PennState College of Earth and Mineral Sciences

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Economic Analysis of Various Gas Compositions - CCS & EGR within Depleted Shale Gas Reservoirs

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INTRODUCTION

Fossil fuels — coal, petroleum, and natural gas — are our main sources of energy, producing the vast majority of fuel, electricity, and heat used by people across the globe. Carbon dioxide remains one of the key contributors to global warming with about 92% of total U.S. anthropogenic CO_2 emissions originating from fossil fuel combustion. As worldwide concerns of climate change become increasingly prominent, a push for cleaner energy and reduced carbon emissions is on the forefront of the oil and gas industry.

ABSTRACT

When is comes to depleted shale gas reservoirs, CCS[1] and EGR[2] are two possible ways in which oil and gas companies may be able to tackle greenhouse gas emissions. This internship aims to provide a research driven analysis of these methods. For the basis of our analysis, a hypothetical situation was fabricated in order to help visualize potential real-life scenarios.

- A coal-fired power plant was chosen as the source of flue gas[3].
- CCS and EGR would be performed on pre-existing shale gas wells.
- The power plant is located about 40 miles from the well pad.
- 1 million metric tons of CO_2 are injected annually.

METHODS

Scenarios 1: CO_2 Injection

Carbon dioxide is stripped from the power plant's flue gas through a process called amine separation. To inject 1 million metric tons of CO_2 per year, the flow must be around 50 million standard cubic feet per day. For EGR, this results in production around 14.4 MCF of natural gas per ton of injected CO_2. Additionally, a tax credit of \$35/ton of CO_2 is available for EGR projects. For CCS, the well does not produce, but the tax credit is \$50/ton of CO_2.

Scenario 2: CO_2 + N_2 Injection

To isolate carbon dioxide and nitrogen gas, oxygen and water vapor are stripped from the flue gas via cryogenic air separation, ion transport membranes, and nickel alloy condensers/heat exchangers. To inject 1 million metric tons of CO_2 per year, the flow must be around 200 million standard cubic feet per day. For EGR, this results in production around 49.0 MCF of natural gas per ton of injected CO_2. Additionally, a tax credit of \$35/ton of CO_2 is available for EGR projects. For CCS, the well does not produce, but the tax credit is \$50/ton of CO_2.

[1] CCS, which stands for Carbon Capture and Storage, is a way of mitigating the contribution of fossil fuel emissions by capturing and subsequently storing carbon dioxide (CO_2) in geological formations.

[2] EGR, which stands for Enhanced Gas Recovery, is used to describe the recovery of difficult-to-recover natural gas. Various mixtures, fluids, and gases may be injected into formations such as tight gas sands, shales, and coal seams to increase recovery.

[3] Flue gas is the emitted material produced when fossil fuels such as coal, oil, natural gas, or wood are burned for heat or power. It consists of nitrogen, carbon dioxide, oxygen, water, SO_x, NO_x, and other particulates.

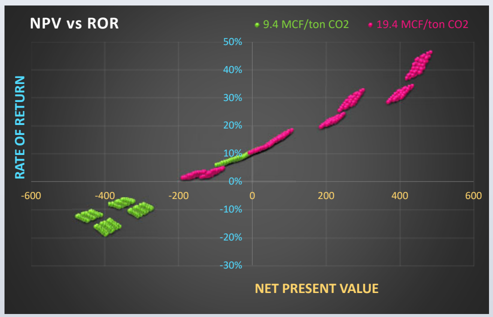
METHODS (CONTINUED)

Scenario 3: Flue Gas Injection

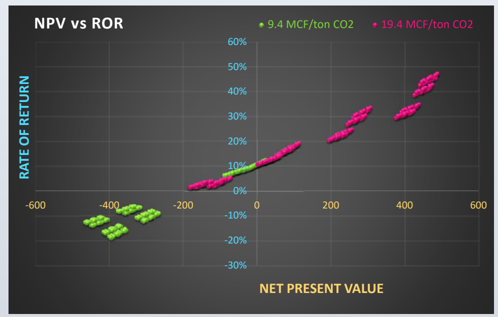
For flue gas injection, the water needs to be removed through the nickel alloy condensers/heat exchangers to prevent pipeline and compressor corrosion. To inject 1 million metric tons of CO_2 per year, the flow must be around 250 million standard cubic feet per day. For EGR, this results in production around 49.0 MCF of natural gas per ton of injected CO_2. Additionally, a tax credit of \$35/ton of CO_2 is available for EGR projects. For CCS, the well does not produce, but the tax credit is \$50/ton of CO_2.

RESULTS OF EGR

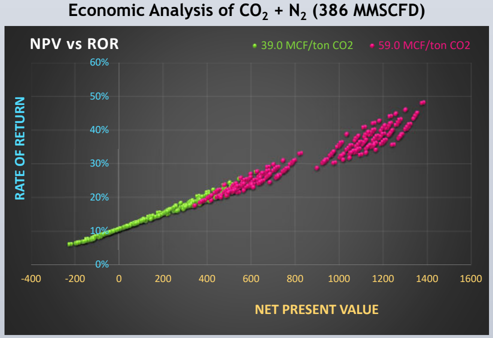
Economic Analysis of CO_2 (53 MMSCFD)



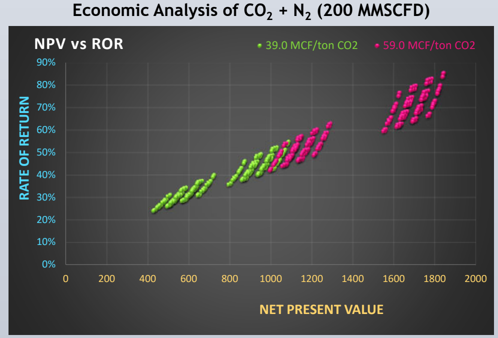
Economic Analysis of CO_2 (50 MMSCFD)



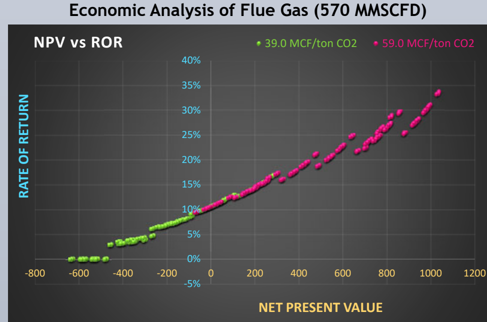
Economic Analysis of CO_2 + N_2 (386 MMSCFD)



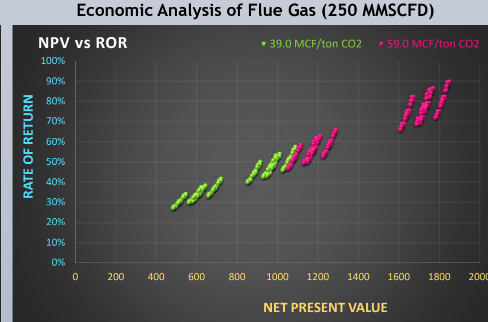
Economic Analysis of CO_2 + N_2 (200 MMSCFD)



Economic Analysis of Flue Gas (570 MMSCFD)



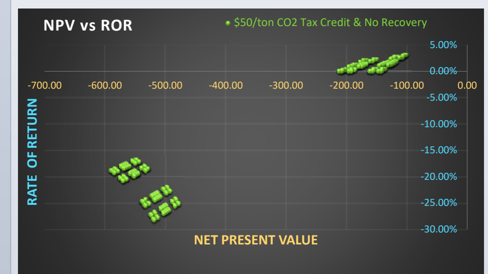
Economic Analysis of Flue Gas (250 MMSCFD)



DISCUSSION

The cost analysis indicates that profitability is extremely sensitive to compressor costs. When the flow is tweaked, it affects total horsepower, kilowatt hours of operation, and the pipeline size. All of these factors, which constitute the majority of costs, depend on the compressors. The graphs indicate that higher liberation rates will almost always lead to better financials. Project engineers should focus on liberating as much natural gas as they can from the depleted shale gas reservoirs to see optimal profit.

RESULTS OF CCS



The ROR of the CCS projects for all 3 scenarios failed to go any higher than 4%, deeming them unprofitable. Project financing such as corporate bonds and commercial loans are known to increase ROR. However, the annual after-cost cashflow has to be higher than the loan repayment; otherwise, debt leads to lower RORs. We suggest that engineering efforts should focus on lowering CAPEX or OPEX enough to get the after-cost cashflow to 7%-10% CAPEX in order to raise RORs above 10%. This middle step of taking a project with an unattractive ROR and passing the 10% hurdle rate by using project financing should unlock industry's ability to develop CCS projects in the near future. Another potential solution would be if the government raised the tax credit from \$50/ton of CO_2 to a more attractable number such as \$80/ton of CO_2.

CONCLUSION

Both CCS and EGR can serve as successful climate change remedies. However, the widespread utilization of such projects has been limited by financial uncertainty. The research that I preformed throughout the internship was challenging due to the lack of available or even relevant data. For future related research, it would be quite advantageous to work with contractors within the industry to price out present cost estimates for specific projects. If such cost estimates prove to be profitable, the oil and gas industry will ironically become leaders in reducing carbon emissions as CCS and EGR become more prominent.

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