Data Mining and Machine Learning Regression Model Development to Forecast Energy Intensity Reduction

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ABSTRACT

Steam Assisted Gravity Drainage (SAGD) is a process used to extract heavy oil and bitumen from deep underneath the Earth's surface.
This process requires a pair of wells, where hot steam is injected underground through the upper well to reduce the viscosity of the bitumen and allow it to flow.
The lower well collects the oil and pumps it to the surface to be processed.
Non-condensable gas (NCG) such as methane, can be used to reduce the amount of steam required, which in turn reduces the economic and environmental impacts of SAGD.
AccuMap was utilized to extract the data from well sites in Northern Alberta.
A Machine Learning Regression model was created using Python to quantify the impacts of implementing NCG co-injection at existing SAGD sites.

Advisor

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INTRODUCTION

Steam Assisted Gravity Drainage (SAGD) is a common process used in the Oil and Gas industry in Alberta.
Hot steam is injected into the upper injector well that lowers the viscosity of the bitumen. The heated bitumen and water drains into the lower well due to gravity and is collected by a lower producer well to be pumped to the surface.

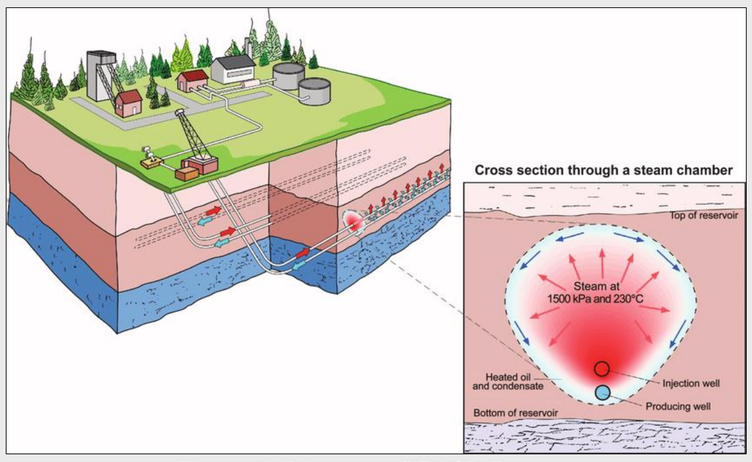

Figure 1: Diagram of SAGD Process

Non-condensable gas (NCG) co-injection can be used at existing SAGD sites to reduce the amount of steam injection required to maintain ideal parameters to extract oil. According to background research, implementing NCG co-injection can reduce Greenhouse Gas (GHG) emissions by 15% and operating costs for SAGD by 20%. This project aims to quantify these values and compare it to our research findings. A Machine Learning Model was created to quantify the environmental and economic impacts of implementing NCG co-injection at SAGD sites.

METHODS AND MATERIALS

Software
AccuMap is a software widely used in the petroleum industry that allows to analyze and extract pipeline and facility data. AccuMap was used to extract monthly data from SAGD sites that use NCG and SAGD sites that have not yet implemented NCG. The parameters extracted include Steam Injected, Oil Produced, Number of well pairs etc.
Machine Learning Model
The libraries used to build the Machine Learning Model for this project are Pandas and scikit-learn. Data sanitization was performed after the data was extracted. Then a Random Forest Regressor model to fit the data to target steam injection values. The model was then used to predict the steam injection values for SAGD with NCG co-injection under ideal conditions.
Methodology
The data from facilities that have already incorporated NCG co-injection at SAGD sites were used to train the Machine Learning Model. This allows the model to predict values for similar sites, that have not yet implemented the SAGD process. This can allow industry specialists to perform a cost-benefit analysis on the implementation of NCG co-injection. The model was validated by verifying that the predicted values outputted were similar to actual values. The R^2 value was used to determine the quality of the model, as well as various other metrics commonly used in Machine Learning such as cross validation, and the analysis of the variance inflation factors.

RESULTS & DISCUSSIONS

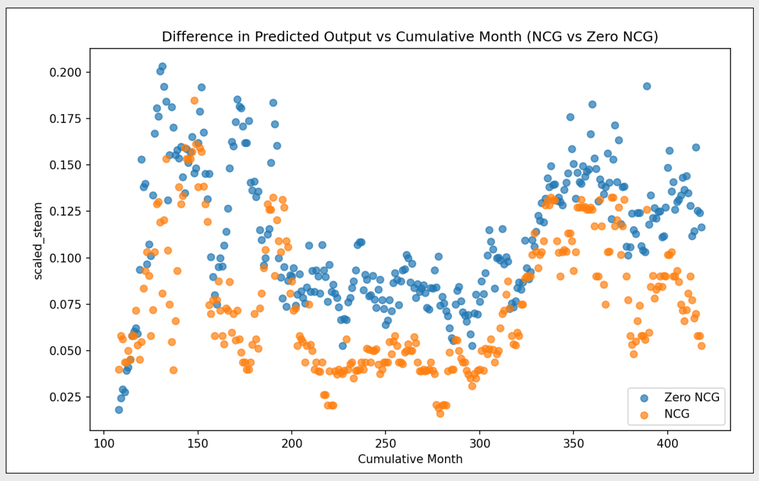

Figure 2: Difference in Predicted Output vs Time

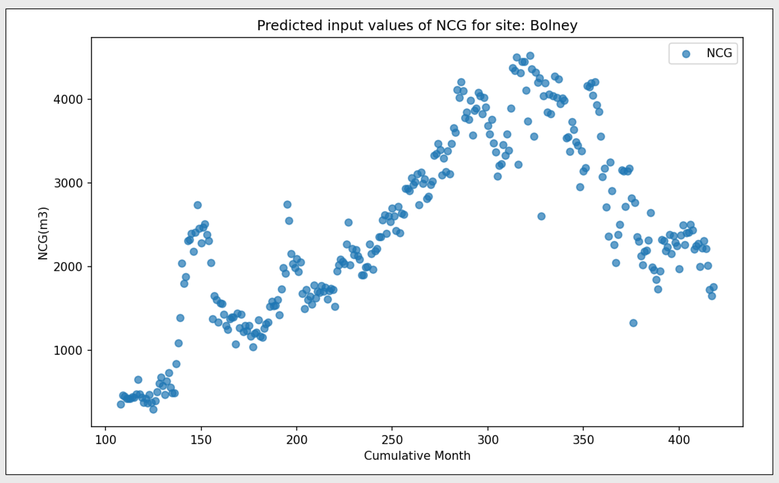

Figure 3: Predicted NCG values for Bolney Site

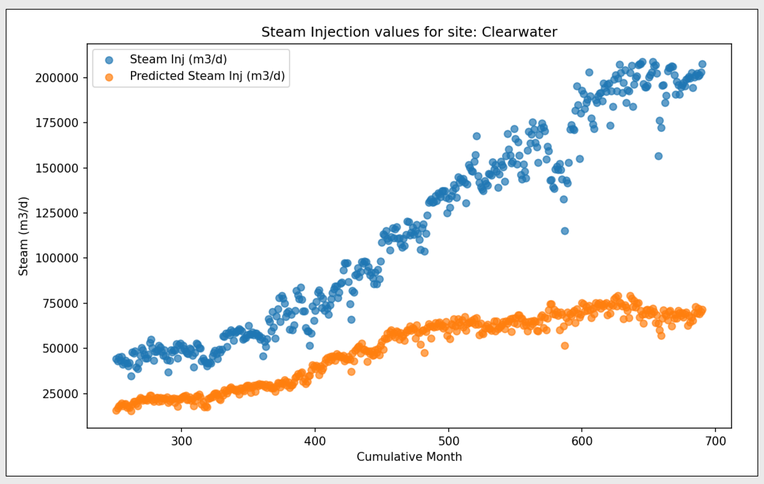

Figure 4: Steam Injection Values for Clearwater

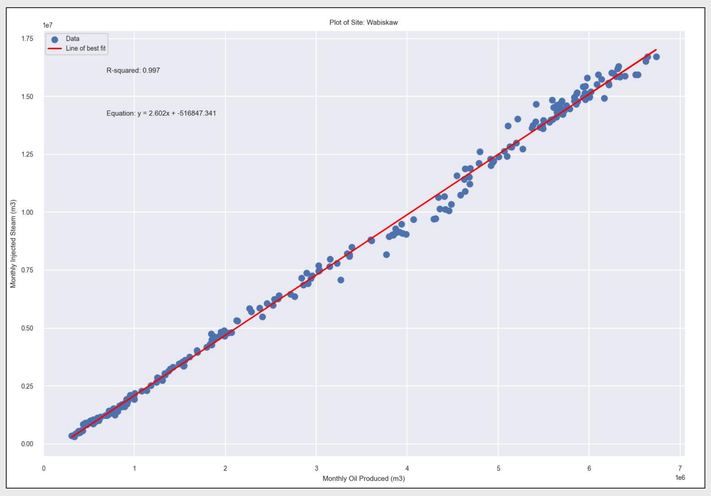

Figure 5: Monthly Steam vs Oil Values of Wabiskaw Site

CONCLUSIONS

This project allowed to gain an understanding of how SAGD and NCG processes are executed in the Oil and Gas Industry. The group gained experience with industry software such as AccuMap by analyzing and extracting data. Various SAGD sites were analyzed in Northern Alberta, to ensure validity of the results. The machine learning model that was built allowed us to estimate the reduction in steam injection requirements for various sites. As exemplified at the site Clearwater, as the steam chambers expand, the pressure requirements increase dramatically, and the temperature requirements increase slowly. Due to this behavior, the gains from NCG implementation are most apparent in the later stages of the SAGD process. As such, the benefits of implementing NCG raise steeply over time, and can be quantified to find the breakpoint at which the upfront costs of implementation are outweighed by the future savings.

REFERENCES

1. Overview – Advanced Water Research Lab (2022). Available at: https://awrl.ca/overview/#:~:text=SAGD%20Facts&text=One%20of%20the%20in%2Dsit
2. SAGD - 2B1stconsulting (2012). Available at: https://2b1stconsulting.com/sagd/ (Accessed: 4 October 2022).
3. "Sketch of steam-assisted gravity drainage (SAGD) [Online]. Available: https://www.researchgate.net/figure/Sketch-of-steam-assisted-gravity-drainage-SAGD-scheme-representative-of-the-facilities_fig1_273693778. [Accessed: Mar. 26, 2023]