment was conducted between conventional and advanced chemical programs. The impact on chemical technology is not just CAPEX or OPEX for surface facilities.

Sub surfaces scale control

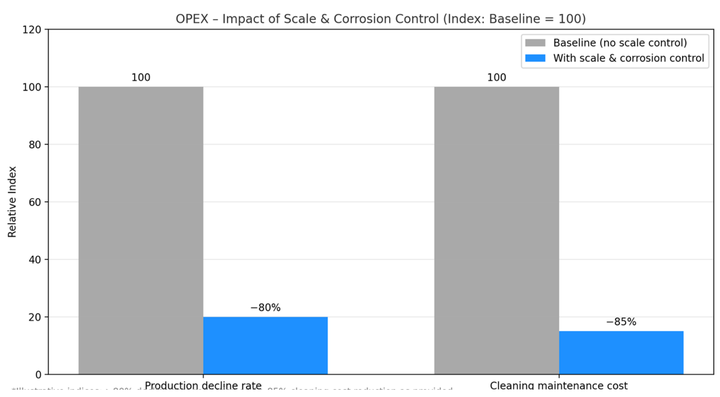
- Implementing scale control for production wells through the use of scale inhibitors (such as calcite inhibitors), corrosion inhibitors, and routine well cleaning offers significant benefits, including a substantially lower decline rate in well productivity, prolonged well lifespan, and the ability to maintain power generation efficiently and cost-effectively. It will save up to 8.6 million USD for drilling new well. Meanwhile, as for operating expenditures can cut decline rate up to 80% and maintenance cleaning cost by 85% (Nietzen, 2015)

Table 3: Cost of Mechanical Cleanouts.

Item	Cost /year
Cleanouts	$731,325
Lost generation	$2,635,187
Total	**$2,708,319**

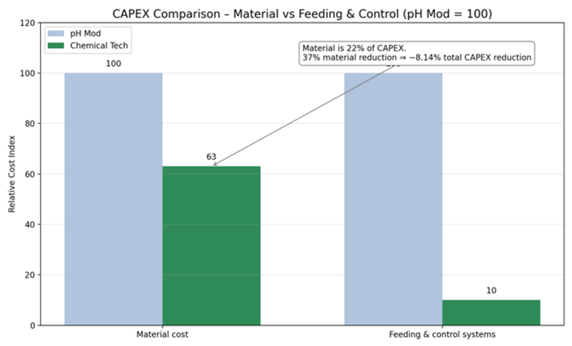
Table 2: Cost of the Inhibition System

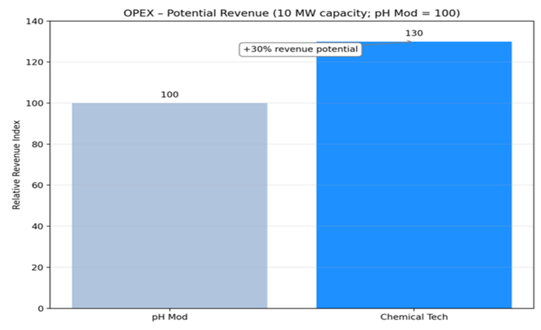
Cost Category	Total Annual Cost
Field	$82,430
Plant	$77,790
Equipment	$45,145
Total	**$205,365**



Scale inhibitors for surface facilities

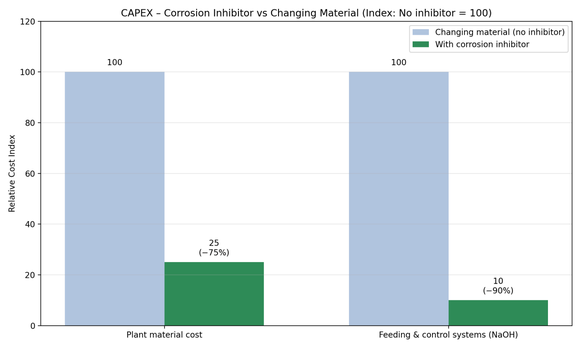
- Scale inhibitors in surface facilities (for example in binary case), a comparative analysis is conducted regarding the materials utilized as part of the capital expenditure and the feeding systems currently implemented in Indonesia. Additionally, the operational expenditure is evaluated in relation to the potential revenue generated from power production, assuming a plant capacity of 10 MW.

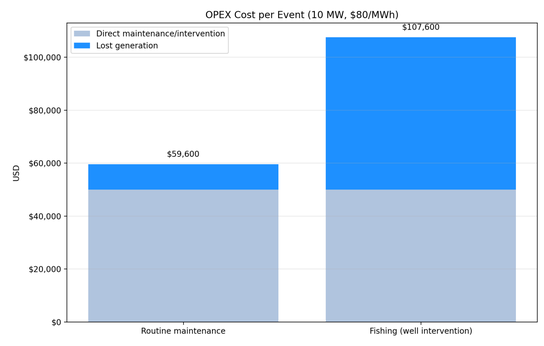




Corrosion inhibitors for surface facilities

- Chemical corrosion inhibitors can control general and localized corrosion in acidic geo thermal fluids under high temperature and pressure. They should work in vapor, liquid, and two-phase environments without changing the brine's pH. Instead of replacing pipeline materials, which can be extremely costly, the use of chemical corrosion inhibi tors can save up to 75% in material expenses. In contrast to the commonly used NaOH, which may alter the pH and subsequently trigger scaling issues downstream, corrosion inhibitors do not significantly affect pH. As a result, when fluids encounter other wells, there is minimal change in pH, reducing the likelihood of scale formation.





DISCUSSION

Implementing chemical technologies in geothermal operations directly addresses the adverse effects of brine chemistry. Compared to traditional methods like pH modification (which require expensive corrosion-resistant alloys), advanced scale and corrosion inhibitors enable the use of standard materials, reducing CAPEX. These solutions also lower OPEX by minimizing maintenance frequency, downtime, and loss of generation. Therefore, continuous innovation in chemical technologies is essential to achieve affordable geothermal power generation.

CONCLUSION

Chemical Technology for Affordable Geothermal

	CAPEX Required	OPEX Required	Complexity & Time	Risk	SAVING IMPACT CAPEX	SAVING IMPACT OPEX
Sub Surfaces Scale Control	+++	+	+++	+	+++	++++
Surfaces Scale Control	+	++	++	+	+++	++++
Acidic Well Corrosion Control	+	++	++	++	+++	++

+ : qualitative ranking scale

Symbol	Interpretation
+	Low
++	Moderate
+++	High
++++	Very High

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