On-Site Flare Gas Utilization

Generating Electricity and Flue Gas for EOR

Env 452: Connections in Energy
Flare Gas Capture Team
Jacob Goyne, Victor Holten, Rui Wang

Mission Statement: Our goal is to provide oil production groups with an on site system that will utilize flare gas in an enhanced oil recovery process. This system will effectively eliminate flaring and provide an environmentally beneficial and economically profitable use for the natural gas that is currently being flared.

Regulation and Rules:

As of September 30th, 2014 oil producers are required to abide by production allowances to limit flaring and increase natural gas capture.The policy introduced in July of 2014 sets goals for limiting the flaring of natural gas produced to 23% in January 2015, 10% by 2020, and potentially 5% beyond that. Currently, the primary method for reducing gas flaring is increasing natural gas capture.

Flare in North Dakota:

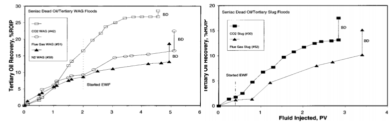
About 30% of gas extracted in North Dakota is uncaptured. In 2013, North Dakota flared 114 billion cubic feet gas, 96 billion (84%) of this was from Bakken wells. Between 2010 and 2014, wells in the Bakken flared 263 billion cubic feet of gas worth more than $854 million. In many oil wells the problem is the inadequate pipeline infrasture to capture and transport the oil associated natural gas.

Flue Gas:

Flue gas is the purified exhaust of fuel combustion, with ~ 85% of N2 and 15% CO2. Compared to CO2, injecting flue gas is more energy intensive but less carbon intensive. Flue gas is chosen considering the limited CO2 available and the energy and cost advantage of avoiding large scale gas separation.

Based on the assumed gas composition, complete combustion of each ton in air yields 2.711 ton of CO2 (18%) and 12.75 ton of N2 (8.2%), as well as 2.017 ton of H2O and 38 kg SO2.

Figure 2a,b. Compare Flue Gas OR Efficiency with CO2, N2

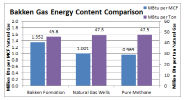


Gas Component:

Oil field associated gas, particularly that in the Bakken formation, is very rich in higher alkanes. According to the report from North Dakota Pipeline Authority, one thousand cubic feet of raw natural gas from a Bakken/Three Forks contain around eight to twelve gallons of higher alkane. As a result, the Bakken oil associated gas contains 35% more energy per mass (figure 2). The estimated gas composition is recorded in table 1. H2S is assumed at 1% and have minimal impact on energy output.

Table 1. Calculated Gas Component and Energy of Bakken Field

		Higher Alkanes (Natural Gas Liquid)				
	Methane	Ethane	Propane	Butane	Pentane C5	Decane C10
Volume	1 MCF	10 Gallon				
Mass percentage	100.00%	46.99%	24.53%	14.79%	6.32%	7.37%
Chemical Conc.	68.30%	19.80%	7.00%	3.20%	1.10%	0.70%



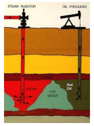
Field Analysis:

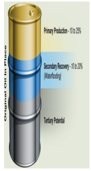
Our project is focusing on 9 oil and gas producing Continental Resources wells in Bowman County, North Dakota. Each field has an average oil production of 38.4 barrels per day. These fields were chosen due to their tight geographical grouping as well as their consistent and large volumes of gas flared, 209 thousand standard cubic feet per day. Because these fields are mainly focused on oil production, most gas that is found during the production process is flared. Furthermore, their production of gas consistently exceeds their amount flared per day, indicating the potential to replace old technologies in exchange for our, potentially more efficient ones.

Key Facts: *Flare 209 MCF/day, produce 38 bbls/day, all very similar wells*

Enhanced oil recovery(EOR):

Enhanced oil recovery is the process of increasing the production life of an oil or gas field by injecting different fluids into the well. Typically, oil recovery goes in 3 stages. **Primary**, simply drilling a hole into the formation. **Secondary,** drilling injection wells and injecting either nitrogen gas, water, or natural gas into the well. **Tertiary** is where high pressure and temperature CO2 is injected into the formation. Our project will be classified as secondary recovery and will work by increasing the viscosity of oil by increasing sub surface pressure.





Gas Capture:

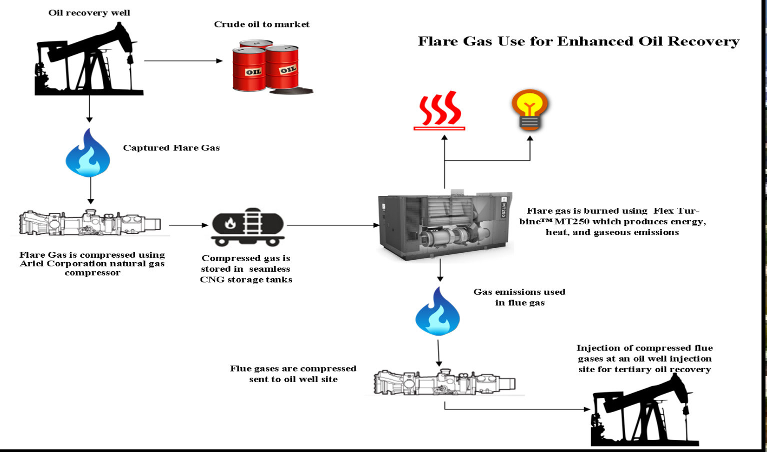
Sites flare approximately 209 MCF per day. However, the flow rate of the gas coming out of the system varies between 1500 and 7000 pounds per hour. Based on average flow rate of 3000 pounds per hour, each well flares approximately 4 hours per day.

Gas Compression:

The ArielCorp 6 Throw JGA/6 has rated power of 840 horsepower, sufficiently accommodate the maximum flow rate of 7000 pounds (660 BHP). The natural gas will be compressed to 2.5MPa and delivered to storage.

Gas Storage:

Compressed flare gas will now come to the storage tanks at a pressure of 361 psi. Here the gas will be stored to solve the intermittency of flare gas. The tank is capable of storing 200,000 scf of flare gas at a pressure of 25 MPa



Gas Combustion:

At a rate of 2,483 scf/hour, the FlexTurbine will generate 250 kw/hour and will produce 40,000 scf/hour of flue gas and 4,000 scf of hot water steam. Operating at an efficiency of 30% (13,341 kj/kwh nominal heating value), provides efficient reaction given cost.

Flue Gas Treatment (optional):

Flue gas produced from turbine combustion contain high amount of water and potentially Sulfur Dioxide, which can be corrosive. Based on current EPA SO2 allowance price, we estimated the cost of desulfurization as a minimal value of $43 per year with wet scrubber.

Flue Gas Reinjection:

Gas desulfurized will be compressed and pressurized to 8.17 MPa to meet the flue gas enhanced oil recovery standard. This can be done using ArielCorp 4 Throw JGA/4 with rated power of 540 horsepower (the same JFA/6 for flare gas compression will suffice as well).

Economics:

Total Investment(per site) $265,000.00
Cost of Capital $58,403.89 Yearly Costs $110,000
Generator Capacity 250 kW Efficiency 30% Uptime 24 Hours
Total Electricity Production per Generator 2,190,000.00 kWh
Total Gas Usage 24,908.72 mscf # of Generators needed/site 3
Total Electricity Sold to user/year 6,570,000.00 kWh
Price of Electricity $0.030 Total Electricity Revenue $197,100.00

Conclusion:

Given the relatively high cost of our system and the potential for little yield increase, our technology would not be very practical. While it would be a means to generate electricity on site and use flare gas, the reinjection component adds significant risk of gas fouling which would yield the project worthless. However, if oil prices begin to rise above their historical low, to say $75, then our technology would be practical and would add value.

Reference:

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