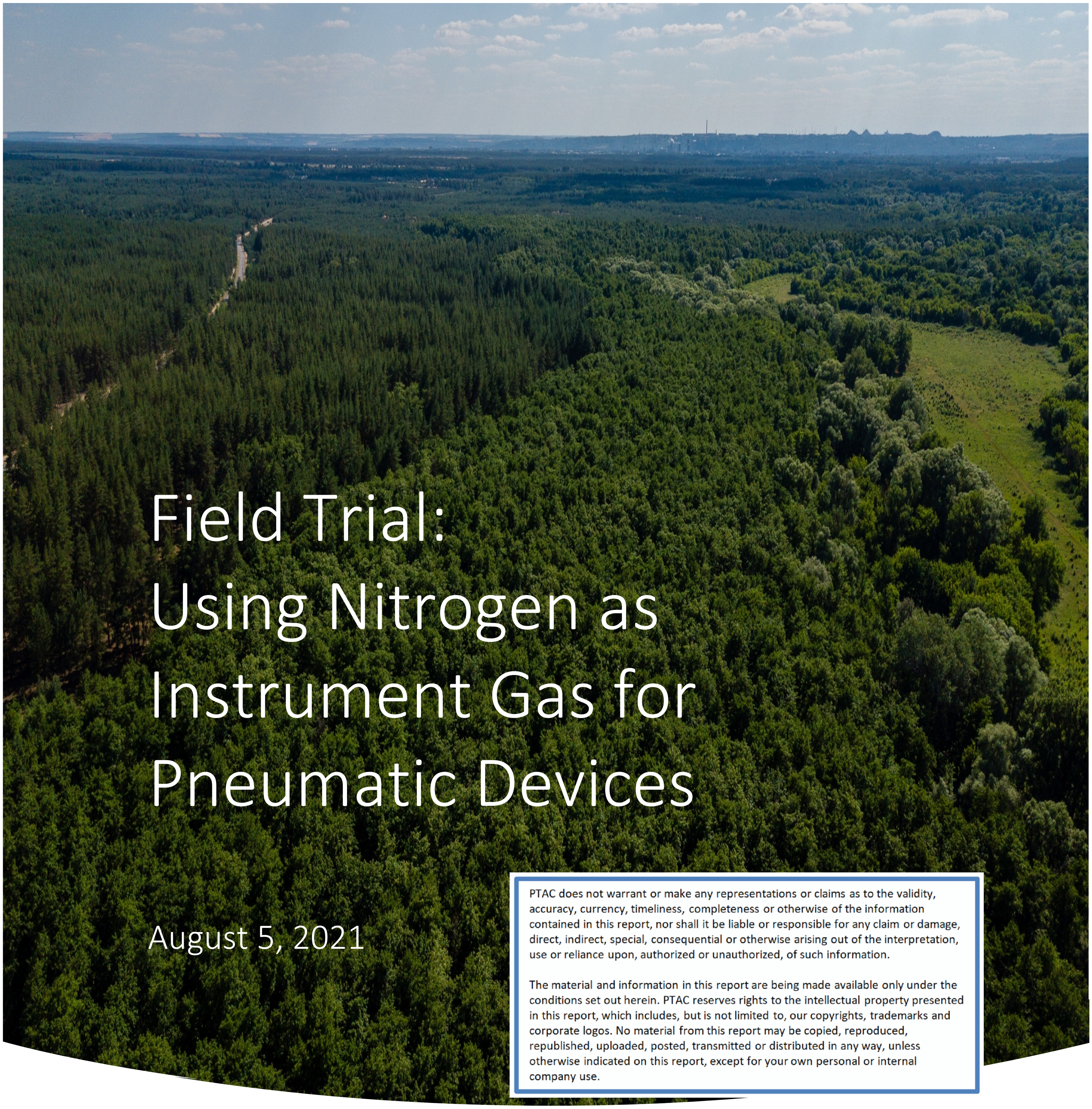

# Field Trial: Using Nitrogen as Instrument Gas for Pneumatic Devices

August 5, 2021



KATHAIROS™

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## EXECUTIVE SUMMARY

In October 2020, Velvet Energy conducted a seven-month trial of two liquid nitrogen-based instrument gas systems at Rosevear near Edson, Alberta. A subsequent one-month trial of a "commercial ready" system was conducted at the same location. The Kathairos units reliably and efficiently eliminated all greenhouse gases associated with the routine venting of methane from pneumatic devices, while not generating any onsite emissions of their own. Nitrogen displaced 37,779 $Sm^3$ of methane that would have otherwise been vented, which is equivalent to 523 tonnes of $CO_2$ or 114 cars on the road for one year. The success of this trial validates nitrogen as a viable alternative to fuel gas, allowing Velvet Energy and other upstream producers to quickly and confidently convert sites to zero emissions.

This report provides an overview of the technology, as well as a detailed explanation of the installation, operations, costs and emissions reductions associated with the field trial.

## HIGHLIGHTS

- 523 tonnes $CO_2$ equivalent eliminated over an eight month period (valued at $21,000 at $40/tonne carbon pricing)
- Demonstrated the effectiveness of nitrogen to eliminate methane venting from pneumatic devices
- Six months continuous operation of demonstration units; no operator involvement required
- Four weeks continuous operation of a commercial unit; no operator involvement required
- Refined and optimized digitized telemetry systems
- Monthly emissions reports submitted to Velvet Energy
- Successful verification and registration of the carbon offsets generated through the trial
- $2,700 saved in fuel gas recovery (at $2/MMbtu)
- Nitrogen approved for use by Alberta Environment and Parks in the quantification of emission offsets
- Proves to be more cost effective than all other solutions

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*"It's simple, reliable, repeatable and effective – allowing us to quickly convert all sites to zero emissions."* - *Scott James, VP Velvet Energy*

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# BACKGROUND

Since inception, Velvet Energy's approach to sustainability has focused on its people, the communities where they work, and the environment. In the last four years, Velvet's production has increased by 69%. However, their direct emissions intensity has *dropped* 14% over this period and their methane emissions intensity has dropped by 18%. As part of its environmental, social and governance (ESG) leadership, Velvet has commissioned several initiatives to 1) eliminate methane emissions at well sites, 2) minimize impact on water sources and 3) limit surface land footprint.

FIGURE 1: LOCATED NEAR EDSON, ALBERTA, VELVET'S ROSEVEAR SITE ENCOMPASSES 4 PRODUCING WELLS

In order to compare various emissions elimination technologies side-by-side, Velvet Energy conducted field trials of Kathairos' nitrogen system, an air system, and a solar-electric conversion in late summer 2020. The field trial was supported by the Petroleum Technology Alliance Canada (PTAC) and the Canadian Emissions Reduction Innovation Network (CanERIC). Two nitrogen demonstration units ("demo units") were installed and commissioned at Rosevear, Alberta (LSD 03-31-053-15W5) on September 24, 2020 and put into service on

September 30, 2020.  Initially both demo units supplied nitrogen to a new “greenfield” well (16-06), however in early November two older “brownfield” wells (08-01 & 12-06) were added.  For the remainder of the test, the first demo unit supplied nitrogen exclusively to 16-06 and the second demo unit supplied nitrogen to 08-01 and 12-06.

In May 2021, the demo units were decommissioned and a one-month trial of a 3000L “commercial ready” unit was initiated. This unit supplied nitrogen to all three wells (16-06, 08-01 and 12-06).

# TECHNOLOGY AND DESIGN

## Technology

Nitrogen constitutes 78 percent of the air we breathe and is a not a greenhouse gas. Since nitrogen is separated from air and is ultimately released back to air, it is abundant in supply. Nitrogen is non-toxic, non-corrosive, non-flammable and waterless, making it the ideal candidate to replace gas used by pneumatic devices.

Liquid nitrogen becomes gas naturally when exposed to temperatures above -196°C, such as everyday temperatures (even during winter). When stored in a tank, liquid nitrogen builds pressure rapidly as it becomes gas. Using basic thermodynamic principles, Kathairos’ patent pending technology vaporizes prescribed amounts of liquid nitrogen at required pressures. The gaseous nitrogen is then delivered to pneumatic devices at the temperature, pressure and quantities required for normal operations. Similar to the industrial gas and commercial propane industries, after several weeks the tank is refilled by a delivery truck.

## Design

The Kathairos units are designed for long-term storage of liquid nitrogen and operation is automated to maintain set pressure and flow. The storage tanks are comprised of an alloy steel inner vessel encased in an outer vacuum shell. The insulation system between the inner and outer vessels consists of composite insulation and high vacuum to ensure liquid retention times in excess of 120 days. The insulation system, designed for long-term vacuum retention, is permanently sealed at the factory to ensure vacuum integrity. Two exchangers, a pressure build and an ambient vaporizer, convert liquid nitrogen to nitrogen gas though heat exchange with ambient air.  The ambient vaporizer also heats the nitrogen gas to ambient temperatures. The system is comprised of several primary plumbing circuits (Figure 2), as described below.

### Fill

The unit is furnished with a top and bottom fill line so the driver can control the tank pressure while filling.  The driver controls the pressure in the tank during filling by adjusting the flow through the top and bottom fill valve. Product flowing into the bottom of the tank will raise the pressure and product flowing into the top of the tank will lower the pressure. Adjusting each valve properly will allow the driver to hold a consistent pressure in the tank throughout the entire delivery.

## Pressure Build System

The pressure build circuit is used to build pressure back in the tank after a delivery or to maintain pressure as liquid is withdrawn from the tank. As the tank pressure drops below the pressure build set point, the regulator opens which allows liquid to flow by gravity from the bottom of the tank, through the internal vaporization coil and back into the gas phase (top) of the tank. As more and more gas fills the space above the liquid the pressure inside the tank increases.

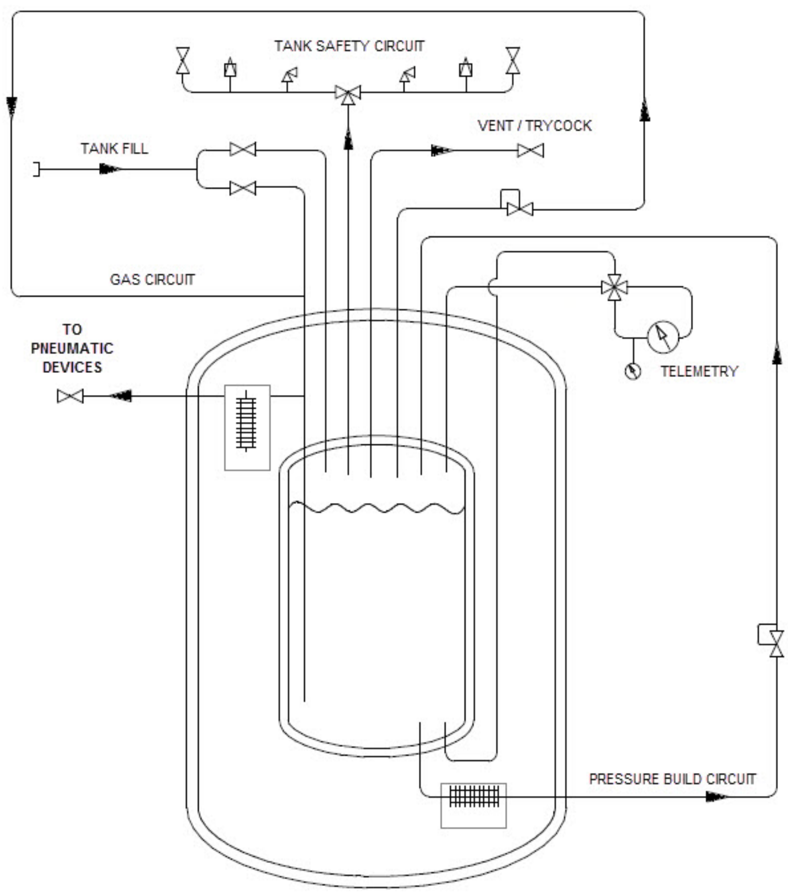



FIGURE 2: PROCESS FLOW DIAGRAM

## Economizer

The economizer circuit allows for the customer to utilize the natural heat leak that occurs in every cryogenic storage vessel. When the pressure is above the set point of the economizer regulator, it opens. This allows gas to be withdrawn directly off the headspace of the tank and travel through the internal vaporization coils, to warm the cold gas, and out the gas use valve. This will result in lowering the pressure of the tank.

## Gas Use

The gas use leverages the internal vaporizer to supply gaseous nitrogen to pneumatic devices. The unit is an on-demand systems and will supply nitrogen as required by pneumatic devices.

## Full Trycock

The full trycock is an internal line that ends inside the inner vessel at the highest level to which the vessel is intended to be filled. If this valve is opened during the later stages of filling, it will emit vapor (very cold vapor) until the liquid level reaches the open end of the line, when it will start to emit liquid. The change from vapor emission to liquid emission is both visible and audible. At this point the fill is terminated.

### Safety

The units have a tank pressure relief device, which is set at the factory. As a secondary pressure relief device, the vessel is further protected from over-pressurization by a rupture disc. The rupture disc will burst completely to relieve inner tank pressure in the event the tank relief valve fails, and pressure exceeds the rupture disc setting. The vacuum space is protected from over-pressurization by use of a tank annulus rupture disc assembly.

## Demonstration Units

In summer 2020, Kathairos constructed two full-scale demonstration units to validate nitrogen as a viable alternative to fuel gas and air to power pneumatics.  The units were designed according to pneumatic supply requirements for a typical wellsite separator package. Key components included a support base, vacuum insulated storage tank, an ambient vaporizer, automated pressure-temperature-flow control and remote telemetry.

The liquid nitrogen storage tank is a conventional vacuum insulated design, comprised of a stainless-steel vessel nested inside a carbon steel shell and a vacuum held between both vessels. Each tank's capacity is 2,520L gross (666 US gallon) with a maximum allowable working pressure of 8.9 bar (100 psig).

The ambient vaporizer, which convert liquid nitrogen to gas and heats it, are an extended fin design made from aluminum.  As pneumatic device dynamic vent rates can vary widely, an oversized exchanger was selected with a peak vaporization rate of 73.6 $Sm^3/h$ (2,600 scfh).

Moving forward with the trial, Kathairos reviewed Velvet's Process and Instrumentation Drawings (P&ID's) to ensure each device was accurately captured and high and low vent rates properly estimated.  It was determined that a demo unit had 25 times the required vent rate for well 16-06. As a result, two additional wells were added on November 8, 2021.

To provide a comfortable safety margin above the minimum pressure required to operate Velvet's emergency shutdown valves (50 psig), the demo units were automated to provide 90 psig nitrogen gas.

FIGURE 3: TWO HAND-BUILT NITROGEN DEMONSTRATION UNITS

## Commercial Unit

Kathairos' commercial units are conveniently manufactured as a compact free-standing integrated system and come in 10 different sizes of varying tank capacities (1000L - 5500L) and vaporization rates (0-170 $Sm^3/h$). The system maximum allowable working pressure (MAWP) is 24.1 bar (350 psig). The exchangers are integrated into the vacuum space, with the outer vessel acting as an extended fin, maximizing heat transfer and minimizing approach temperature to ambient. The peak flowrate of an integrated design is 38.2 $Sm^3/h$ (1350 scfh). For higher flow applications, an external "hang on" vaporizer is used, which provides peak flowrates of up to 170 $Sm^3/h$ (6000 scfh).

Units are selected based on flow requirements and optimum refill frequency. The results of the six-month trial indicated that a 3000L system with a net capacity of ~1900 $Sm^3$, would require a refill every 10-14 days during peak winter months and every 4-5 weeks during low summer months. With the peak winter vent rates well within the vaporization capability of the 3000L unit, it was selected and began trials on May 6, 2021.

FIGURE 4: 3000L COMMERCIAL UNIT

## INSTALLATION AND COMMISSIONING

The units are installed by picker truck on either a rig mat, railway ties, concrete or compacted gravel. Stainless steel tubing is typically used to tie-in to an existing fuel gas header.

At Velvet's site, the units were installed on a rig mat and ½ inch tubing was used to tie-in to their separator packages. Velvet protected one segment of under roadway buried tubing with a PVC jacket. Upon mechanical completion of the tubing runs and tie-in, the tubing connections were leak tested.

During the tubing installation, the Demo Unit's inner tank was "conditioned" to -196°C. This is accomplished by simply introducing cold nitrogen gas followed by small amounts of liquid nitrogen, until the pressure stabilizes. Once completed, the tank(s) were completely filled and the telemetry units calibrated for operation. Calibration included gauge verification, over-the-air function tests and signal strength optimization.



FIGURES 5 &6: INSTALLATION PHOTOS

Installation and commissioning of both units took less than one day. Upon receipt of a Certificate of Inspection Permit from the Alberta Boilers Safety Association (ABSA), the units were officially operating on September 30, 2020. There were no interruptions to production operations.

The commercial unit is an integrated system and lighter in weight than the demo units. As a result, the installation time was reduced by half and the footprint reduced to 3 $m^3$.

FIGURE 7: INSTALLED DEMONSTRATION UNITS

## OPERATIONS

The Velvet separator packages had a common oilfield configuration, including a condensate and water control loop, inlet and outlet pressure control, an emergency shutdown (ESD) system and two pneumatic pumps (one operating, one spare). No pneumatic end device needed to be altered or changed out to accept nitrogen. With no moving parts, no generator and no solar-battery array, the Kathairos demonstration units ran continuously for seven months with no operator support required. Since its installation on May 6, 2021, the commercial unit has also run seamlessly.

Velvet opted to install a permanent oxygen monitor in the greenfield separator building and had the operators simply use their personal monitors to check oxygen levels before entering the brownfield separator buildings (similar to routine methane check).

The only issue encountered during the trial was on October 29, 2020 a pressure relief valve leaked liquid nitrogen.  A phase transition piece was added (known as a "candy cane") and no further leaks resulted. This design improvement has been incorporated on all future designs.

There were no issues with supplying nitrogen at or near ambient temperatures.  In fact, the ambient temperature remained below freezing for 29 days in January-February and the nitrogen supply temperature to the regulators remained above zero.  Also, in late January, a two-week polar vortex blanketed much of North America, with overnight temperatures reaching as low as -45°C at Rosevear. The units operated flawlessly during this period and easily met the demand of the increased methanol pump rates.  The units were also subject to high winds, without incident. There was no theft or damage to any of the units.

FIGURE 8: DEMONSTRATION UNITS IN OPERATION DURING POLAR VORTEX

In December, it was reported that an instrument gas regulator diaphragm was leaking nitrogen. Upon inspection, the diaphragm appeared to be dried out. Swelling of Buna-N (nitrile) may occur when water molecules are present such as in saturated fuel gas. Swell induced ageing impacts the wear and sealing properties of nitrile. As nitrile's permeation resistance is only rated fair to good, nitrile will permeate small molecules like water (0.27 um) and oxygen (0.3 um), but not large molecules like nitrogen (0.31 um) and methane (0.41 um). Switching to nitrogen, which has a -196°C dewpoint, may remove permeated or trapped water molecules, potentially impacting sealing properties. This occurred on only one regulator and Velvet simply swapped the diaphragm with new material. There were no further issues. Moving forward, we recommend that instrument gas regulator diaphragms on older wells be inspected and replaced as required, with new diaphragms as part of the nitrogen system installation.

### Telemetry

To remotely monitor the two demonstration tanks, a Digi Connect modem, a Sensor2Cloud and the Bell network were used. Remote monitoring is critical to ensuring the tanks do not run out of liquid nitrogen and for determining emission reductions (next section). The level sensor (0-200 in.H20, 0-5V), manufactured by Chart Industries, uses the industry standard method for measuring cryogenic liquid level. Specifically, a differential pressure instrument connected to the top and bottom of the tank which reacts to the pressure difference caused by the weight of the liquid. Tank pressure was monitored as an additional data point. A Wika pressure sensor (0-600 psig, 0-5V) was used for pressure monitoring. Pressure and level data were uploaded to the Sensor2Cloud portal every six hours.

Kathairos began testing the integrated Anova system on December 21, 2020. This system is completely assembled and tested at the factory. It provides an advantage of an extremely accurate, fit-for-purpose Endress Hauser digital level sensor (0-100 in.H2O) and a Wika pressure sensor. The Anova system uploads hourly data, twice per date, to a portal that automatically calculates emissions reductions. The portal is accessed via computer over the web or via mobile device though an APP. The Anova unit is equipped with a local display that provides current level and pressure values.

Kathairos concluded the testing of the Digi/S2C/Bell system on March 31 and elected to proceed with Anova systems on all subsequent units. For the foreseeable future, and to aid in any unforeseen troubleshooting, the Kathairos system will still arrive from the factory with a local mechanical Wika level and pressure gauge.

## EMISSIONS REDUCTIONS

The Kathairos Solution completely eliminated methane venting from pneumatic devices at remote locations and has recently been approved in Alberta for use towards carbon credits.

One of the key benefits of the Kathairos Solution is its ability to provide extremely accurate emissions elimination data. Nitrogen has a gas equivalency ratio (GER) of 1.2762, so for each standard cubic meter ($Sm^3$) of nitrogen used, 1.2762 $Sm^3$ of methane is eliminated. By continuously monitoring the liquid level, we can accurately quantify methane emissions at site. The remote telemetry units (RTU's) upload twice per day, hourly data to a web-based portal for convenient and accurate monitoring. Monthly emissions reports were provided to Velvet that detailed vent rates, total nitrogen usage, mitigated methane emissions, sales gas recovery estimates, and carbon offset value.

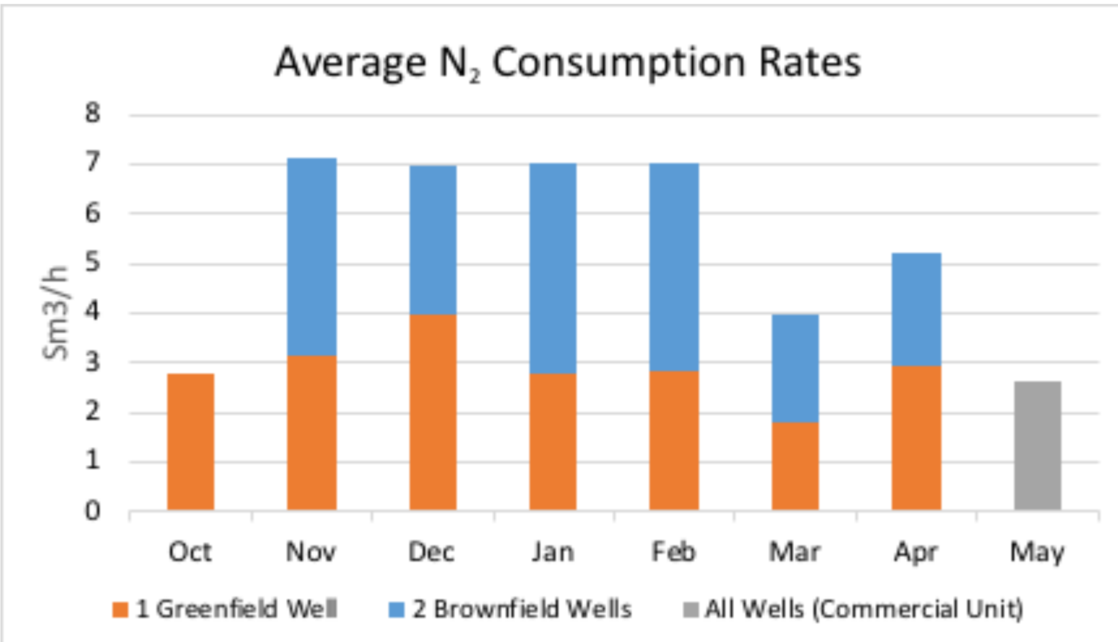



FIGURE 9

Remote well sites differ in terms of their levels of methane venting from pneumatic devices. The annual methane vent amount from a pneumatic pump depends on the make and model of pump, injection rate, plunger size, injection pressure, and the number of months per year the pump is operating. Kathairos' field pilot tested the emission rate from two brownfield wells and one greenfield well. As demonstrated in the above graph (Figure 9), average monthly vent rates changed over the course of the project duration. Average vent rates ranged from 1.08 $Sm^3/h$ on each of the brownfield wells in March 2021 to 3.99 $Sm^3/h$ on the greenfield well in December 2020.

In October, only the greenfield well was serviced, which reflects the lower total monthly nitrogen consumption rate for the month. As demonstrated in the above graph, the cumulative vent rate for the three wells was much higher in the winter (November-February) than spring. By May, average vent rates and monthly nitrogen consumption rates had fallen significantly.

Vent rates are directly related to total volumes of nitrogen consumed and amount of methane displaced. Table 1 on the following page summarizes the nitrogen consumption and methane eliminated over the duration of the field trial, from October 2020 to May 2021.

TABLE 1: NITROGEN USAGE PERFORMANCE SUMMARY

| **Demonstration Unit 1 (Servicing Greenfield Well 16-06-054-15W5)** | | | | |
|---|---|---|---|---|
| Month | Average Hourly $N^2$ Consumption ($Sm^3/h$) | Total $N^2$ Consumption ($Sm^3$) | Average Hourly Methane Eliminated ($Sm^3/h$) | Total Methane Eliminated ($Sm^3$) |
| Oct-20 | 2.80 | 1,999 | 3.57 | 2,551 |
| Nov-20 | 3.14 | 2,223 | 4.01 | 2,837 |
| Dec-20 | 3.99 | 2,969 | 5.09 | 3,789 |
| Jan-21 | 2.77 | 2,057 | 3.54 | 2,625 |
| Feb-21 | 2.85 | 1,915 | 3.64 | 2,444 |
| Mar-21 | 1.80 | 1,338 | 2.30 | 1,708 |
| April-21 | 2.93 | 1,826 | 3.74 | 2,330 |
| **Demonstration Unit 2 (Servicing Brownfield Wells 08-01-05315W5 & 12-06-054-15W5)** | | | | |
| Month | Average Hourly $N^2$ Consumption ($Sm^3/h$) | Total $N^2$ Consumption ($Sm^3$) | Average Hourly Methane Eliminated ($Sm^3/h$) | Total Methane Eliminated ($Sm^3$) |
| Oct-20 | - | - | - | - |
| Nov-20 | 4.00 | 2,112 | 5.10 | 3,450 |
| Dec-20 | 2.99 | 2,225 | 3.82 | 2,840 |
| Jan-21 | 4.25 | 3,160 | 5.42 | 4,033 |
| Feb-21 | 4.20 | 2,824 | 5.36 | 3,604 |
| Mar-21 | 2.16 | 1,608 | 2.76 | 2,052 |
| April-21 | 2.31 | 1,663 | 2.95 | 2,122 |
| May-21 | 1.37 | 86 | 1.75 | 110 |
| **3000L Commercial Unit (Servicing All 3 Wells)** | | | | |
| Month | Average Hourly $N^2$ Consumption ($Sm^3/h$) | Total $N^2$ Consumption ($Sm^3$) | Average Hourly Methane Eliminated ($Sm^3/h$) | Total Methane Eliminated ($Sm^3$) |
| 21-May | 2.64 | 1,602 | 3.37 | 2,044 |
| **TOTAL (All 3 Wells)** | | | | |
| | | | | |
| **8 Month Field trial** | | **29,608** | | **37,779** |

Table 1 above highlights the total amount of nitrogen used each month, and the corresponding tonnes of methane displaced. A total of **29,608 $Sm^3$ nitrogen was used** over the eight-month project duration.

In total, the Velvet field trial eliminated a total of 37,779 $Sm^3$ (or 20.9 tonnes) of methane from three wells. The global warming potential of methane is significantly (25x) higher than CO2 and as a result, **523 tonnes of $CO_2$ equivalent was eliminated over the eight-month project**

**<u>duration</u>**. The nitrogen units eliminated 100% of methane venting from pneumatic devices on site. Nitrogen usage decreased in May due to the two of the methanol pumps being shut in for the summer, lowering the average vent rates over the month.

There are minimal lifecycle emissions associated with the technology. Emissions occur through the production and distribution of nitrogen. For the pilot, there were minimal emissions associated with nitrogen transport, given that there was a bulk storage unit located on site. Even in a commercial setting, however, the emissions involved in the production and distribution of nitrogen make up less than 2.5% of the emissions eliminated through the solution and do not impact the total offsets generated through the project.

To generate carbon offsets through the project, the Government of Alberta approved a Deviation Request to use nitrogen for the calculation of carbon credits. An independent third party is currently verifying the offsets, which is required for the registration and serialization of offsets with Alberta Carbon Registries.

Kathairos technology has positive environmental impacts beyond its ability to eliminate greenhouse gas emissions. First, the Kathairos Solution requires no on-site power generation to operate. Second, it does not require water to operate and does not impact local water resources. The system is a self-contained system and fits easily on existing well sites, with minimal disturbance to the surrounding environment.

As demonstrated in the Velvet Energy field trial, using nitrogen as instrument gas for pneumatic devices will allow Canada's energy industry to significantly advance their environmental objectives while profiting from carbon offset revenues.

## ECONOMICS

The field trial demonstrated the economic viability of the commercial build out of the technology.

The solution's all-in costs are determined by the size of the system and volume of nitrogen consumed. The costs associated with the solution are three-fold:

1) Upfront costs are limited to **one-time tie-in costs**, which range from $2,000-$4,000 per well.

2) **The Kathairos unit** has a low capital cost (starting under $20,000), which can be paid for in the form of low monthly lease rates.

3) **Liquid nitrogen distribution** (tank refills). Because nitrogen use directly reflects the actual amount of methane being mitigated, producers can be confident that their nitrogen costs will always be lower than the value of offsets generated. Liquid nitrogen

costs decrease substantially in the summer months, when pneumatic pumps are often turned off.

There is a lifetime guarantee with no further operating costs associated with the system. The table below (Table 2) provides total yearly cost estimates for typical locations, based on average vent rates and the number of wells at location.

TABLE 2: ANNUAL COST AND CO2E REDUCTION ESTIMATES OF THE KATHAIROS SYSTEM

| Pad Configuration | Annualized Hourly Vent Rate (Sm3/h) | Vent Rate - Winter (Sm3/h) (5 months) | Vent Rate - Summer (Sm3/h) (7 months) | Total Annual Cost ($/yr) | Total Annual CO2e Eliminated (t CO2e/yr) | Total Cost per Offset ($/CO2e) |
|---|---|---|---|---|---|---|
| **SCENARIO 1 Base Case:** | | | | | | |
| 1- well pad | 2.00 | 2.70 | 1.50 | **$ 9,300** | **283** | **$ 33** |
| 2- well pad | 4.00 | 5.40 | 3.00 | **$ 17,600** | **565** | **$ 31** |
| 3- well pad | 6.00 | 8.10 | 4.50 | **$ 25,600** | **848** | **$ 30** |
| **SCENARIO 2 Low Case:** | | | | | | |
| 1- well pad | 1.22 | 2.00 | 0.80 | **$ 7,100** | **184** | **$ 39** |
| 2- well pad | 2.44 | 4.00 | 1.60 | **$ 13,300** | **367** | **$ 36** |
| 3- well pad | 3.66 | 6.00 | 2.40 | **$ 19,100** | **551** | **$ 35** |

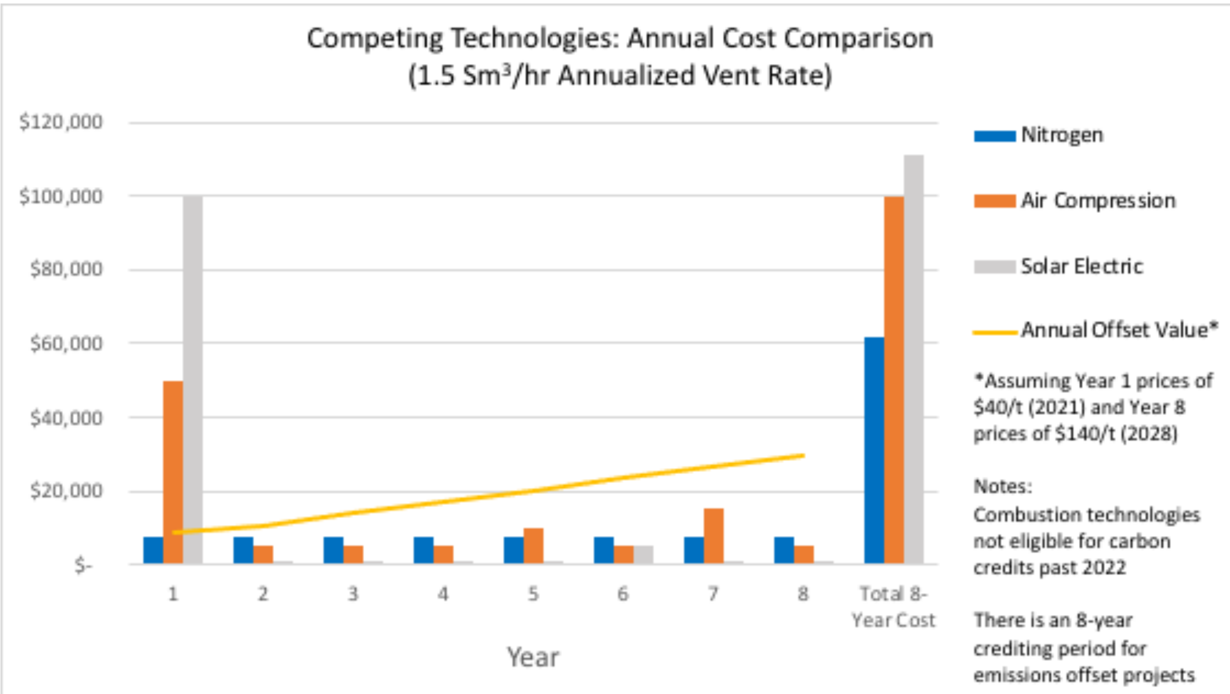
**Fuel gas venting assumed to be 90% methane*

There have been significant variations among producers as to what the actual pneumatic emission rates are from a well (hence the amount of nitrogen needed to displace the methane). The first scenario contemplates an annual, per well, vent rate of 2 $Sm^3/h$, consisting of a rate of 1.5 $Sm^3/h$ for seven months in the summer, and a rate of 2.7 $Sm^3/h$ during the five winter months when the pneumatic pump is operating. These rates are similar to those experienced on the brownfield wells of the original seven-month test of the system with Velvet Energy. The second scenario above shows a low-side sensitivity for vent rates during the winter and summer months, and their resulting operating costs. In all scenarios, the forecast carbon price results in an excess value to the producer after all costs are considered. Kathairos is able to provide location-specific cost estimates at the producer's request.

## Comparison to Existing Technologies

Compared to other emissions elimination technologies, nitrogen provides an extremely reliable and cost-effective solution. Unlike nitrogen systems, solar electric solutions are expensive, costing up to $100,000 to install single separator packages and convert pneumatic devices to electric. While Kathairos offers variable cost based on fluctuating vent rates and actual emissions eliminated, solar electric systems need to be sized for maximum vent rates. Given large upfront capital costs, there is a long payout period for these systems, and batteries and solar panels often require being replaced over the life-of-well. A nitrogen system, meanwhile, requires no parts to be replaced, no changes to existing facilities or operations, and can begin generating a profit through excess carbon credits within the first year of operation. Solar electric system batteries can also be liable to theft and may be unreliable in various weather conditions. The Kathairos units have no risk of theft and, as demonstrated through the Velvet field trial, operated flawlessly in all weather conditions, including extreme temperatures and wind speeds.

FIGURE 10




Nitrogen also presents an attractive alternative to power generation to air compression technologies, which typically require increased operator attention, need to be sized for maximum flow, produce on-site emissions and are expensive, ranging from $50,000-$150,000 (plus system tie-in) in up-front costs. Air compression systems are complicated, involving rotating parts that depreciate quickly and must be overhauled or replaced every two to four years. The Kathairos technology however, has a twenty-year depreciation and requires no new parts or operator involvement. The Kathairos systems do not require on-site power generation, which results in emissions, inefficiencies and may be unreliable. The key benefit of the nitrogen solution is its simplicity, which reinforces its reliability. As demonstrated in the Velvet field trial, nitrogen is incredibly reliable, with no system downtime or disruption to operations.

On-site combustion technology is another methane abatement solution that unlike nitrogen, is unreliable. Combustion solutions require continuous flow of fuel gas and introduce back pressure on pneumatic devices, causing failure. These systems often demand considerable operator attention, involve on-site emissions and can be costly to tie-in to each pneumatic device. A nitrogen system meanwhile, has a single line that ties directly into the fuel gas system. Additionally, while it can be difficult to accurately measure the amount of emissions eliminated through combustion technologies for carbon offset verification, Kathairos provides exceedingly simple and accurate emissions data, given that the amount of nitrogen used is directly correlated to the tonnes of $CO_2$e eliminated.

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*"Without question this is the best solution to eliminate methane emissions from pneumatic pumps" - Darrel Hughes, Bruin Pump Canada*

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## NEXT STEPS

As demonstrated through the 8-month field trial, the Kathairos Solution eliminates methane venting at remote locations simply, reliably, and affordably. Please contact one of our team members to discuss the technical aspects of this field trial and how Kathairos' technology can help advance your environmental goals while generating profits through emission offsets. Kathairos also offers producers the option of trialing the technology in order to demonstrate the simplicity and reliability of the solution prior to making a commitment.

## CONTACT

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