PROJECT SUMMARY AND OUTCOMES

RETROFITTING GAS-DRIVEN PNEUMATIC PUMPS TO REDUCE METHANE EMISSIONS IS FEASIBLE, COST-EFFECTIVE AND RESULTS IN MATERIAL GHG REDUCTIONS

Bluesource partnered with NAL Resources and Outlier Resources to optimize forty-two (42) 5100 Series Pumps. The pumps were optimized by upgrading select internal components and changing the plunger size from 3/8” to 1/2" to deliver the same amount of chemical in a more efficient way. During this exercise, vent rates were measured before and after the plunger change and component upgrades. Increasing the plunger head size of a 5100 series pump resulted in an average reduction of 37% in vented emissions across thirty-seven statistically representative pump tests. A total of 674 tCO2e emissions per year is estimated to be reduced from this project. Pump retrofit campaigns such as this can reduce methane emissions from a larger population of pumps in Albera, in a way that is economically feasible to complete.

Prepared by Blue Source Methane ULC as part of the Methane Consortia Program

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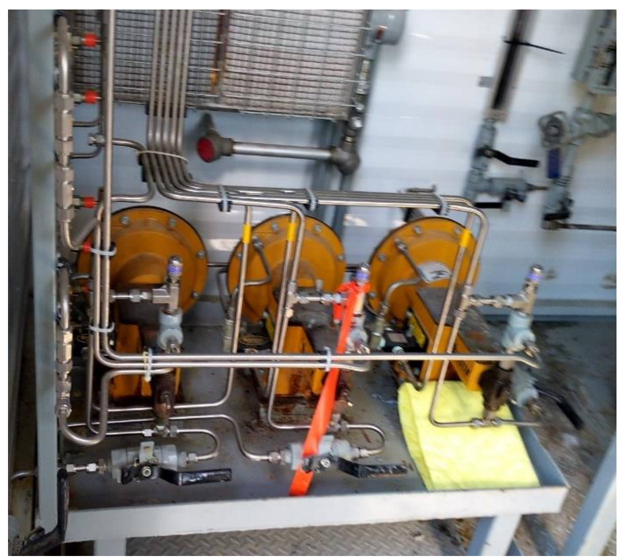
Project Summary

Many oil and gas facilities depend on pneumatic chemical injection pumps to inject assorted chemicals into pipelines and vessels to inhibit corrosion, hydrate formation, and freezing amongst other purposes. To operate, pneumatic chemical pumps depend on the readily available instrument gas on site as their power source. Since pumps are powered by instrument gas, they release greenhouse gases to the atmosphere, including methane and carbon dioxide, upon each stroke as part of their normal operating design. The revision to the Quantification Protocol for Reduction of Greenhouse Gas Emissions from Pneumatic Devices (the 'Protocol') in May 2020 provided a pathway for additional offset credit opportunities, including emission reduction projects for pneumatic gas driven chemical injection pumps that do not fall under Provincial methane regulation by removing the finite Protocol end date. Unfortunately, the economic feasibility of converting pneumatic gas driven pumps to electrified pumps, usually powered by solar, is limited by high upfront costs especially for marginally emitting pumps. As a result, many of these pumps in Alberta will not be converted, ultimately emitting a considerable amount of methane into the atmosphere for many years to come. Bluesource hypothesized that optimizing the size and configuration of a pneumatic pump, rather than its power source, could also lead to significant emission reductions. Therefore, Bluesource sought to test this hypothesis by collaborating with PTAC, Spartan Controls, PTW Energy, NAL Resources and Outlier Energy to conduct a pump optimization pilot project, with funding provided by PTAC through the Methane Consortia Program ('MCP'). Existing pneumatic pumps were optimized by changing the plunger size and upgrading internal components to continue utilizing instrument gas, but with a lower emissions footprint.

Background



Operators of oil and gas sites will set a pump to inject a certain amount of chemical per day. Each pump is equipped with a plunger, which transfers chemical from the storage tank, into the injection point. Pump manufacturers have a range of plunger sizes that are associated with each pump model. For 5100 series pumps (produced by different manufacturers, and one of the most widely utilized pumps for oil and gas producers in Alberta), there are four plunger sizes available: 3/16, 1/4, 3/8 and 1/2 inch. Pumps with smaller plungers require more strokes to achieve the target injection rate as opposed to pumps with large plungers. Each time a pump strokes, methane is vented into the atmosphere. Given the same injection rate, smaller 5100 series plungers (3/16", 1/4" and 3/8") will vent more methane opposed to a 5100 series pump with a larger (1/2") plunger as they require more strokes to complete the same injection rate. Therefore, Bluesource targeted pumps with a 3/8" plunger owing to prevalence in the field and greater injection volumes.

This PTAC Pump Optimization project included the optimization of forty-two (42) 5100 Series pumps by changing the plunger size from 3/8" to 1/2" and measuring the vent rate before and after the plunger change. By increasing the size of the plunger, the same amount of chemical may be injected but more efficiently and with fewer strokes, resulting in a reduction in vented methane. By optimizing the plunger size of 5100 model pumps (CVS, Texsteam, and Bruin), Bluesource estimated 40-50% of emissions could be reduced compared to baseline metrics.

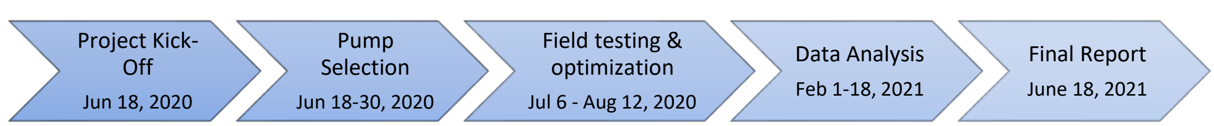
This initiative included the following vendors:

Partner	Objective
GreenPath Energy Ltd.	Field measurement of pre and post pump retrofit emissions using EMEAS skid
PTW Energy Services Ltd	Sourcing and installation of optimized pump components
Outlier Energy and NAL Resources	Pump location hosts
Bluesource Methane	Project coordination, GHG modelling and report creation
Spartan Controls	EMEAS deployment and resulting vent rate analysis and calculations
Total ($)	

The main milestones and deliverables from this project were as follows:

1. Bluesource to provide each producer with a list of candidate pumps,
2. Producer to review and provide additional data parameters where required,
3. Producer to approve pump list,
4. Combined pump list sent to PTW and Greenpath,
5. PTW and Greenpath to coordinate logistics and safety procedures with each producer,
6. PTW and Greenpath to complete the on-site pump retrofit and record the pre and post vent rates,
7. Spartan Controls to review field data, and calculate the vent rate associated with the 3/8” plunger and the 1/2” plunger,
8. All pump retrofit data and vent rate data to be provided to Bluesource,
9. Bluesource to analyze results and model the GHG reductions associated with the project,
10. Bluesource to prepare project summary and findings report.

Project Schedule



Technology Summary

Bluesource has successfully executed a large high-bleed pneumatic retrofit program in Alberta utilizing carbon finance and aggregation; whereby Bluesource inventoried over 50,000 devices and retrofitted over 11,500 controllers with 38 oil and gas producers. The program was able to accelerate the conversion of high-bleed pneumatic devices across Alberta and pull forward methane emission reductions. The program utilized advanced data management, a variety of third-party vendor partnerships, economies of scale, and efficient logistics to deploy thousands of retrofit solutions. These key factors and learnings may be translated to other emission reduction projects, forming the foundation for this Pneumatic Pump Retrofit solution.

This project targeted the large population of pumps that are still venting methane but will have neither a regulatory mandate for reduction, nor an economically feasible pathway to become electric. The opportunity to retrofit gas-driven pneumatic pumps by changing the plunger diameter and ensuring pump operational integrity with updated o-rings, packing material, check balls and springs will achieve emission reductions in a faster, cost-effective manner.

The scope of the project included a total of 42 (5100 Series) chemical injection pumps (Table 1). Of the 42 pumps retrofitted, 26 were manufactured by Bruin, 5 were CVS, and 11 were Texsteam. The results of 5 pumps were excluded due to the vent rate data appearing flawed and causing noticeable outlier implications. Based on an analysis of over 15,000 pumps from Bluesource's pneumatic inventory, the Bruin 5100 is the most common pump type in Alberta, closely followed by the Texsteam 5100 and CVS 51-Series pump. Therefore, the manufacturer sample size was chosen to represent the three most common pumps observed in the field. The plunger head for each pump was changed from a 3/8" plunger to a 1/2" plunger, as 3/8" is also the most common smaller-range plunger size.

Table 1: Summary of Pump Optimization tests completed by Producer and Pump Manufacturer.

Producer	Bruin	CVS	Texsteam	Grand Total
NAL Resources	22	2	6	30
Outlier Resources	4	3	5	12
Grand Total	**26**	**5**	**11**	**42**

Purchase and Installation Process

Once the final list of sites and respective chemical pumps were determined, Bluesource coordinated with each producer to ensure enough chemical was readily available per site to complete the tests and confirmed that the pumps being optimized met the scope of the project (5100 series pump with a 3/8" plunger).

During testing, both PTW and Greenpath met with each producer to complete the necessary safety permits and initiated testing. The 5100 series chemical pumps with 3/8" plungers were activated, if they were not running at the time due to summer chemical injection cycles, and all relevant information was recorded in an Information Test Record (see Picture 4 in the Appendix). GreenPath used an EMEAS skid supplied by Spartan Controls, which is a flow computer that compensates for temperature and pressure and logs flow rate data of the supply gas to the pump. GreenPath and PTW completed the initial baseline test to measure the vent rate of the 5100 chemical pumps with 3/8" plungers. PTW then replaced the 3/8" plunger with a 1/2" plunger, and changed other pump materials such as the fluid head, o-rings, packing material, check balls (all pump materials provided by PTW). PTW manually adjusted the pump to ensure that the injection rate of the project scenario matched the injection rate of the baseline scenario prior to retrofit using the rate gauge associated with each pump. The following parameters were recorded at the time of optimization, per pump:

- Surface LSD / Downhole UWI
- Pump Make and Model
- Plunger Head Size (inches)
- Stroke Length (inches)
- Supply Pressure (PSI)
- Injection Rate (L/D)
- Injection Pressure (PSI)
- Vent RateTest Runtime (mins)

After the field retrofits were complete, Spartan Controls synthesized and reviewed the vent rate information for the pre and post project configurations, 3/8” and 1/2” plungers, respectively. Bluesource and Spartan Controls discussed the findings and Bluesource conducted additional GHG calculations to compare the projected emission reductions with the realized results.

Emissions Profile

Projected GHG reductions

This project was anticipated to mitigate 1,600 tonnes carbon dioxide equivalent (CO_2e) annually, or 16,000 tonnes CO_2e over 10 years, assuming a 40 tonne CO_2e/year/per pump reduction and a total of 40 optimized pumps. The projections used values and coefficients from AER Reference Manual 15[1], the quantification methodology prescribed in the AEP Pneumatics Protocol, and pump inventory data during a desktop calculation exercise. The calculations used the following values to determine the emission projections:

- Pump Make/Model
- Plunger Size
- Stroke Length
- Theoretical optimized pump plunger size
- P2 Coefficient, P1 Coefficient, P0 Coefficient
- Pump Injection rate
- Chemical Injection Pressure (PSI) (kPa)
- Chemical Injection Pressure (kPa),
- Gas composition values for CO_2 and CH_4

Bluesource anticipated the following reductions from 1 Texsteam 5002, 1 Texsteam 5005 and 1 Bruin 5100, as demonstrated in the calculation summary below.

ANNUAL

Baseline Emissions			$t\ CO_2$	$t\ CH_4$	$t\ N_2O$	$t\ CO_2e$	Total (tonnes CO_2e)
SS	B7	Vented Gas	0.5397	14.9565	-	-	374.5
TOTAL			0.54	14.96	-	-	374.452
Compare to B7 Sheet Calculation							374.452

Project Emissions			$t\ CO_2$	$t\ CH_4$	$t\ N_2O$	$t\ CO_2e$	Total (tonnes CO_2e)
SS	P7	Vented Gas	0.064	1.774	-	-	44.4
SS	P9	Fuel Extraction and Processing	0.417	0.008	0.000	-	0.6
TOTAL			0.481	1.782	0.000	-	45.0409
Compare to P7/P8/P9 Sheet Calculation							45.0409

Annual Net Emissions Reductions	0.06	13.17	(0.00)	-	329.00
annual average emissions per pump (in tCO2e)					109.67 /pump

Therefore, the assumed emissions profile was as follows:

- Total Baseline emissions: 374.5 tonnes CO_2e
- Total Project emissions: 45.0 tonnes CO_2e
- Annual Net Emission reductions of all three pumps: 329.5 tonnes CO_2e
- Annual average emission reduction per pump: 109.7 tonnes CO_2e

The estimates took into consideration fluctuation in emissions from pump to pump given differing operating characteristics and seasonal operating conditions.

[1] Manual 15 Equation 14 for emission rate (m3 vent gas/L/pump), Manual 15 Equation 14 for emission rate (m3 vent gas/L/pump)^2

Findings: Realized GHG Reductions in the Project

As noted above, the annual average reduction per pump was estimated to be 40 tonnes/year, based on 3 pumps: two of which were 5000 series, and one was a 5100 series model. The pumps which were included for testing and pump optimization however were all 5100 series model pumps and all pumps had 3/8" plunger heads. While initially contemplated, stroke length modifications were excluded from the project scope as most pumps observed in the field injected chemical with a full stroke length as opposed to a half stroke length as was indicated in the initial desktop review. Therefore, the scope of the project ultimately included 5100 series pumps only, in an effort to optimize the most common pumps observed in the field. In addition, the half stroke parameter was excluded since all the pumps across the two producers were of the full stroke configuration, yielding 42 pumps in total. Understandably, these divergences from the initial proposed project scope impacted the emission reductions Bluesource expected to see.

On average, a 37% reduction in emissions was realized through the retrofit and optimization of 5100 series pumps with larger plungers. Fig. 1 illustrates the reductions per pump for the thirty-seven (37) out of the forty-two (42) tests completed. Five (5) pumps were excluded from the results as they were statistical outliers or because no vent rates were recorded during either the baseline or optimized testing periods. Prior to the field study, it was predicted that changing the plunger head on a 5100 series pump from a 3/8" to a 1/2" would reduce the vent rate of a pump by approximately 40% to 50%. The measured results from the project yielded a percent reduction range of 30% to 45%, based on the 25th and 75th Quartiles of the thirty-seven (37) recorded reduction tests (Figure). The variance between the estimated and field calculated reductions may be attributed to the age, mechanical condition, supply and injection pressure variation, configuration of the pump, the exclusion of the 5000 series models, and variance in the assumed versus actual injection rates.

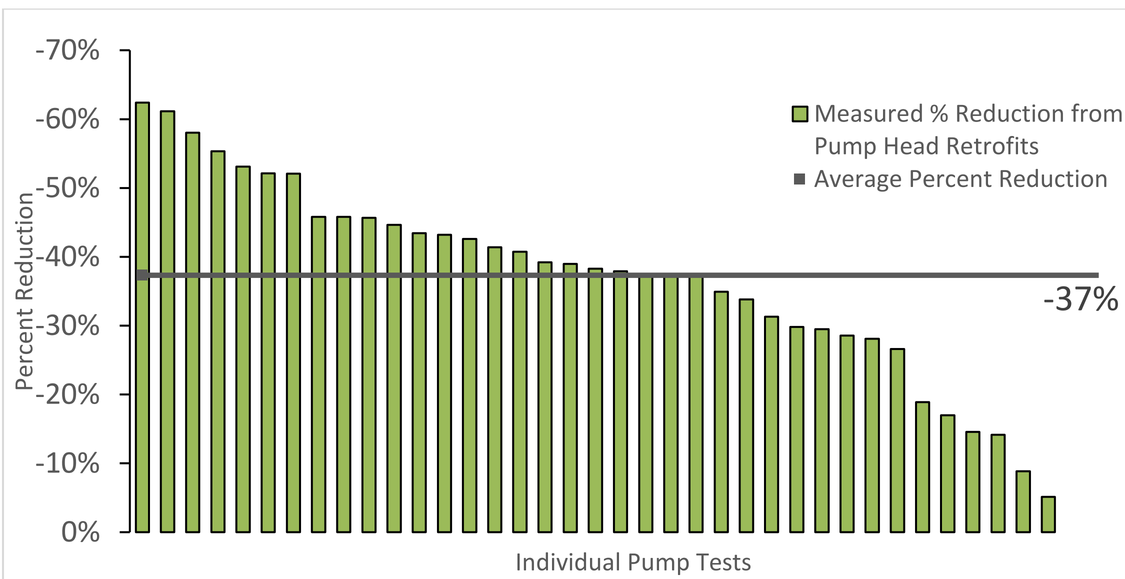


Figure 1: Measured Percent Reduction of Pump Vent Rates from replacing the plunger head from a 3/8" plunger to a 1/2" plunger from 37 chemical injection pumps in Alberta.

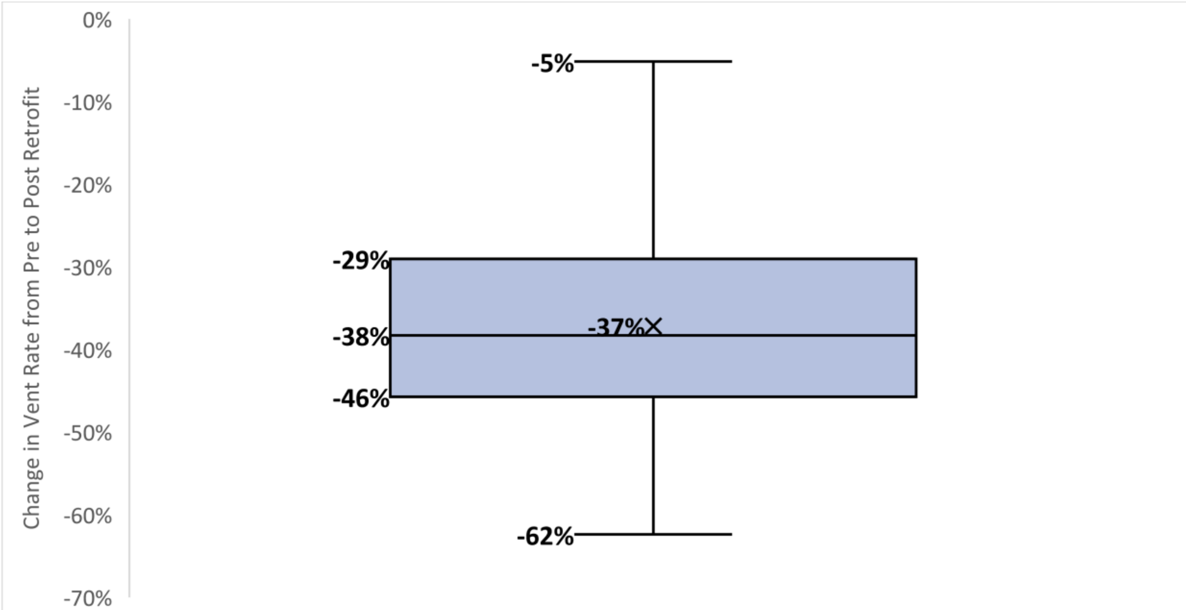


Figure 2: Whisker plot of all 37 field % reduction values resulting from the measurement of the vent rates pre and post plunger head optimization of 5100 series pumps. Average percent reduction of -37% and upper and lower quartile ranges of -46% and -29% respectively.

Based on these results, an annual total of 674 tCO_2e of greenhouse gas emissions will be reduced through this optimization project (Table 2). This is assuming that the injection rate of the pumps will remain relatively consistent and that each pump will operate for at least six months out of a calendar year, owing to the seasonal nature of these pumps. On average, each pump is expected to reduce 18 tCO_2e greenhouse gas emissions per year.

Table 2: Project annual greenhouse gas emissions reduced (tCO_2e).

Count of Representative Tests Completed	Average Measured % Reduction from Pre & Post plunger Optimization	Total Projected Emissions Reduced (tCO_2e/year)	Average Projected Emissions Reduced (tCO_2e/pump/year)
37	-37%	674	18.2

Abatement Cost Summary

- Emission reductions per pump, per year: 18 tonnes CO_2e
- Number of pumps optimized with relevant testing: 37 pumps
- Total emission reductions per year: 674 tonnes CO_2e /year
- Emissions over 10 years: 6,740 tonnes CO2e
- Cost per tonne: $49,737/6,740 tonnes CO2e = $7.38/tonne

Project Findings

Finding #1: Plunger diameter optimization can yield predictable and material reductions.

This project confirmed that the injection rate and pressure of the pump are the largest contributing factors when determining the total vented emissions from pneumatic pumps. Since the total amount of chemical injected into a well and the injection pressures are site specific, it is unlikely that either of these parameters can be manipulated (significantly) to reduce vented gas emissions. However, one variable that operators can alter is the size of the plunger in the pump. This project confirms that the size of a pneumatic plunger head plays an important role in contributing to the total vented emissions of a pneumatic pump. By changing the plunger head from 3/8" to 1/2", oil and gas producers may expect a 30% to 45% reduction of their on-site pneumatic pump emissions, equating to approximately 18 tCO_2e in emissions under equivalent operating conditions. Bluesource has demonstrated that there are material reductions as a result of increasing the plunger size of a chemical injection pump. If the results of this project were to be applied to a larger population of pumps, increasing the plunger size of five thousand 5100 series pumps across Alberta may yield up to 91,000 tCO_2e reductions per year. This effort would be equivalent to removing approximately 20,000 vehicles off the road for one year. Table 3 below illustrates two examples of the theoretical reductions achieved by optimizing two models under the Bruin 5100 series.

Table 3: Pump emissions and theoretical percent reduction of Bruin 5100 pumps based on an increase of plunger size, where the pump is optimized with the next available larger plunger.

Pump Make Model	Baseline Plunger Size	Optimized Plunger Size	Theoretical % Reduction*	Injection Rate (L/Day)	Emissions Reduced (tCO2e) (Operates 6 months)
Bruin 5100	1/4"	3/8"	55%	30	39
Bruin 5100	3/8"	1/2"	43%	30	14

*Based off Pump Coefficients from Manual 15. This study showed the average reduction to be slightly lower at 37% using measured vent rates.

Finding #2: Plunger diameter optimization is cost effective and could leverage carbon markets for accelerated results.

Increasing the plunger size of a pneumatic pump is an inexpensive and simple way for oil and gas producers to reduce their overall methane emissions from their oil and gas operations. If possible, oil and gas operators should consider increasing the size of each of their existing pumps plunger to the next available size according to the pump manufacturers bulletin; resulting in average reductions of up to 45 percent in vented methane emissions (

Table **3**). However, from our experience, without a catalyst for action, this environmental benefit is likely to not occur by itself, especially on older, more marginal producing assets that are not at the top of the maintenance priority list for producers.

Given the abundance of 5100 series pumps in Alberta and the opportunity for emission reductions, Bluesource believes that there could be a carbon credit pathway for producers to be incentivized to modify their chemical injection pumps through plunger retrofits. This approach was successful for converting the fleet of high-bleed pneumatic controllers to equivalent low-bleed controllers prior to the January 2023 compliance date. If Alberta Environment & Parks (AEP) were to consider expanding the Pneumatics Protocol to include pneumatic pumps retrofits and optimizations as eligible project activities, pumps that are additional to provincial and federal regulations and are not economically feasible to become zero venting through a pump electrification may still achieve material emission reductions. Thus, if Bluesource, other project developers, and oil and gas producers were able to execute a chemical injection pump optimization project under the Alberta Offset System and leveraging carbon markets, this could result in substantial emissions reductions and contribute to Alberta's goal of a achieving a 45% reduction in methane emissions by 2025.

Finding #3: Importance of accurate inventory data

Another key learning from this project was the importance of obtaining and maintaining an accurate pump inventory. The tests completed in the field were contingent on having correct pump data, including make model, plunger size, stroke length, injection rate, injection pressure, and supply pressure. The scope of the project was to retrofit 5100 series pumps that have a 3/8" plunger head. In many cases, the initial pump data we were working with was either out-dated or incorrect. Since sites were selected based on the assumption that they contained a 3/8" – 5100 series pump, and PTW and Greenpath often discovered different pump configurations on site and had to proceed to the next site: project efficiencies were lost and travel time and costs increased. For pump optimization to be creditable and verifiable under ISO 14064, employing robust data integrity measures are critical. At a minimum, this would include frequently completing and maintaining pneumatic equipment inventories, including pneumatic devices and pumps on an annual basis and ensuring that relevant Management of Change results are reflected in the inventory.

Finding #4: Locking in the reductions

Lastly, this project focussed solely on plunger optimization since it involved the physical replacement of one part for another. Initially, Bluesource contemplated adjusting the stroke length, but upon further consideration opted to exclude this potential optimization tactic owing to the understanding that anyone could easily revert the stroke length back to its original length by moving a pin. Bluesource felt that unless you could lock in the stroke length modification, the effort would not contribute to long-lasting and high integrity emission reductions. Should Bluesource or others wish to pursue an offset credit pathway for optimization activities, there must be assurance that the reductions are long-lasting. Should a proponent wish to modify the stroke length to achieve reduce emissions, a strategy to ensure the modified stroke length does not change should be implemented and is any additional modifications to the stroke length are made, they must be accounted for in a Management of Change process.

Closing Remarks

Bluesource would like to thank PTAC, GreenPath Energy Ltd., PTW Energy Services and Spartan Controls Ltd for the support and financial contributions that allowed this pump optimization project to be completed. Bluesource would also like to recognize the project hosts, NAL Resources and Outlier Resources, for their dedication and commitment to innovation in the field of methane reduction initiatives. Through this project, it was confirmed that the size of a pump plunger plays an integral role in contributing to the overall vented emissions. If carbon credits were available to project developers and oil and gas producers for the optimization of existing pneumatic pumps under the Alberta Offset System, a considerable amount of methane emissions could be reduced: sooner, and cost-effectively.

Appendix

Picture 1. Photo of GreenPath and PTW at a double well battery in the Olds Field, measuring the vent rate of an optimized Bruin 5100 with a ½” plunger.

Picture 2. Photo of a 3/8” plunger head of a Bruin 5100 pump, which was replaced with a ½” plunger.

Picture 3. Photo of the Emeas Skid flow computer which was used to measure the vent rate of pre and post plunger head retrofits.

BMRP PTAC Installation Test Record

bluesource

PRODUCER NAME:	NAL	SURFACE LSD: e.g. xx-xx-xxx-xx Wx	04-32-033-01W5
AREA/FIELD:	Olds/Harmattan	DOWNHOLE LSD(S): e.g. xxx/xx-xx-xxx-xx Wx/xx	100/04-32-033-01W5

EXISTING PNEUMATIC PUMP - BASELINE CONDITION			
MANUFACTURER:	CVS	PROCESS SERVICE:	SWEET ☐ SOUR ☑
PUMP MODEL NO.:	Series 51	TYPE OF CHEMICAL INJECTED: e.g. Methanol	Methanol
SERIAL NO.:	N/A PAINTED OVER		

	BASELINE SCENARIO: EXISTING PUMP	OPTIMIZED SCENARIO 1: MODIFIED PLUNGER ONLY	OPTIMIZED SCENARIO 2: MODIFIED PLUNGER & STROKE LENGTH
STROKE LENGTH:	☐ HALF ☑ FULL	☐ HALF ☑ FULL	☐ HALF ☑ FULL
MEASURED STROKE LENGTH (IN):	1 (1)	1 (1)	1 (1)
PLUNGER DIAMETER (IN):	0.375(3/8)	1/2	1/2
STROKE COUNT PER MINUTE (#)	8 ☐	9 ☐	5 ☐
INJECTION VOLUME (L):	20L/day	36 L/day	20 L/day
MEASURED VENT RATE (M3/HR):	Provided by Spartan after all tests are complete	Provided by Spartan after all tests are complete	Provided by Spartan after all tests are complete
SUPPLY PRESSURE (PSIG):	30	30	30
INJECTION PRESSURE (PSIG): 1 PSI = 6.895 KPA	17PSI	17 PSI	17 PSI
CONDITION:	Good	Good	Good
TEST RUN TIME:	5 min	5 min	5 min
TEST FILE NAME:	04-32-33-01W5_PRE RETROFIT PUMP1	04-32-33-01W5_PRE RETROFIT1 PUMP1	04-32-33-01W5_PRE RETROFIT2 PUMP1
COMMENTS:	PRE 13:16 - 13:21 , POST1 13:45 - 13:50 , POST2 13:58 - 14:03		

PLUNGER INSTALLED BY:		TEST COMPLETED BY:	
NAME:	Jeremy	NAME:	Drew Chorney
DATE:	06.08.2020	DATE:	06.08.2020
SIGNATURE:		SIGNATURE:	

Picture 4. An Information Test Record that was completed by PTW and GreenPath on site.