FREDERICKS
CUSTOM SOLUTIONS

Oil and Gas Research Program

North Dakota

Industrial Commission

Application

Project Title: Improving Gas Capture Systems at Flare Sites in North Dakota

Applicant: Fredericks Custom Solutions

Principal Investigator: Jesse Fredericks

Date of Application: June 1, 2024

Amount of Request: $729,640

Total Amount of Proposed Project: $1,459,280

Duration of Project: 40 months

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ABSTRACT

North Dakota flares a higher percentage of its produced natural gas than any other state according to the Energy Information Administration (EIA, 2020). One of the major challenges both regulators and upstream oil and natural gas producers face when it comes to flaring is dealing with the low-volume-low-pressure (LVLP) flares that exist on most oil production pads. This is all gas that makes it into the crude oil and produced water storage tanks (O&WST). Some of the logic behind not requiring oil companies to report how much natural gas is flared from their storage tanks is because it only ends up being roughly 5-15% of the overall gas flared on location, but the other reason is because there are not many options for most oil producers that are both efficient and economical, so they flare it.

Fredericks Custom Solutions (FCS) and our partners believe we have the technology to mitigate the amount of natural gas that is flared from O&WST. The technology is called a Venturi Gas Processing Plant or Venturi System (VS) and is in the process of being designed to deal specifically with natural gas from O&WST. If and when we launch the VS, FCS will introduce this technology into the United States, and to the best of our knowledge, into the world. This technology has been proven, but it has never been used in this application. Introducing the VS will reduce emissions, create jobs and opportunities, further the research of this technology's potential, and be more economical for oil and gas producers to deal with their LVLP flares.

Objective: Our goal is to advance efficient, cost-effective, and inclusive gas capture technologies for wider implementation at natural gas emission sites in North Dakota. Developing improved systems is crucial for the growth and adoption of gas capture technology.

Expected Results: This project aims to enhance our understanding of best practices for gas capture systems through comprehensive data collection, advanced remote monitoring, and system testing. As data is acquired, we will develop training and educational manuals. The outcomes of this project are expected to boost confidence in the early adoption of this gas capture technology and increase natural gas investments in North Dakota.

Duration: The duration of the project will be 3 years and 4 months, from January 2025 to May 2028.

Total Project Cost: The total project cost is $1,459,280. The amount requested from the Oil and Gas Research Program (OGRP) is $729,640. Funding will be matched by Fredericks Custom Solutions (FCS) members and through in-kind labor, totaling $729.640.

Participants: Partnerships include 1LNG, H2E, Flex Flow - DNOW, a local CAT dealer (probably Butler), Bell Supply, AH, BDS (Watford), and whichever oil producer we deploy the VS with (to be determined, but likely Chord Energy or Devon Energy).

PROJECT DESCRIPTION

Introduction to Project

The specific problem that will be addressed by FCS is the excessive flaring of associated natural gas in the Oil & Gas (O&G) industry, which is particularly prevalent in North Dakota. The Energy Information Administration (EIA) found that in 2019, "North Dakota accounted [for] 38% of the total U.S. vented and flared natural gas." (EIA 2020). The Office of Fossil Energy and Carbon Management says that "In 2020, North Dakota accounted for 24 percent of the total vented and flared natural gas (1.15 billion cubic feet per day) in the United States." (FECM 2022). As mentioned above, North Dakota flares a higher percentage of its natural gas, roughly 19% in 2019, than any other state (EIA 2024). Despite advancements in extraction technologies, the lack of infrastructure to capture associated gas efficiently has led to a continuation of significant flaring, posing environmental concerns and economic inefficiencies. In a report by the Department of Energy they state that "a distributed network of technologies and infrastructure are needed to effectively reduce daily venting and flaring volumes as producing regions evolve. These distributed technology alternatives [currently available] to reduce flared volumes are often not currently cost-competitive" (2021). FCS aims to transform flared gas streams into valuable resources by offering cost-effective innovative gas capture and emissions reduction technologies, thereby addressing both environmental and economic challenges faced by oil producers and midstream operators.

The project will focus on making gas capture systems more practical, cost-effective, and environmentally sound, so that eventually this technology will be able to accommodate higher demand, larger operations, and broader implementation. Specifically, this project will focus on the gas capture from the LVLP flares, which accounts for roughly 5-15% on the average oil site. It is difficult to get an exact number on how much gas is flared on the LVLP lines because more often than not, it is not required for oil producers to report it yet. Still, with decades of experience in the oilfield, many of FCS employees are confident in this 5-15% estimate. Many newly drilled wells will flare over 500 mscfd (mcf/d) for the first two or three of production. Part of the reason for less regulations with the LVLP flare is because it's a lower gas volume than the high pressure flare, and thus even less economical for oil producers to deal with. Still, with North Dakota flaring the highest percentage of its natural gas than any other state, these LVLP flare volumes add up fast. FCS wants to introduce a technology that helps solve this problem, which in turn helps producers lower their emissions, increase profits, and stay ahead of regulations, which in turn helps the O&G industry overall make advancements into a cleaner and more sustainable future.

Oil producers currently only have a few options with their LVLP flares. The first one, as mentioned above, is to just flare it. This is what most oil producers do. The unique thing about the gas coming out of the O&WST to the LVLP flare is that it is much richer in C3+ (See Appendix D for tank vapor gas samples within the Bakken oil field). For a quick reference on what C3+'s consists of: C3 is propane. Anyone who owns a gas grill or lives in a rural area knows the importance of propane. C4 is butane. Butane, as well as many of the C5+'s, are a common gasoline additive that improves engine performance. C4 is also a common refrigerant. According to Johnson, "In the United States, Isobutane (same chemical formula as butane, but a slightly different chemical structure) is quickly becoming the standard refrigerant when it comes to home refrigerators and freezers." (2018). Many of the C3+'s are also used as feedstock for the petrochemical industry which produces things like rubber for shoes, tires, cars, and plastics. When it comes to food preservation alone, refrigerants and plastics have increased the standards of living drastically over the past 100 years globally. All of this reveals that flaring the C3+'s is a waste of our natural resources. Nonetheless, this is almost always the case with the C3+ rich gasses coming from the O&WST. Besides flaring, the second option that oil producers explore is adding a Vapor Recovery Unit (VRU) to pull gas vapors out of the tanks and step them up to a high enough pressure to send them down the sale pipeline to gas processing plants. This has become increasingly popular over the past decade. The problem producers run into in North Dakota is either pipelines are already at full capacity, so adding this gas to it isn't an option, or the location is a stranded well, meaning there is no pipeline at all. Thus, the oil producer will have no choice but to resort back to flaring.

Lastly, we offer a third option that requires setting up a portable gas processing plant on the oil and gas well site and liquifying the C3+'s, storing them on site, and trucking them out to market. The O&G industry currently knows of only two ways to do this, and there are a few reasons most oil producers don't usually explore them. (Our project will last three years and four months, but the average project in this application would last 3-5 years. The comparisons below on investments are over a five year period to show the cost difference in initial investments and maintenance. The Venturi System we deploy for this project could very well be on the initial location for five years but will be self-sustaining after three years and four months. Labor costs are not included in these projections). The cheaper upfront costs of the current two options for oil producers would be to set up a VRU to pull out the tank vapors to step up the pressure of the gas to go into a three-stage 100 horsepower (hp) compressor. Then the high pressure gas leaves the compressor to a JT gas plant where most of the C3+'s are liquified and sent to an NGL storage vessel to be trucked off to market. The upfront cost is roughly $885,000 and the equipment maintenance cost for five years is roughly $430,000. So, this five year investment would cost roughly $1,315,000 , not including operations costs. It is possible to make a return on this investment, but it requires a lot of time and expertise. The second option is to use a VRU and send the gas through a mechanical refrigerant unit (MRU) to liquify most of the C3+'s to take to market. The upfront cost would be $1,050,000 and equipment maintenance cost for five years would be $335,000, which brings the overall investment to roughly $1,385,000, not including operation costs. (For the purpose of this grant and the fact that many oil pads are not connected to grid power, we are assuming that the investment includes the purchase of a 200 kW natural gas generator for $200,000, and the five year equipment maintenance cost for that would be $125,000. The oil producer could rent a generator for five years, but the costs would be significantly more.) Thus, in today's gas capture industry, there are only two options for processing the gas on location: the JT package or the MRU package. Of the two options, most producers would choose the MRU package. This is because with a JT package tank vapors are pulled into a compressor using a VRU, there is a risk of pulling in enough oxygen with the tank vapors, which under high compression pressure it could ignite. This could lead to a catastrophic event of serious injuries, loss of life, and/or having to shut in the wells and terminate operations.

Given the high costs, risks involved, and need for operational expertise, most oil producers stick to flaring off their tank vapors that are rich in C3+'s. This is where we provide the third option: the Venturi System. The upfront investment is roughly $850,000, and the equipment maintenance cost for five years is $125,000 (which is just for the generator). The maintenance cost of the VS over five years is nearly $0! (more details below). This makes the total investment over five years, not including operational costs, $975,000. That's $410,000 cheaper than the next best option, which makes a significant difference on the return-on-investment (ROI). The costs of operations will also be drastically lower, making the ROI even greater, because the VS will eventually require less operational expertise and much less in person oversight (more details below). The Venturi System has the potential to make a drastic impact on the way oil producers handle their tank vapors.

How the Venturi Gas Processing Plant (VS) works

The Venturi System eliminates the need for either a VRU and MRU or a VRU, compressor, and JT, depending on what package is at the site. Instead of a VRU, the tank vapors would be drawn into the system using a high-performance venturi pump. The VS uses produced water from the wells as its main component. A pipeline will leave the produced water storage tank and enter a horizontal ESP saltwater pump (produced water from the wells is very high in salt content.) The horizontal pump steps the saltwater from atmospheric pressure to a very high pressure and it through the high performance venturi pump. The Venturi effect is when a gas or liquid flows through a constricted space the pressure decreases and the velocity increases. This creates a vacuum on the tank vapor line pulling the gasses into the system. Upon entering the venturi pump, the tank vapor gasses are instantly entrained and increases to high pressure of the saltwater. Increasing pressure, increases heat, and heat becomes a problem in the liquefaction of gas. Almost providentially, salt can absorb a tremendous amount of heat and works as a phenomenal heat exchanger in the Venturi System. So, the gas is stepped up to a high pressure and cooled off in nearly an instant. Next, the gas and saltwater undergo a drastic pressure drop and most of the C3+'s are liquified and sent to a Natural Gas Liquid (NGL) storage tank to be picked up and brought to market. The saltwater is dropped back to atmospheric pressure and returns to the produced water storage tanks to be cycled again through the system later.

Advantages of the Venturi System

The Venturi System has many advantages to an MRU or JT package. As mentioned above, it is significantly less up front and equipment maintenance costs. For example, the MRU package requires 12 oil changes and roughly 180 gallons of engine oil per year, and the JT package, with a VRU and compressor requiring oil, takes roughly 20 oil changes and 400 gallons of engine oil per year. The VS requires zero oil. This fact alone leads to a lower carbon footprint with the VP system, as it eliminates the carbon footprint of the engine oil itself, the transportation of that oil, and the footprint associated with extraction of this oil. The cost to pay a mechanic 12-20 times a year to change oil on the VRU and compressor add up. Keep in mind, we are not necessarily eliminating any jobs because most oil producers just flare this gas anyways, and all the costs associated with the MRU or JT package is why most oil companies avoid it. VRU's and compressors also require a lot of mechanical work. The VRU's screw compressor needs to be changed out almost yearly because the gas is so wet. Compressors run on ignition combustion engines that require routine mechanical parts and service. The reciprocating compressors require mechanical parts and service every couple month as well. Again, these costs of mechanical parts and service begin to add up fast, especially if there is a major malfunction, and all of these costs are almost completely eliminated by the VS. The only equipment maintenance involved with the VS system is replacing the actual pump roughly every 5-10 years ($25,000), replacing the bearings in the electric motor roughly every 10 years ($7,000), and replacing the thrust chamber roughly every 10 years ($12,000). All the associated maintenance costs are drastically reduced with the Venturi System.

Operation costs for any project must be accounted for. MRU and JT packages require a high degree of expertise and experience to operate, and because there are so many different moving parts to these complex systems, they typically require operators to be on location multiple times a day. This will be true with our VS at first, but because it is such a simple system with extensive remote monitoring capabilities, we plan to only have to do one site visit every other day by the end of the project; and in future VS we plan to only require a couple site visits per week. Thus, operator costs would also decrease drastically compared to a MRU's or JT's operator costs. Thus, the VS will eliminate the need to hire highly qualified gas capture operators, and it will require far fewer site visits. Given all the cost savings associated with the Venturi System, processing the gas becomes economical for oil producing companies and flaring that gas becomes lost profit. Which again, in today's market it's the opposite, it saves oil producers more money to send the tank vapors to the LVLP flare than the cost of deploying and operating an MRU or JT package.

Emissions Reductions

This Venturi System in particular will be designed to handle 500 mcf a day on an oil pad that is not connected to grid power. Because tank vapors are so rich in C3+'s (see table in Appendix D), we expect to liquify 50-60% of the flare gas in the VS. By liquifying the majority of heavier gasses, the Volatile Organic Compounds (VOC's) and the Particulate Matter (PM's) are greatly reduced from the flare. This is because the heavier gasses don't burn efficiently enough the flare, and that's why we see what appears to be black smoke coming out of most flare stacks, especially LVLP flares. The VOC's and PM's are carried into the atmosphere, but because they are heavier molecules, they contaminate the air in the surrounding communities and can be detrimental to health. Even though LVLP flares are smaller volumes than high pressure flares, their VOC's and PM's emission rates can be similar, so the size of the flare can be deceiving. Since we will be off grid power, we will run a 200 kW natural gas which will consume roughly 50 mcf/d of the lean gas that has been separated from the heavy gasses on the tail end of the VS. Since the engine will then be running primarily on methane and ethane, the two lightest gasses, it will burn much cooler and result in less Nitrogen Oxides (NOX's) in the exhaust and thus in the atmosphere and surrounding communities. Since the engine is burning on lighter gasses, lower BTU ratings, it will also increase the lifespan of the engine. The generator will also come equipped with a catalytic converter which reduces CO by 35% and the VOC's that aren't liquified by 50%. This means by running our VS and generator, we will eliminate roughly 60-70% of the LVLP flare. Additionally, the remaining flare will have a much lower level of emission per cubic foot. Part of this project will be to get gas samples, run emission calculations, and make analyses to share with oil producers and eventually the greater O&G industry. So not only are we saving resources that would otherwise be wasted, we are significantly reducing emissions and the environmental impact. This is why the Venturi System has prospects to make an immense impact on the O&G industry, especially in North Dakota.

Partners

FCS will be partnering with a few different companies: 1LNG, H2E, Flex Flow - DNOW, a local CAT dealer (probably Butler), Bell Supply, AH, BDS (Watford), and whichever oil producer we deploy the VS with (to be determined, but it is anticipated to be Chord Energy or Devon Energy). 1LNG will be helping with the capital investment costs. H2E will be building out the VS and have agreed to use domestic steel (slightly more expensive but aligns better with the objectives of this grant). DNOW will be building out the horizontal ESP pump system with electric motor, speed controls, various other controls, skid, and horizontal ESP. And we will purchase our generator from a local CAT dealer. We will use Bell Supply to buy all our pipe, fittings, and valves to connect the VS to and from the produced water storage tanks. We will be using AH to connect all the electrical systems to the generator and install and terminate the heat trace. BDS (Watford) will be hauling our equipment to location and trucking our NGLs to market.

Objectives

The plan for the proposed project is to begin with securing a site location in the North Dakota Bakken oil field, continue communication with manufacturers for technology needs, manufacturing of technology with the specific mechanisms for optimal implementation at the particular site chosen, deployment of the new enabling technology, monitoring and modifying the Venturi System to run at the optimal rate, and collection of emission reduction data to share with oil producing company, partners, and eventually the greater O&G industry.

The goal is that the system advances from 60% to 95% or higher runtime on a monthly basis, increasing on a monthly basis. Through an electronic monitoring system and daily technician data collection, the system runtime will be increased as system feedback reports stabilize performance. Gas samples will be collected at each load sale. Gas sample data will provide information on the system's ability to precisely filter the gas to contain desired gasses only.

Our goal is to enhance our existing combined gas capture system by integrating a new component that advances efficient, cost-effective, and inclusive gas capture technologies for broader application at natural gas emission sites. We have chosen a technology that utilizes the Venturi Effect to replace two components of current gas capture systems. Through this project, we aim to expand knowledge of the Venturi System and encourage further research and development in the field of advanced gas capture technologies.

Our long-term objective is to commercialize this technology for deployment at more flare sites, aiming to reduce natural gas emissions in the Bakken oilfield and increase the utilization of currently wasted energy and material resources. Throughout this project, we aim to evaluate and analyze the capabilities of this new technology. The focus of this project specifically is to prove out the concept on a LVLP flare, make the system as efficient as possible, and thus be able to bring this new technology to as many oil producers as possible.

To accomplish our program goals, our objectives are:

1. Collect data on potential sites and determine the project site.
2. Have the Venturi System technology manufactured.
3. Maintain and monitor the system regularly, ensuring continuous improvements.
4. Run time efficiency calculation. The goal is that the system advances from 60% to 95% or higher of run time, increasing on a per monthly basis.
5. Collect data on the system's efficiency and performance to evaluate and refine its effectiveness.
6. Collect data on emission reductions.
7. Complete manuals and reports on the Venturi System for training, education, and further research.

Expected Results

We plan to initiate the research using FCS's previous designs and existing data from currently deployed gas capture technology. Our focus will be on implementing a Venturi System Technology to replace two components of the current gas combined gas capture systems. This new technology is expected to reduce costs, increase gas capture efficiency, lower risks, and simplify the overall system, making it easier to deploy at new potential flare sites. This project aims to enhance our understanding of best practices for gas capture gas capture systems through comprehensive data collection, regulated monitoring, and system testing. As data is acquired, we will develop training and educational manuals. The outcomes of this project are expected to boost confidence in the early adoption of this new gas capture technology and influence increased natural gas investments in North Dakota.

Methodology

Results of the project will be used for further gas capture technology advancements in the industry through training manual and material creation. The results will also be used as guidance for optimal integration of the Venturi System in future gas capture advancement projects.

Objective Methodology

1. Collect data on potential sites and determine the site for the project.

1.1. Identify potential sites based on criteria such as proximity to emission sources, land availability, regulatory environment, and infrastructure.

1.2. Gather data on each potential site including geographical features, environmental conditions, and accessibility.

1.3. Conduct feasibility studies and site assessments to evaluate suitability for the project.

1.4. Engage with stakeholders including local communities, regulatory bodies, and landowners to gather insights and address concerns.

1.5. Select the most suitable site based on comprehensive analysis and stakeholder input.

2. Have the Venturi System technology manufactured according to the specifications for the chosen sites.

2. 1. Collaborate with engineering and manufacturing partners to develop detailed specifications for the Venturi System tailored to the chosen sites.

2.2. Establish quality control measures and standards to ensure compliance with specifications during the manufacturing process.

2.3. Monitor progress through weekly meetings to ensure adherence to timelines and quality standards.

2.4. Implement feedback mechanisms to address any deviations or improvements needed during the manufacturing process.

2.5. Coordinate logistics for transportation and delivery of manufactured Venturi Systems to designated sites.

3. Deploy the Venturi System.

3.1. Develop a deployment plan

3. 2. Coordinate with on-site personnel and subcontractors to ensure smooth installation and integration of the Venturi System.

3.3. Provide comprehensive training to FCS Employees on the operation and maintenance of the Venturi System.

3.4. Conduct thorough testing and commissioning to verify system functionality and performance.

3.5. Implement contingency plans to address any unforeseen challenges during deployment.

4. Maintain and monitor the system regularly, ensuring continuous improvements as necessary.

4.1. Establish a maintenance schedule outlining routine inspections, preventive maintenance tasks, and calibration procedures.

4.2. Implement condition monitoring techniques such as pressure testing, temperature readings, and gas sampling to detect potential issues early.

4.3. Conduct regular performance evaluations to identify opportunities for improvement and optimization.

4.4. Implement a feedback loop to incorporate lessons learned from maintenance activities into future system enhancements.

5. Run time efficiency calculation. The goal is that the system advances from 60% to 95% of run time, increasing on a per monthly basis.

5.1. Define key performance indicators (KPIs) for measuring system uptime and efficiency.

5.2. Establish a baseline measurement of current run time efficiency using historical data.

5.3. Analyze runtime efficiency on a monthly basis and track progress towards the target (95%).

5.4. Analyze root causes of downtime or inefficiencies and implement corrective actions.

5.5. Continuously optimize operational processes and procedures to maximize system uptime and efficiency.

6. Collect data on the system's efficiency and performance to evaluate and refine its effectiveness.

6.1. Define metrics for evaluating system efficiency and performance, including capture rate, energy consumption, and emissions reduction.

6.2. Implement data collection mechanisms such as sensors, gas samples, meters, and monitoring software to gather real-time performance data.

6.3. Analyze collected data to assess system effectiveness and identify areas for improvement.

6.4. Conduct regular performance reviews and data audits to ensure data integrity and reliability.

6.5. Utilize statistical analysis and modeling techniques to identify trends and patterns in performance data.

6.6. Collaborate with cross-functional teams to translate data insights into actionable recommendations for system optimization, refinement, and greater emission reductions.

7. Complete manuals on the Venturi System for training, education, and further research.

7.1. Compile comprehensive documentation covering all aspects of the Venturi System, including design specifications, installation procedures, operation manuals, troubleshooting guides, and an emission reduction report.

7.2. Organize content in a user-friendly format with clear instructions and illustrations to facilitate understanding and usability.

7.3. Collaborate with subject matter experts to ensure accuracy and completeness of the manuals.

7.4. Develop training programs and educational materials based on the manuals to support knowledge transfer and skill development.
7.5. Foster a culture of continuous improvement through employee training, feedback mechanisms, and knowledge sharing initiatives. Continuously update and revise the manuals in response to feedback, technological advancements, and evolving best practices.

Anticipated Outcomes

Our long-term objective is to commercialize this technology for deployment at more flare sites, aiming to reduce natural gas emissions in the Bakken oilfield and increase the utilization of currently wasted energy and material resources. Throughout this project, we aim to evaluate and analyze the capabilities of this new technology. The focus of this project specifically is to prove out the concept on a LVLP flare, make the system as efficient as possible, and thus be able to bring this new technology to as many oil producers as possible.

This new technology is expected to reduce costs, increase gas capture efficiency, lower risks, and simplify the combined carbon capture system overall, making it easier to deploy at new potential flare sites. The continued investment into this innovative technology also leads us to expect further benefits for the surrounding community.

Short-term Outcomes:

1. In the first year of the project, we will have the new enabling technology implemented at one site, decreasing gas emissions and improving air quality.
    a. Data from tracking the new system through monitoring the amount of gas captured and the amount of flare that was mitigated.
2. In the second year of the project, FCS will develop manuals and educational resources on the enabling gas capture technology for educating, training, and begin promoting new technology.
3. By the third year, VS will be at 95% runtime on average, FCS will be looking to deploy 1-5 new VS in North Dakota, and oil producers in the region will be aware and interested in using this new technology.

Long-term Outcomes:

1. A decrease in gas capture system deployment cost.
2. An Increase in gas capture ability.
3. An increase in access to low-cost energy for the community.

4. A decrease in environmental exposure and burdens.
5. An increase in energy resilience.
6. An increase in quality job creation, including job training resources for individuals.
7. Commercialization of gas capture technology systems at flare sites in North Dakota.
8. Data on the ability of the Venturi System and the abilities of gas capture technology with more technology advancements. The greater understanding, adoption, and training on this kind of innovative technology will lead to job growth and economic benefits.

Facilities, Resources, and Techniques to be used

FCS is supplied with equipment and skilled workforce for the installation and maintenance of the variety of technologies involved in gas capture systems. FCS has 11 full time employees who, in combination, have the skill and expertise to complete the project. Key participants: Bernie is the head engineer and will help create and review final plans for the VS. He will also do most of the analyses to optimize VS performance, Mitch will lead the team in the project implementation, operations, and maintenance. Andrew, the head generator mechanic, will manage the operations and maintenance of the generator (refer to Appendix B for employee background). The company has connections with local subcontractors that have worked in partnership with FCS on other projects; FCS will utilize local oil field supply companies for routine maintenance and adjustments. FCS is well connected in the industry and is open to utilize new subcontractors, as is applicable. Jesse Fredericks, principal investigator, will manage the program, and he is responsible for managing additional outsourced support for the project. FCS has and will continue to maintain the environmental, safety, and economical standards of the oil and gas industry that are routinely upheld through training and management oversight. FCS has access to the Venturi System designs and can begin manufacturing upon funding approval (see Appendix E: Technology Diagrams). H2E's manufacturing facility will be used to build the Venturi System.

Environmental and Economic Impacts while Project is Underway

Through FCS innovative gas capture systems this initiative aims to mitigate flaring, reduce waste, enhance community benefits by producing usable gas resources for the community's utilization that was a previously harmful gas byproduct. Our enabling technology research and development project will further improve the efficiency, adaptability, and cost-effectiveness of current gas capture systems.

Our research and development project of incorporating new enabling technology displays FCS ability to develop adaptable technology that is innovative to the needs of the Bakken oil field. The greater environment and North Dakota communities suffer from excessive high and low volume flaring sites, which our company is capable of managing. The new enabling technology brings new opportunities for low volume gas capture at a much lower cost. This project will become self-sustaining as we increase its efficiency and give us the opportunity to begin to commercialize it. The long term impacts of this technology will decrease the cost of gas resources in the area, making it more affordable for the community and improving air quality through mitigation of natural gas release into the atmosphere.

Ultimate Technological and Economic Impacts

Our project proposes an opportunity for the oil and gas industry to support innovative, advanced technology that will benefit rural North Dakota through increased safety, decreased costs of gas, and enhanced environmental protection. Additionally, if the Venturi System becomes a widely used technology to capture C3+ rich gas from the tank vapors, it creates jobs throughout the oil and gas and manufacturing industries throughout North Dakota and the US. First, companies like DNOW will be able to manufacture more horizontal ESP's. Midstream companies like FCS will be able to grow and hire more people. We truck the NGL's to market on a weekly basis per site, so the need to hire more truck drivers will grow. Gas processing plants will grow, be able to hire more people, and send more raw materials to manufacturers across the US, which in turn will be able to make more final products and grow. This technology has the potential to create more jobs down the whole chain, from production to final products.

The Venturi System offers an improved alternative to using a VRU. With the Venturi System, the heat is efficiently managed as it is absorbed into the saltwater and transferred into the condensates. This means the system remains clean and efficient, unlike the VRU, which can lead to system washouts. As a result, we expect the Venturi System to operate more reliably and efficiently. The more efficient these systems become, the more incentivized both the community and the oil and gas industry will be to adopt them, leading to broader benefits for the community, all parties involved, and the environment. Because of the science behind the venturi effect, this technology will go beyond gas capture into carbon capture technologies. The science is very promising, and FCS looks to help lead the way in using similar Venturi Systems for carbon capture. This project will give us the base knowledge and experience with Venturi Systems to go beyond more efficient gas capture technologies.

Why the Project is Needed

Low pressure flares have minimal monitoring and requirements, so are often overlooked, but they add up to make a negative impact from GHG emissions and are a wasted resource that have potential to be used for local communities in the area and the wider US. Negative environmental impacts associated with previous energy development in the area includes air pollution, land degradation, and the wasteful burning of valuable natural gas. The combustion of fossil fuels, such as the oil extracted from regions like the Bakken, releases emissions into the atmosphere, contributing to climate change. Air pollution from flaring and industrial operations is harmful to human health. Tran et al. found that emissions due to flaring in areas with high flaring intensity, including ND, were attributed to increase in premature deaths, childhood asthma exacerbations, childhood asthma emergency department visits, and respiratory hospitalizations due to PM2.5, NO2, and ozone compared to areas with baseline emissions (2024). In another study by Blundell and Kokoza, flaring of natural gas has been identified as a likely source of increased respiratory illnesses. Research by Washington State University shows that hospital visits for respiratory issues spiked in areas with significant flaring (2022). The cost of flaring doesn't just damage the environment, it puts lives at risk. The discovery of oil and gas has revolutionized the world in terms of travel, electricity, and overall quality of life, but it has also exposed humanity to new dangers. FCS would be a proud partner in helping mitigate some of these hazards, and the quicker we can test out Venturi System and bring it to market, the more potential it has to make a significant impact in reducing emissions, protecting the community, and creating more jobs and opportunities; but like any new technology, and especially in the oil and gas industry, people tend to be very hesitant and reluctant until the new technology is proven out in the real world.

STANDARDS OF SUCCESS

The portion of the project that is to collect data on the viability and feasibility of the Venturi system implementation will be evaluated by the following metrics:

1. Manufacturing of the Venturi System with Engineering approval
    a. Within two months of the grant, the engineers have finalized plans and started the manufacturing process.
2. Venturi System deployed.
    a. Within 4-6 months after the grant is awarded, FCS has deployed the VS on an LVLP flare site.
3. Monthly system runtime increases of 5%
    a. The most important factor in our operations is runtime. When we maintain uptime, we liquify more NGL's for sale to markets. In our experience of doing other gas capture

operations on high pressure flares, typically about a 65% runtime leads to break even on cost. Anything above 65% runtime is profitable.

   b. We plan to be able to reach 65% runtime in the first month and increase 5% a month after that. So after six months, we hope to be at 95% percent runtime for the remaining 2.5 years of the project. We believe the biggest factor in our runtime will be our generator because of the simplicity of the VS. With a generator mechanic on staff, and with over a dozen other natural gas generators in operations in other applications in the oil field, we feel confident in our ability to maintain consistent runtime.
   c. We will measure our runtime based on engine hour trackers on the horizontal ESP motor and trackers on the generator to keep records. Part of the goal of this project is to prove a high runtime to take to the oil producers operating in North Dakota.

4. Gas sampling is the second best way to measure our project for efficiency and emission reductions.
   a. Reducing emissions is one of the primary objectives of this project.
      i. We will start by taking three gas samples on three separate days from the LVLP flare line before the VS is in operation as are baseline gas.
         1. In year one, once the VS is operational, we will continue to take gas samples of the LVLP flare gas (now reduced by 60-70%) to know the composition of the gas being flared. We will do this within three days after the VS is operational, then every two months after that.
         2. In year two, we will take gas samples off the LVLP flare line on a quarterly basis, and in year three, twice a year. This is because we don't expect the gas composition to change much over time. In the event it does begin to have noticeable changes, we will go back to quarterly or even by monthly.
      ii. To get exact measurements on emission reductions, we will meter the LVLP flare line.
         1. We will place a meter before and after our VS. This will tell us how much gas we capture and how much gas still goes to flare.
            a. We will keep records on a monthly basis throughout the entirety of the project. This will allow us to know how the volumes change over the course of three years. Second,

knowing the gas volumes alongside the gas compositions from sampling, we be able to get nearly exact emission reductions on a monthly, yearly basis, as well as nearly exact emission reduction numbers by the end of the project.

iii. There are minor adjustments we can make to get better market quality gas.

1. This includes making minor pressure and saltwater flow rate adjustments. These changes don't make significant differences in gas quality, but they do make some. For the six months, we will make records of the gas sample from the brought to market on a monthly basis. For the rest of year one through year three, we will keep records of gas samples brought to market on a quarterly basis.

5. Venturi System training materials and manuals in development.
   a. Year one: Learn the system and create a training manual draft to train other employees within FCS
   b. Year two: Create a formal training manual and user manual. The User manual will include what to expect in performance in all four seasons as equipment and gas behave differently in hot, warm, and cold weather.
6. Education and training on gas capture technology systems and advancements for the community.
   a. In year three, FCS will create an official report of efficiency and emissions reduction to take to other oil producers in North Dakota. There is a chance this report could be developed by year two in the event that the VS is very successful in year one, which is definitely a possibility. The report would include the low maintenance cost results of the project.

These standards of success will determine if the Venturi System is a viable technology. If FCS gets the positive results we are expecting with the VS, we anticipate many oil producers operating in North Dakota to adopt this new technology. The project standards of success will confirm that the research portion of the project is complete, and that data is used to benefit the oil and gas industry through shared information on gas capture technology advancements.

As mentioned above, the Venturi System, if successfully implemented, will have a very positive impact on the North Dakota and US economy. Right now, most tank vapors across North Dakota are being flared. This is a lost opportunity cost. By bringing this C3+ rich gas to market, we create more midstream jobs for company like ourselves, more manufacturing jobs for products like horizontal ESP, more sales jobs for these manufacturing companies, more trucking jobs who truck the liquified gas to gas plants, more trucking jobs who truck that gas from there to other markets, the need for more semi-trucks and diesel mechanics, more jobs for gas marketers, and more jobs for end-use manufacturers the use C3+'s for thousands of different applications. The upside of this technology working efficiently will have a vast reach on job creation in North Dakota.

These standards of success will be evaluated in biannual progress reports that have a review of the budget, timeline, technology development completion, and technology performance data, emission reduction data, and data on economic impacts with third party companies (i.e., NGL trucking companies, ets.) We are excited to share this information with NDIC, producers in the oil and gas industry, and eventually the great oil and gas industry. FCS believes the Venturi System is a very promising new technology.

BACKGROUND/QUALIFICATIONS

FCS has a successful background in gas conditioning, compression, NGL recovery; power generation, and data mining; and we're quickly expanding our reach into gas lifts, gas to grid projects, compressed natural gas (CNG); and low pressure tank gas. Our company's adaptable and highly skilled team is capable of managing and completing this project proposal as they have with over 9 other projects of similar characteristics and demands. Biographical sketches and qualifications of key personnel are provided in Appendix B.

MANAGEMENT

Jesse Fredericks, President, will be the Principal Investigator of the project and will be responsible for project management and planning throughout the entire duration of the project. He will manage the timeline of the project, to ensure that the objectives and outcomes are met from this project. Jesse will assess that the project is in alignment using: monthly budget tracking; monthly field site management reports, monthly community meetings with educational discussions of the oil and gas industry and the innovative work FCS is doing under the grant, regular communication and collaboration with O&G producers and midstream operators, and adherence to timeline dates for corresponding tasks.

FCS has delivered complete combined gas capture system projects to 4 partners in the past 2 years. Jesse has successfully managed the deployment of each of these projects within the budget and time proposed to partners. He has done this through good planning, a great staff, and from over a decade of experience in the oil field. Jesse's history of successful project management endorses his ability to effectively manage this project.

Bernie Claydon, Lead Engineer, will review the engineering of the new technology and make adjustments as feedback is received. He will review data collected about the technology performance during field testing to determine what alterations need to be made and any improvements that could be made.

Mitch Hopperstad, Lead Operator and Technician, is assigned to daily managing, collecting data for optimization for development, and keeping records and logs for the Standards of Success. He will develop training programs, manuals for training, manuals, for the new technology for employees and operators working with FCS.

TIMETABLE

Month 1: FCS engineer to review plans for Venturi System

Month 1-4: Manufacture/build Venturi System for our specific site requirements. DNOW to manufacture the horizontal ESP for site requirements.

Month 4: Deploy Venturi System on LVLP site

Month 4-14: Operator site visit, twice a day. Engineer site bi-weekly site visit. Collect and implement data from Standard of Success Year 1 above. Biannual report 1 and 2. Go from 65% runtime to 95% runtime.

Month 15 - 27: Operator site visit, once a day. Engineer monthly site visit. Collect and implement data from Standard of Success Year 2. Biannual report 3 and 4. Training and operation manuals complete. Maintain 95% runtime.

Month 28 - 40: Operator site visit, every other day. Engineer bi-monthly site visit, Collect and implement data from Standard of Success Year 3 above. Biannual report 5 and 6. Final project report. Maintain 95% runtime.

BUDGET

Project Cost	NDIC's Share	Applicant (FCS) Share	Total
Manufacturing, materials, deployment, labor	$729,640		
Labor (in-kind contribution)		$488,938	
Cash Contribution		$240,702	
Total Project Cost	$729,640	$729,640	$1,459,280

See detailed budget breakdown in Appendix C.

Budget Justification

FCS is a newly formed company that has only been in operations for about 2 years. Because we are a newly formed private company, we have very limited resources. We have confidence we can raise the $240,702 of cash we need to contribute to this project, but anything much higher above that, would become unfeasible at this point in our company's capacity. We are grateful to have been introduced to this new technology and now just need additional funding to help bring it to market. As mentioned above, high performance venturi's are used in other applications, but to the best of our knowledge, this would be the first use in this application potentially in the world, but for sure in the United States. This is a very exciting opportunity! We feel very justified in the amount we're asking for. To be able to deploy a gas capture system with a generator, plus maintenance parts and labor for both, plus pay to staff an engineer, management, and operator crew for three years, all for under $1,750,000 is unheard of in the gas capture industry. The operator expenses decrease drastically by year three as well. By the time we launch the second Venturi System and feel confident in the remote monitoring, we hope to bring the overall cost of this same package, plus staff expenses for three years, closer to $1,500,000. This has the potential to revolutionize the way oil and gas operators across North Dakota handle their tank vapors.

CONFIDENTIAL INFORMATION

No confidential information is included in this application. Confidentiality regarding research activity conducted under the program is handled in separate agreements between FCS and industry partners.

PATENTS/RIGHTS TO TECHNICAL DATA

No patentable technologies are expected to be created during this work.

TAX LIABILITY

Fredericks Custom Solutions has no outstanding tax liability to the State of North Dakota nor any of its political subdivisions.

STATUS OF ONGOING PROJECTS

Fredericks Custom Solutions has not previously been awarded an OGRP funding and does not have any ongoing funded projects.

APPENDIX A: Bibliography

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APPENDIX B: Biographical Sketches

Name: Bernie Claydon
Position Title: Lead Engineer

Primary Organization & Location: Fredericks Custom Solutions LLC

Professional Preparation (educational)

Previous Organization(s) and Location(s)	Degree (if applicable)	Receipt Date (MM/YYYY)	Field of Study
South Alberta Institute of Technology	Bachelors	1965-1987	Petroleum Engineering Technology {honors}
Fairview Vocational College	High School Matriculation {honors}	1983-1984	Matriculation
		2013	International Well Control Forum – Supervisor Well Control
		2013	IADC WellCap Supervisor
		2011	Project One Management
		2011	IADC Rig Pass / SafeStart
Shell Training Centre, Vancouver, B.C., Canada		1996	Shell Canada Retail Management Training Program
Robert Gordon's Institute of Technology, Aberdeen, Scotland		1990	Offshore Survival Training
Halliburton Services Ltd. Technical Centre, Calgary, Alta., Canada		1985-1987	Laboratory Technician Trainee

Appointments and Positions (professional)

Start Date – End Date	Appointment or Position Title, Organization, and Location
2022-Present	Engineer, Fredericks Custom Solutions, Mandaree, ND
2018-2022	Consulting Engineer, MESSCO
2014-2018	Consulting Engineer, Business & Technology Development, Drilling Optimization, NeftServiceHolding, LLC Perm, Russia
2012-2014	Drilling, Workover and Intervention Specialist/Superintendent, Baker Hughes Integrated Operations, Dubai, UAE
2011-2012	Group Product Line Manager, Weatherford, Algeria
2008-2011	Coiled Tubing Drilling Technologies Development Manager, Weatherford Dubai, UAE

2006-2008	Drilling Engineer & Workover Specialist, TNK-BP, Buzuluk, Russia
2004-2006	Coiled Tubing Drilling Engineer / Supervisor, SurgutNeftGaz, Surgut, Russia
2002-2004	Field Manager/Supervisor, BJSP, Hassi Messaoud, Algeria
1999-2002	Wellsite/Coil Tubing Supervisor, Cancoil Services, Calgary, Alberta, Canada
1996-1999	Business Owner, Golden Shell / Circle K, Golden, B.C., Canada
1994-1996	Business Development, Highland Corod Inc., Nisku, Alberta, Canada
1993-1994	Corrosion Technologist, CET, SaskOil Inc., Regina, Saskatchewan, Canada
1990-1993	Well Service Supervisor, Dowell Schlumberger Inc., Aberdeen, Scotland
1988-1990	Petroleum Technologist, CET, Canadian Fracmaster, Red Deer, AB., Canada
1984-1988	Petroleum Technologist, CET, Halliburton Services, Alberta

Products (Products Most Closely Related to the Proposed Project)
Bernie was assigned to expand on the NGL project and assist with R&D for additional flare and fugitive gas mitigation projects. The first NGL Unit was successfully manufactured and deployed in August 2018 for a major producing company. By mid 2019, 9 NGL units had been manufactured and deployed to the field under contract with 3 of the largest producers operating in North Dakota.

Bernie has developed a product specifically for the Colorado market to address the regulators requirements for mitigation of surface casing natural gas leaks and pressure buildup. This product has been well received and the business annual revenue has grown from zero to in excess of $1.5 million dollars to date.

Name: Jesse Fredericks
Position Title: President

Primary Organization & Location: Fredericks Custom Solutions LLC, Mandaree, ND

Professional Preparation (educational)

Previous Organization(s) and Location(s)	Degree (if applicable)	Receipt Date (MM/YYYY)	Field of Study
Fort Lewis College			Exercise Science
McPherson College			Biology

Appointments and Positions (professional)

Start Date – End Date	Appointment or Position Title, Organization, and Location
2022-Present	President, Fredericks Custom Solutions, Mandaree, ND
10/14-2/16	Flowback Foreman, Pale Horse Services, Mandaree, ND
9/13-9/14	Derrickhand, Unit Drilling, North Dakota
7/10-6/13	Derrickhand, H&P Drilling, New Town, ND

Products (Products Most Closely Related to the Proposed Project)

Other Significant Products, Whether or Not Related to the Proposed Project

Other Qualifications
Jesse has worked in the Oil and Gas Industry since 2009. With experience on both the drilling and production side of the industry, Jesse has a diverse skill set that allows him a unique perspective when assessing the landscape of the industry.

Alongside his team, Jesse has successfully brought the latest and greatest technologies to the Oil & Gas and Energy industries, thereby enhancing the efficiency, economics, and environmental sustainability of his partners' projects. By founding FCS, a gas capture and flare mitigation company based on the Fort Berthold Indian Reservation in Western North Dakota, operating in the Williston Basin, he has effectively prevented the waste or underutilization of natural gas assets through a diverse and holistic approach to pipeline alternative gas capture. Jesse’s vision has led the company to leverage a comprehensive suite of technologies including Gas Processing, Gas Conditioning, Gas Compression, Power Generation, Data Mining (BTC), Liquified Natural Gas (LNG), Compressed Natural Gas (CNG), Low Volume/Low Pressure Flare Capture (LV/LP), and Emissions Monitoring and Reporting Equipment. The outcome of these combined technologies is successfully captured and utilized natural gas assets. Additionally, he has provided niche technology services to Producers, aiding them in meeting increasingly stringent regulatory requirements and environmental standards.

Name: Mitch Hopperstad
Position Title: Technician

Primary Organization & Location: Fredericks Custom Solutions LLC

Professional Preparation (educational)

Previous Organization(s) and Location(s)	Degree (if applicable)	Receipt Date (MM/YYYY)	Field of Study
University of Colorado	Bachelor of Science	05/2012	Economics

Appointments and Positions (professional)

Start Date – End Date	Appointment or Position Title, Organization, and Location
2021-Present	Technician, Fredericks Custom Solutions, Mandaree, ND

Other Qualifications

Mitch's years of experience in the Bakken oil field developing and implementing our gas capture and mitigation strategies had allowed him to gain a holistic understanding of the industry, the technology available, and the needs to improve the gas management issues in North Dakota.

APPENDIX C: Budget Details

System Labor Cost (Including Deployment)	NDIC's Share	Applicant (FCS) Share	Total
Manufacturing High Performance Venturi System & Overhead	$90,000		$90,000
Manufacturing 3-Phase Separator	$10,000		$10,000
Initial Engineering Consulting Fees		$10,000	$10,000
Year 1: Engineering & Truck Fees (Bi-weekly site visits)		$15,600	$15,600
Year 2: Engineering & Truck Fees (Monthly site visits)		$7,200	$7,200
Year 3: Engineering & Truck Fees (Bi-monthly site visits)		$3,600	$3,600
Year 1: Operator & Truck Fees (Two site visits per day)		$193,450	$193,450
Year 2: Operator & Truck Fees (One site visit per day)		$96,725	$96,725
Year 3: Operator & Truck Fees (Site visit every other day)		$48,363	$48,363
Project Management and Compliance Fees (3 years)		$30,000	$30,000
Training Programs, Manuals, Emissions research (3 years)		$9,000	$9,000
Generator Mechanic & Truck Fees, general and non-engine parts (3 years)		$45,000	$45,000
Generator Mechanic & Truck Fees, engine top-end and turbo (3 years)		$20,000	$20,000
Labor Costs for Deployment of Trucking and Electricity. See Appendix D.	$20,352		$20,352
Labor for Deployment of Piping. See Appendix D.		$10,000	
Total Labor Cost	$120,352	$488,938	$609,290

Venturi System Material Budget			
Product	NDIC's Share	FCS Share	Cost
Horizontal ESP Package			$225,000
High Performance Venturi Package, 3-phase sep. included			$200,000
NGL Storage Vessel, 18,000 gal			$125,000
CAT 200 kW Natural Gas Generator			$200,000
Heavy Duty Engine Oil (870 gal - 3 years)			$12,000
Engine Top End Replacement (20,000 hours)			$30,000

Engine Turbo Replacement (20,000 hours)			$4,000
Water pump, oil pump, actuators, alternators, belts (3 years)			$8,000
Spark plugs, ignition coils, oil filters, air filters (3 years)			$9,000
Materials for site Deployment (See Details in Appendix D)			$36,990
Total Material Cost	$609,288	$240,702	$849,990

Deployment Cost: Materials and Labor			
Deployment Material Cost Breakdown	Price Per Unit	Quantity	Total Cost
2' pipe skd. 80	$14.08/ft	200 ft	$2,816
1" pipe skd. 80	$7.86/ft	200ft	$1,572
4" pipe skd. 80	39.34/ft	100 ft	$3,943
4" Hammer Union fig. 200	$78.14	22	$1,719.08
2" Hammer Unions fig. 200	$17.10	60	$1,026
1" Hammer Union fig. 200	$10.47	40	$418.80
1" Back Pressure Valve (Storage vessel)	$500	1	$500
4" T's skd. 80	$127.08	8	$1,016.64
2" T's skd. 80	$21.78	20	$435.60
1" T's skd. 80	$7.49	14	$104.86
1" Ball Valve	$41.01	3	$123.03
2" Ball Valve	$142.29	3	$426.87
4" Ball Valve	$234.29	1	$234.29
1" Check Valve	$73.30	3	$219.90
2" Check Valve	$136.40	3	$409.20
4" Check Valve	$265.12	1	$265.12
1" x 3" nipples	$1.71	54	$92.34
2" x 3" Nipples	$4.72	72	$339.84
4" x 3" Nipples	$25.81	28	$722.68
1/2" needle valve	$17.37	12	$208.44
1/4" needle valves	$18.40	6	$110.40
1/2" plugs	$1.18	6	$7.08

3/4" plugs	$1.54	14	$21.56
Pipe stands	$75	40	$3,000
Electric copper wire (Generator to ESP - Length is site dependent)			$15,000
Material Total Cost			$34,733.00
ND State Tax (6.5%)			$2,257.65
Material Total Cost (with Tax)			$36,990.65
Deployment Labor Cost Breakdown Cost			Cost
FCS Pipe fabrication and install			$10,000
Trucking fee			$10,000
Winch Tractor fee			$1,500
Electric Install heat trace and insulation ($35/ft)			$7,000
Total Cost			$28,500
ND State Tax (x 6.5%)			$1,852.50
Total Cost (with Tax)			$30,352.50
Grand Total Materials and Labor (with taxes)			$67,343.15

Deployment materials and labor budget are included within the first two tables. This third table holds a further detailed breakdown of the cost of our deployment.

APPENDIX D: Tank Vapor Gas Samples

SPL

Certificate of Analysis

Williston Laboratory
5057 Owan Industrial Park
Unit 5
Williston, ND 58801

HC Hatfield
Moneyhun Equipment Sales & Services
, ND

Mar. 30, 2022

Sample Point: Storage Vapor (Dirty NGL)

Analyzed: 03/30/2022 10:36:26 by SPL

Sampled By: Greg B
Sample Of: Gas Spot
Sample Date: 03/29/2022
Sample Conditions: 150 psig, @ 32 °F
Method: GPA 2286

Analytical Data

Components	Mol. %	Wt. %	GPM at 14.696 psia		
Hydrogen Sulfide	0.0000	0.0000		GPM TOTAL C2+	18.198
Nitrogen	0.8042	0.6812			
Carbon Dioxide	0.8820	1.1738			
Methane	35.5751	17.2578			
Ethane	30.9700	28.1597	8.3415		
Propane	7.4293	9.9063	2.0613		
Iso-Butane	5.2234	9.1804	1.7215		
n-Butane	19.0208	33.4302	6.0393		
Iso-Pentane	0.0784	0.1710	0.0289		
n-Pentane	0.0129	0.0281	0.0047		
n-Hexane	0.0004	0.0010	0.0002		
Cyclohexane	0.0003	0.0008	0.0001		
Hexanes	0.0006	0.0015	0.0002		
Heptanes	0.0011	0.0033	0.0005		
Methylcyclohexane	0.0005	0.0015	0.0002		
Benzene	0.0001	0.0002	0.0000		
Toluene	0.0001	0.0003	0.0000		
Ethylbenzene	0.0000	0.0000	0.0000		
Xylenes	0.0001	0.0003	0.0000		
Octanes	0.0003	0.0010	0.0002		
Nonanes	0.0004	0.0016	0.0002		
Decanes Plus	0.0000	0.0000	0.0000		
	100.0000	100.0000	18.1988		

Calculated Physical Properties	**Total**
Calculated Molecular Weight	33.07
GPA 2172 Calculation:	
Calculated Gross BTU per ft³ @ 14.696 psia & 60°F	
Real Gas Dry BTU	1906.9
Water Sat. Gas Base BTU	1874.6
Relative Density Real Gas	1.1525
Compressibility Factor	0.9904

Data reviewed by: Amber LaBelle, Laboratory Technician

Quality Assurance: The above analyses are performed in accordance with ASTM, UOP, GPA guidelines for quality assurance, unless otherwise stated.

Page 1 of 1

Certificate of Analysis

Williston Laboratory
3111 1st Ave W
Williston, ND 58801

HC Hatfield
Hatfield Energy Consulting
478 Granite Circle
Chuluota, FL 32766

July 06, 2023

Method:	GPA 2286	Sampled By:	Steve White
Analyzed:	07/03/2023 12:09:06	Sample Of:	Gas Spot
		Sample Date:	06/29/2023 15:50
		Sample Conditions:	.42 psig, @ 110.5 °F

Analytical Data

Components	Mol. %	Wt. %	GPM at 14.696 psia		
Hydrogen Sulfide	0.0030	0.0022		GPM TOTAL C2+	26.993
Nitrogen	6.3636	3.8468			
Methane	4.8057	1.6636			
Carbon Dioxide	0.1936	0.1839			
Ethane	20.3713	13.2181	5.5409		
Propane	35.1553	33.4516	9.8503		
Iso-Butane	4.6322	5.8098	1.5417		
n-Butane	16.2155	20.3377	5.1992		
Iso-Pentane	2.7592	4.2958	1.0263		
n-Pentane	3.8316	5.9654	1.4126		
Hexanes	1.6270	3.0255	0.6790		
n-Hexane	1.2439	2.3131	0.5202		
Benzene	0.0870	0.1466	0.0248		
Cyclohexane	0.4572	0.8303	0.1582		
Heptanes	1.7298	3.7403	0.8117		
Methylcyclohexane	0.2880	0.6102	0.1177		
Toluene	0.0534	0.1062	0.0182		
Octanes	0.1659	0.4089	0.0864		
Ethylbenzene	0.0010	0.0023	0.0004		
Xylenes	0.0044	0.0100	0.0017		
Nonanes	0.0108	0.0299	0.0062		
Decanes Plus	0.0006	0.0018	0.0004		
	100.0000	100.0000	26.9959		

Calculated Physical Properties	**Total**	**C10+**
Calculated Molecular Weight	46.34	142.28
GPA 2172 Calculation:		
Calculated Gross BTU per ft³ @ 14.696 psia & 60°F		
Higher Heating Value, Real Gas Dry BTU	2571.1	7742.9
Water Sat. Gas Base BTU	2527.6	7607.8
Relative Density Real Gas	1.6309	4.9126
Compressibility Factor	0.9807	

Data reviewed by: Curtiss Kovash, Laboratory Director

Quality Assurance: The above analyses are performed in accordance with ASTM, UOP, GPA guidelines for quality assurance, unless otherwise stated.

APPENDIX E: Technology Diagram