Vermillion River Gas Utility

ENERGY EFFICIENCY AND EMISSIONS ASSESSMENT

Prepared for Alberta Climate Change Office
Contract Number 18CCO810

This document represents an electronic version of the original hard copy document that is signed dated and retained on file, a copy of which can be mailed to you upon request.

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Revision History

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A	January 16, 2018	F McCarthy	Issued for Review	
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1	March 27, 2018	F McCarthy	Changes per client request	C. Norman

Disclaimer

The intent of this Scoping Assessment report is to identify energy efficiency opportunities and emissions reductions opportunities and savings associated with recommended Energy Efficiency Measures (EEMs). However, this report is not intended to serve as a detailed engineering design document. It should be noted that detailed design efforts may be required in order to implement the recommended upgrades. As appropriate, costs for those design efforts are included as part of the cost estimate for each measure.

While the recommendations in this report have been reviewed for technical accuracy and are believed to be reasonably accurate, the findings are estimates and actual results may vary. As a result, SysEne Consulting and Alberta Climate Change Office are not liable if estimated savings or economics are not actually achieved. All savings and cost estimates in the report are for informational purposes and are not to be construed as a design document or as guarantees.

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1 Introduction

The County of Vermillion River Gas Utility (CVR Gas Utility) is a regional utility which collects natural gas from a variety of sources for distribution throughout a large supply network. The utility also aims to identify new uses for recovered natural gas and has the responsibility of balancing gas supply with demand. The CVR Gas Utility is a member of the Federation of Alberta Gas Co-Ops.

Figure 1 – Vermillion County Gas Utility Team

While the focus of the county-owned natural gas system is to provide gas to residents of the county, the system is also in the unique position of both supplying and purchasing gas to/from oil and gas producers within the county boundaries. The CVR Gas Utility has been able to provide a variety of services to oil and gas producers including:

- Gas infrastructure to operate production facilities (wells, batteries, disposals, plants, etc.)
- Construction of gas collection infrastructure for recovery of vent gas from production facilities,
- Purchasing of vent gas back onto the general County system.

The intent of these projects was to recover gas for use at production sites however the implementation of this infrastructure has also helped producers reduce a considerable amount of carbon emissions as a result of not having to flare on site. Current estimates of the carbon emissions associated with vent gas recovered and transported in the county is equivalent to 490,000 CO_2E tonnes/year.

Alberta Climate Change Office (ACCO) hired SysEne to assist CVR Gas Utility in the identification of energy savings and carbon emission-reduction opportunities within the utility distribution network. In a workshop with key stakeholders, SysEne identified that the largest opportunity for energy and carbon reduction was the recovery of vented, flared and fugitive emissions from oil and gas sites in the area. CVR Gas Utility has had past success with methane recovery projects and recognises that as well as reducing carbon emissions, these projects provide an opportunity for cost savings both the producers and the utility.

Through the workshop SysEne gathered insights from participants including a number of case studies which illustrated both the challenges and the opportunities for recovery of natural gas. This report presents a summary of these insights and provides detailed analysis including:

- Overview of CVR Gas Utility operations and current methane recovery activities,
- An overall opportunity analysis for vented gas recovery in the region,
- Discussion on regulatory drivers for methane emission reduction,
- Case studies of methane recovery and utilization including challenges and benefits,
- Recommendations.

SysEne also noted some opportunities for improved energy efficiency which are discussed in Appendix C.

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2 Executive Summary

The County of Vermillion River Gas Utility which is a member of the Federation of Alberta Gas Co-Ops, is interested in the efficient collection and use of natural gas in its jurisdiction and is dedicated to ensuring natural gas can be continuously recovered and effectively moved from all suppliers to all users. CVR Gas Utility understands that the efficient use of natural gas is good for business and the environment.

The County of Vermillion River (CVR) has a large number of oil and gas sites which report high volumes of vented and flared methane emissions in close proximity to its distribution network. It is understood that methane reduction is a key focus for Canada's carbon targets, with a stated reduction target of 45% methane by 2025. CVR Gas Utility is ideally located to help both the province and oil/gas producers meet these methane reduction targets and has already illustrated the effective recovery and utilization of vented natural gas through a number of successful projects. CVR Gas Utility wishes to increase the uptake of these projects; however, key barriers exist which need to be identified and overcome to increase project success.

A rough estimate of the gas available and its value for recovery in the Lloydminster area is summarized in Table 1 below. This conservative estimate, based on an oil production area within Vermillion River County of 3600 km^2, illustrates the overall value and carbon emissions associated with methane vented from producers in the region.

Methane Reporting Source	**CH_4 Emitted (tCH_4/hr)**	**Carbon Emissions (tCO2eq/yr)**	**CH_4 Value ($/yr)**
CH_4 Emissions from Reported Vented Gas in Lloydminster	4.6	1,000,000	$5,200,000
Estimated Unreported CH_4 Emissions in Lloydminster	2.1	460,000	$2,400,000
Total	**6.7**	**1,460,000**	**$7,600,000**

Table 1 Annual methane emissions, carbon emissions, and cost

CVR Gas Utility has a number of projects, both implemented and proposed, to recover and use associated gas in the short, medium and long term. These projects, if successfully implemented could recover and use a large portion of the gas that is currently vented and flared within the county. A sampling of these projects is presented in table 2.

Gas Recovery Projects	**CH_4 Emitted (tCH_4/hr)**	**Carbon Emissions if 100% Vented (tCO2eq/yr)**	**Carbon Emissions if 100% Flared (tCO2eq/yr)**	**CH_4 Value ($/yr)**
CH_4 Recovery from producer compressor (Implemented)	0.025	5,400	400	$28,000
CH_4 Recovery from oil producer (Proposed)	0.53	117,000	2600	$186 ,000
Total	**0.56**	**122,400**	**3,000**	**$214,000**

Table 2 - Recovery Projects (Implemented and Proposed)

Based on SysEne's review of the drivers and risks, there are two key areas the gas utility must focus on to ensure continued success for methane recovery projects.

1. Ability of the CVR Gas Utility to accept varying quantity of recovered gas year-round.

   Mitigation Options

   - Increase base load gas consumption by adding large gas consumers (i.e. industrials, power plant)
   - Increase interconnection and control in the distribution network to smooth the gas demand,
   - Add reservoir infrastructure (i.e. CNG/LNG) that can act to store gas during peak supply periods,

2. Project investment requirements don't match oil producer's investment requirements. Gas recovery projects have low risk and a long payback (due to low cost of gas) and compete for capital with oil wells which have a higher risk and short payback.

   Mitigation Options:

   - Creative project structuring wherein the gas utility invests in the capital to reduce or eliminate capital cost for the producers. Project costs would provide a long-term infrastructure invest for the utility.
   - Improve economics for projects through identifying opportunities for carbon offset credits,
   - Identify carbon cost reduction associated with post-2023 (end of current carbon exemption) carbon levy.
   - Provincial regulation and enforcement to encourage oil producers to conserve gas that is currently vented or flared. Provincial regulations could change the economic balance to make gas conservation projects the most cost-effective approach for oil producers.

Recommendations

While this report is specific to the CVR Gas Utility, the following recommendations would be applicable to any member of the Alberta Gas Co-Op that wishes to utilize recovered gas.

1. Develop a Strategic Plan for Methane Recovery

A strategic plan over the long term can help to ensure the projects are developed to meet the CVR Gas Utility's requirements over the long term. SysEne recommends the CVR Gas Utility include the following components in their Vent Gas Utilization plan:

- Strategy
- Technical
- Economic
- Environment

2. Develop a Project Evaluation Framework and Project Management Tool

SysEne recommends that the CVR Gas Utility develop a gas recovery "project evaluation framework" which uses a number of tools to improve the identification, evaluation and ultimately selection of vent gas recovery and utilization projects.

This project evaluation tool will also help prioritize the projects. Based on this prioritization the CVR Gas Utility can develop a project pipeline (list of projects and the stage of implementation) and approach the various producers in the region in a strategic partnership approach versus a project by project approach.

SysEne recommends that ACCO consider incentivizing recovery and use of gas that would otherwise be vented or flared. Incentives could include

- Granting carbon offsets for projects,
- Allowing recovered gas to be sold without the carbon levy,

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3 Information Provided

SysEne Consulting generated the information in this report based on a facilitated workshop with the Vermillion River County Gas Working Group, held on October 24th, 2017. This workshop focused on energy conservation through the efficient recovery and utilization of methane as well as operational efficiency in the CVR Gas Utility. CVR Gas Utility also provided the following information about the site:

- Overview of previous gas recovery projects,
- Gas utilization projects and economic evaluation,
- Distribution system layout,
- Distribution system control description,
- Specifications for distribution system,
- Gas supply and demand profiles.

4 Analysis Assumptions

In evaluating energy use and greenhouse gas (GHG) emissions SysEne assumed the emission factors shown in Table 2 below.

FUEL	UNIT	GJ equivalent (LHV)	tonnes CO2 equivalent
Natural Gas (used as fuel)	1 GJ	1	0.0506
Natural Gas (flared)	1 M3	0.037	0.0018
Natural Gas (vented)	1 tCH_4		25

Table 3 Emissions factors for fuels used by CVR Gas Utility

In evaluating opportunities, SysEne assumed the following:

- Price of Natural Gas $3.57/GJ
- SysEne did not include carbon offsets. Natural gas recovery may not be eligible for carbon offset credits for sites flaring or venting more than 500 m3/day of stable gas supply, as these sites are regulated by Alberta Energy Regulator (AER) Directive 60.

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5 Gas Utility Overview

The boundary of this opportunity identification was the County of Vermillion River Gas Utility distribution network and the oil production operations near this distribution network.

5.1 Overview of CVR Gas Utility Operations

Currently the County of Vermillion River Gas Utility serves approximately 3,200 residential and industrial customer accounts. The gas is sourced from ATCO, TransCanada and AltaGas pipelines, as well as Canadian Natural Resources (CNRL) and a growing number of vent gas suppliers. All gas sold to residential customers is purchased through Gas Alberta Inc.

The CVR Gas Utility has a very large service area, over 5500k m^2, and its customer base is served from relatively few high-pressure feeds. Their high-pressure pipeline system is much more extensive than that of most gas utilities. For further system and operating detail see Appendix A.

CVR Gas Utility operates 24/7, year-round. The gas utility owns and operates twelve tap stations where gas is purchased through Gas Alberta. Tap stations, often referred to as Regulate, Meter, Odorize (RMO) Stations, serve the following functions:

- Regulate high-pressure gas from transmission systems down to distribution pressures.
- When the gas pressure is dropped, the gas cools so heating is required to prevent freeze-off.
- Meter the amount of gas purchased from transmission systems.
- Add odorant if required.
- Remote monitoring of volumes and pressures to detect leaks or other problems.

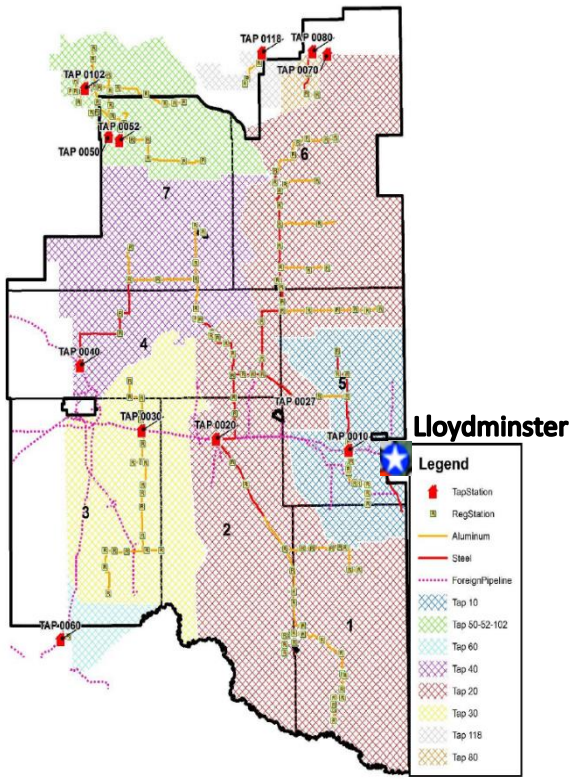

Figure 2 -Vermillion River County Gas Distribution Network

CVR Gas Utility has always had a close relationship with the oil producers in the region and has constructed a number of collection and distribution systems that allow producers to utilize their own vent gas for their operations (typically for operation of wellsite equipment), sell their excess gas onto the County system, or a combination of the two. In 2008, the County of Vermillion River won the Climate Change award for embarking on an investment in a heavy oil casing vent gas gathering project. Since 2008 CVR Gas Utility has made steady progress towards increasing the amount of vent gas capture, including the recent addition of 25,000 mcf/month on the Tap 20 system. Vent gas gathering provides benefits to Vermillion River County in reduction of vented methane, construction revenues, and purchase of gas at a reduced price.

Vermillion River County residents benefit from the additional revenue generated by these industrial services, from the income being invested back into the system, and from the environmental benefits of reduced methane and flaring emissions. CVR Gas Utility would like to explore more ways to use this gas within the utility distribution network so that more gas can be productively recovered.

As the Environment and Climate Change Canada (ECCC) inventory of overall methane emissions in Alberta (Figure 3) indicates, the government goal of 45% reduction in 2012 methane emissions by 2025 will need to be achieved primarily through reductions from conventional oil and gas operations, specifically venting and fugitive emissions. As is also indicated in Figure 3, the volume of unreported venting emissions is high; recent studies indicate total emissions could be three to five times higher than currently reported. The large volume of unreported venting indicates that it may be a challenge for CVR Gas Utility to accurately assess vent gas recovery projects and identify methane recovery opportunities as they may be unknown and unreported.

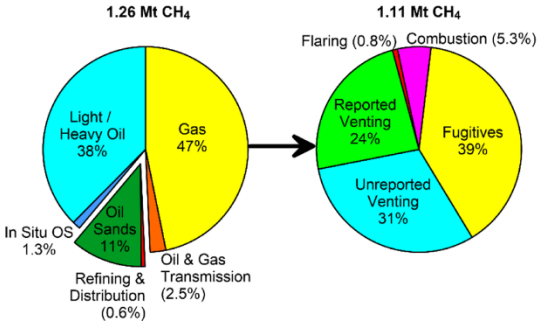

Figure 3 - 2014 Methane emissions from the oil and gas sector in Alberta (ECCC's National Inventory Report). The left pie chart = contributions from different upstream production types; the right pie chart illustrates the emission types from natural gas and conventional oil production (excluding mined oil sands).

The CVR Gas Utility region has significant heavy oil production, mostly in the form of CHOPS (cold heavy oil production with sand). This type of extraction frequently involves venting of methane from the production directly to atmosphere. This venting is represented by a geographic distribution based on industry reported venting volumes from 2016, shown in Figure 4. It can be seen that the venting volumes are significantly higher in the Lloydminster region than the remainder of the province. Figure 5a illustrates more clearly the area identified with the 60 km x 60 km black box north of Lloydminster in Figure 4. Figure 5b illustrates the correlation of vented gas to oil and gas infrastructure in the Vermillion River County. Overall there are 2291 heavy oil wells, 214 gas wells, 0 gas plants, and one in-situ oil sands battery/injection facility within in the Lloydminster area. Most, if not all, of these heavy oil facilities are CHOPS facilities. Table 2 below outlines the volume and associated value of the methane emissions for the boundary area indicated in Figure 5. The reported numbers in figures

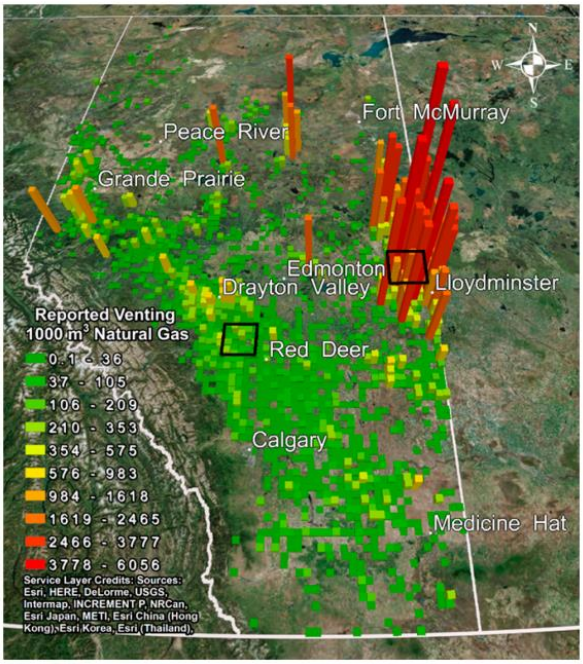

Figure 4 - Geographic Distribution of Vented Methane

4 and 5 and Table 2 are conservative estimates for Vermillion County as they are based on a boundary area approximately 40% smaller than the county boundary.

Based on the information presented in Figures 4 and 5, it is clear that methane recovery in the Lloydminster and Vermillion River County area will be a key focus for Alberta's methane emission reduction targets. This focus on methane reduction offers an opportunity for Vermillion River County to play a key role in the recovery and effective utilization of this vented natural gas.

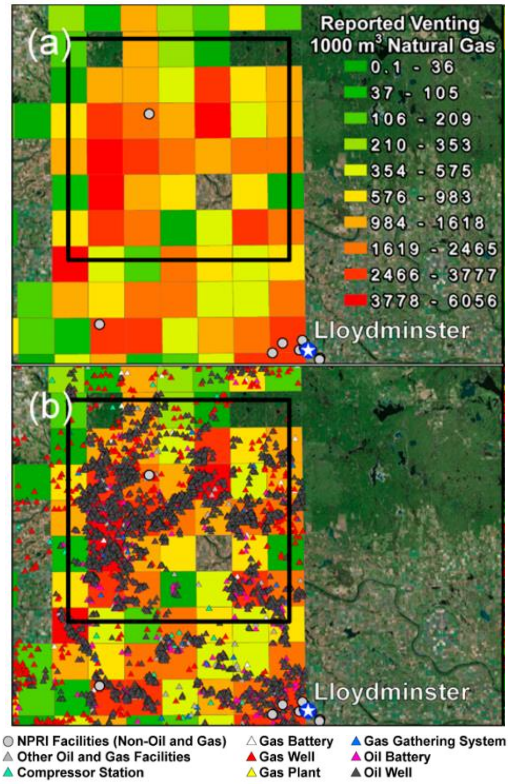

Figure 5 – Distribution

Natural Gas Source	Volume (tCH_4/hr)	Emissions, tCO2eq/yr	Value, $/yr
CH_4 Emissions from Reported Vented Gas in Lloydminster	4.6	1,000,000	$5,200,000
Estimated Unreported CH_4 Emissions in Lloydminster	2.1	460,000	$2,400,000
Total	**6.7**	**1,460,000**	**$7,600,000**

Table 4 Annual methane emissions, carbon emissions, and cost

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5.2 Methane Recovery Regulatory Drivers

In March 2016, the Government of Canada published proposed regulations for the oil and gas sector in order to achieve Canada's methane reduction goal. Methane emissions are a potent greenhouse gas that is 25 times more powerful than carbon dioxide and makes up about 15% of Canada's total GHG emissions. The oil and gas sector is the largest contributor to methane emissions in Canada. The government's strong commitment to methane reduction in a relatively short time period indicates that increased regulation for high methane emitting producers, like those in the Vermillion River County, will be forthcoming.

Federal Regulations

Environment and Climate Change Canada published proposed regulations to reduce methane emissions from new and existing oil and gas infrastructure in 2017. These "outcome-focused regulations" apply to oil and gas facilities that extract, produce, process, and/or transport crude oil and natural gas, including oil wells and pipelines. The first federal requirements come into force in 2020, with the rest of the requirements coming into force in 2023.

The requirements target two critical areas of interest to CVR Gas Utility:

1. **Compressors**: The regulations will require measurement of the flow rate of methane emissions from sealing systems, at least once per year, as of January 1, 2020. Corrective action is required if those emissions exceed 0.023 m^3 per minute for reciprocating compressors and 0.17 m^3 per minute for centrifugal compressors. All new compressors installed will be required to capture gas from sealing systems.
2. **Facility production venting**: Upstream oil and gas facilities will be required to limit vented volumes of methane to 250 m^3per day as of January 1, 2023. These facilities will need to capture the gas and either use it onsite, re-inject it underground, send it to a sales pipeline, or route it to a flare. Facilities that vent less than 40,000 m^3 per year without destroying or selling any gas would not be required to destroy or conserve the gas.

Provincial Regulations

The Alberta government proposed regulations are intended to deliver on Alberta's "commitment to reduce emissions of methane from the oil and gas sector by 45% below 2012 levels by 2025". The Alberta government proposes the methane reductions will come from:

- Applying new emissions design standards to new Alberta facilities. Applying standards at the planning stage will be less expensive that requiring upgrade of existing facilities.
- Improving measurement and reporting of methane emissions, as well as leak detection and repair requirements.
- Developing a joint initiative with the federal government on methane reduction and verification for existing facilities and backstopping this with regulated standards that take effect in 2020.

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For several years, flaring and venting in Alberta has been subject to the Alberta Energy Regulator's (AER's) Directive 60. The current release of Directive 60 (2016) requires that any operators flaring or venting more than 900 m3 of gas per day perform an economic analysis yearly to show that other alternatives are not cost effective. The AER may investigate flared or vented volumes as low as 500 m3 /day if it appears that gas is stable. The economic analysis must be available for AER's review and a Public Information Package, including a summary of the economic analysis, must be available for public review.

Cost and benefits

The cost to implement the new regulations for oil and gas industry is estimated at $3.3 billion over the 2018-2035 period[1]. This indicates an opportunity for CVR Gas Utility as there will be a strong focus by the oil and gas industry on investing in low cost and reliable methane recovery solutions.

[1] Canada Gazette Vol. 151, No. 21 — May 27, 2017 Regulations Respecting Reduction in the Release of Methane and Certain Volatile Organic Compounds (Upstream Oil and Gas Sector)

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6 Opportunities and Challenges for Natural Gas Recovery and Use in Vermillion River County

6.1 Recovery of Vented Methane

Industry reported venting in the Lloydminster region in 2016 was recently estimated at 60,602,000 m^3/yr of gas with an average methane release of 6.7 t CH_4/hr. Estimates on the value of this methane is well over $10M per year. Recent airborne measurements indicate this value could be 3-5 times higher than reported. As illustrated in Figure 6, most of reported methane release in the Lloydminster area is from venting.

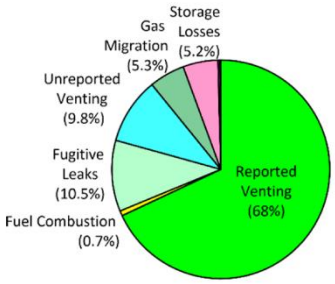

Figure 6 - Lloydminster Region Methane Emission Sources

Vermillion River County has been active in the assessment and investment in vent gas capture and use with cooperating industry partners. Since 2008 many economical projects have been implemented to capture and utilize vented gas. In total the CVR Gas Utility connected projects gather enough vented gas to fuel 7,500 homes year-round, correlating to 490,000 CO_2E tonnes/year in reduced greenhouse gas emissions. Utilization of vented methane offers an income generating opportunity for both the producer and the utility. This profitability can be shown in another way as having a negative or low cost for recovery systems as shown in the marginal abatement cost curve, Figure 7.

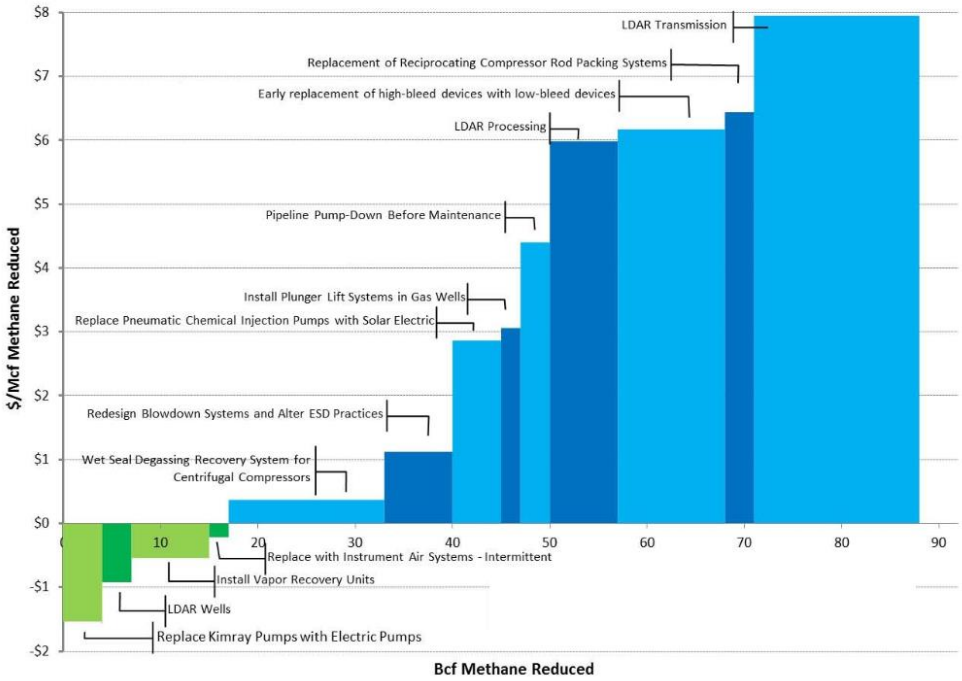

Figure 7 - Marginal Abatement Cost Curve for Methane Reduction

CVR Gas Utility recognises the value of recovering and utilizing vented methane and is interested to continue investment in these projects. During the workshop, technical and economic drivers and barriers were discussed and identified.:

- Economic:
  - Improve the assessment process to identify new and existing methane recovery opportunities,
  - Identify opportunities to break down the perceived economic barriers to investment in these projects (technology, regulations, additional benefits, etc.)
  - Improve the tracking of projects parameters (infrastructure changes, ownership, regulation etc.)
  - Better understanding of the benefits, challenges and risks associated with these methane recovery projects from the producers' perspective,
- Technical:
  - Develop additional vent gas sources that allow CVR Gas Utility to reduce pressure on backbone infrastructure,
  - Add/expand high pressure infrastructure in areas where bottlenecks exist and create more links between systems.
  - Connect portions of the system serving mainly residential, to systems serving higher volume industrial customers.
  - Review the application of booster compressors at strategic locations on the distribution system,
  - Approximately 40% of the gas sold is used primarily for heating of homes and buildings in winter. As such the system is not able to consistently accept the gas in summer months,

In the workshop the team discussed several case studies that illustrated these drivers and barriers. Two of the case studies are summarized below; full details are given in Appendix B.

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Case Study 1: Successful Implementation
Compressor Vent Gas Recovery and Interconnection

In December 2016, CVR Gas Utility completed a connection to recover gas from a producers' compressor station. The project required connection of a skid-mounted Regulate, Monitor, and Odorize (RMO) unit connected to the pre-existing compressor. In the winter months, the compressor supplies 25,000 GJ/month and ATCO supplies 75,000 GJ/month. In the summer months the compressor supplies 25,000 GJ/month and ATCO supplies 13,000 GJ/month.

Key factors leading to the success of the project were:

- A suitable compressor, which was already in a similar service, was available at the site. The producer had slated the compressor for decommissioning due to low wholesale gas prices, but CVR Gas Utility was able to offer a higher gas price which made it worthwhile for the producer to continue operating the compressor.

Key challenges were:

- Due to the volume and distance, the gas had to be supplied to a 400 psi main,
- The added supply from the producer may affect CVR Gas Utility's firm demand from ATCO, which could result in a higher price.

Case Study 2: Project Not Implemented
Grouped Oil Wells Vent Gas Recovery and Interconnection

An oil producer contacted CVR Gas Utility about adding an interconnecting pipeline so that 18,000 to 19,000 m3/day of gas which is currently vented from a group of wells could be collected and supplied to their processing facility and into CVR Gas Utility 's distribution network. The producer is currently buying gas to serve their processing facility. The estimated value of the gas is per year and the producer would save approximately /month.

Key factors leading to the project not being implemented were:

- The payback period is too long. Oil producers have limited interest in applying capital to non-core and long payback projects.
- The project investment risk is high. Potential return is based on long-term vent gas production and oil well economic viability.
- There is no carbon pricing mechanism that provides incentives for capturing and using vent gas over flaring vent gas.

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6.2 Utilization of Recovered Methane

Supply of vented methane in the region is continuous and the volume of gas produced can fluctuate significantly based on a variety of parameters that are difficult to measure. Methane recovered from producers' sites must be consumed as it is produced. CVR Gas Utility can take a large volume of this gas in the winter when demand for residential heating is high (40% of the demand). However, in the summer months heating gas demand drops to zero and there is not enough demand on the system to consume the volumes of vented gas.

Some options to use the recovered gas during these periods of low demand, include:

1. The utility could reduce the amount of gas supply from ATCO and take a larger portion of recovered gas when it is available:
    - This likely already occurs to some degree; however, ATCO will be challenged to manage the gas available for the utility as the demand fluctuation increases. The gas purchasing contract with Gas Alberta also likely has contractual firm capacity requirements, demand charges and minimum volume requirements which could significantly increase the overall cost of gas for CVR Gas Utility, making it unprofitable to take on the recovered gas.

2. Producers could sell gas and operate parallel flares to be used in periods of low demand.
    - The capital and operating cost of parallel incinerator/flare systems would likely have prohibitive overall economics both OPEX and CAPEX. In situations where flares or combustors already exist having the redundancy for gas use may justify the cost to keep these systems operational.

3. CVR Gas Utility can identify and develop additional demand sources for natural gas that can be used to balance the seasonal variation in the gas demand load profile.
    - Natural gas demand can be increased in the summer by connecting large industrial demands, (oil or gas facility or power plant) operators that have a more consistent demand for natural gas.
    - Interconnection with other gas utilities is another option that can offer flexibility in managing the changing demand load with the changing supply load. Development of compressed natural gas (CNG) or liquified natural gas (LNG) which can significantly increase demand on a more consistent annual basis and act as a potential storage or reservoir.

The workshop identified the third option as the preferred option. Three case studies illustrate the benefits and challenges associated with this approach. The case studies are summarized below and presented more fully in Appendix B.

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Case Study 3: Not Implemented Adding Large Industrial Demand
Excess Gas Sale to Large Oil and Gas Producers

CVR Gas Utility has identified oil and gas facilities as potential industrial users of recovered gas. The oil and gas facilities currently buy gas from ATCO. CVR Gas Utility could deliver gas to these large facilities through CVR Gas Utility's own pipeline system or the producers distribution network.

Key factors that could lead to success to this project are:

- CVR Gas Utility will likely be able to provide gas to large facilities at a lower price than is currently being paid to ATCO therefore lowering the cost to producers.
- Large facilities can accept gas of varying quality (e.g. field gas).
- If recovered gas is considered as having a lower carbon intensity than conventionally-produced gas, this project will also allow the producers to reduce their GHG emissions.

Case Study 4: Interconnection with Other Gas Utilities
Use of Recovered Gas to Help Supply Neighboring Gas Utilities

CVR Gas Utility has identified the area northeast of their current service area as a suitable candidate for transmission of gas to another gas utility. Currently, the area has limited supply. CVR Gas Utility would have to invest in a pipeline to move the gas to the adjacent utility.

Key factors that could lead to success of the project are:

- It will allow CVR Gas Utility to reduce the pressure on the Tap 20 backbone system, which will make more vent gas locations economical.
- The tie-in will provide backup for customers north of the North Saskatchewan River

Case Study 5: Development of CNG or LNG
CNG Vehicles

The County of Vermillion River has undertaken a pilot project to convert county vehicles to use CNG and bi-fuel (CNG or gasoline). Two trucks were converted in 2017. Based on the success of the program, the county plans to convert five more vehicles in 2018. The vehicles are fueled at a natural gas compressor station in the county yard. The county is investigating converting heavy vehicles and adding a commercial fill station.

Key factors that could lead to success of the project are:

- Use of CNG provides a significant cost savings compared to gasoline or diesel. It also greatly reduces GHG emissions.
- This program opens additional markets for the sale of natural gas.
- Addition of CNG storage can be used as a "gas reservoir" to help balance the system for peak supply management

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7 Conclusions and recommendations

7.1 Conclusions

The case studies discussed in this report illustrate the significant opportunity available to the CVR Gas Utility in the recovery and utilization of natural gas from producers in the region. There are many positive drivers which make the technical, economic and environmental case for recovering and utilizing associated gas increasingly attractive. Despite these positive motivators the case studies also illustrate that prohibitive challenges exist and prevent recovery projects from being implemented, as is illustrated in Case Study 2.

To promote future recovery and utilization of associated gas projects it is important that the CVR Gas Utility understand these challenges and work to put in place mitigations that will help increase success. Based on the case studies reviewed and the workshop discussion, an overview of the key challenges and potential mitigations is presented below.

Key Technical Challenge

- Availability of the CVR Gas Utility to accept varying quantity of associated gas year-round.

Mitigation Options

- Increase base load gas consumption by adding large gas consumers (i.e. industrials, power plant)
- Increase interconnection and control in the distribution network to smooth the gas demand,
- Add reservoir infrastructure (i.e. CNG/LNG) that can act to store gas during peak supply periods,

Key Economic Challenge

- Project investment requirements don't match producers' investment requirements and may compete unsuccessfully for capital funding. Gas recovery projects have minimal risk and a long payback due to low cost of gas and compete for capital with oil wells which have higher risk short payback.

Mitigation Options:

- Creative project structuring where CVR Gas Utility invests in the capital to lower or eliminate cost for the producers and the cost is paid back to the utility over the long term,
- Improve economics for projects through identifying opportunities for carbon offset credits, Identify carbon cost reduction associated with post-2023 (current exemption) carbon levy.

7.2 Recommendations

7.2.1 Develop a Strategic Plan for Methane Recovery

Recovery of large volumes of methane has significant opportunities as well as challenges for CVR Gas Utility. These factors need to be understood and planned over the long term to ensure the projects that

are developed meet CVR Gas Utility's requirements over the long term. SysEne recommends the County include the following components in their strategic plan.

Strategy:

- CVR Gas Utility's overall interest in the recovery and utilization of natural gas. Benefits and risks apply to the overall organization and stakeholders.

Technical:

- Estimate of long-term opportunity for recoverable gas volumes available: Accurate measurements of both the site gas production and gas demand.
- Infrastructure – Detailed project information on available infrastructure.

Economic:

- Long term gas price, installation cost, and transmission costs.
- Cost of carbon emissions:
    - Impact of the future \$50/tCO_2e cost of carbon to the proposed projects,
    - Potential sale of carbon offsets: if methane were to incur the carbon cost of \$50 tCO_2e, methane recovery may a value of \$1250/tonne methane reduced.
    - Opportunity to aggregate methane capture and recovery projects under one application for carbon credit.

Environment:

- Impacts of provincial and federal regulatory requirements, considering the impacts to operators and the requirements for recovering vented volumes, carbon offset availability,
- AER is increasing enforcement of venting requirements and well vent measurements.

7.2.2 Develop a Project Evaluation Framework and Project Management Tool

SysEne recommends that the CVR Gas Utility develop a gas recovery "project evaluation framework" which uses a project evaluation tool. The project evaluation tool can help to identify and prioritize potential projects.

Based on the list of potential projects, CVR Gas Utility can develop a project pipeline (See figure 8 below) outlining a list of projects and the stage of implementation. CVR Gas Utility can use this tool to approach the various oil producers in the region as strategic partners.

CVR Gas Utility should discuss with the oil producers the economic and technical considerations that would meet or not meet the producers' investment requirements. These requirements should then be entered the project evaluation criteria. Projects could then be put in a "parking lot" and moved back in the pipeline for consideration when changes to regulatory, technical and economic conditions occur.

CVR Gas Utility can continually re-evaluate the projects and update the project pipeline as conditions change. This information is useful for both the producers and regulators. It can be used to inform producers of upcoming opportunities that can provide regulators with information to shape policies that drive uptake of vent gas recovery options.

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7.3 Next Steps

7.3.1 CVR Gas Utility

1. Review this report with key staff. Develop a strategic, long term plan for methane recovery opportunities which addresses the opportunities and barriers the utility has identified as critical.

2. Implement the project evaluation and management tools outlined in 7.2.2. Projects that are simple and low capital cost should be prioritized and developed as soon as practical.

3. Work with the ACCO, AER, and other provincial bodies to further the understanding of carbon price impacts to methane recovery projects and illustrate the opportunities for methane recovery associated with various carbon pricing options.

7.3.2 ACCO

SysEne recommends that ACCO consider incentivizing recovery and use of gas that would otherwise be vented or flared. Incentives could include

- Granting carbon offsets for projects
- Allowing recovered gas to be sold without the carbon levy

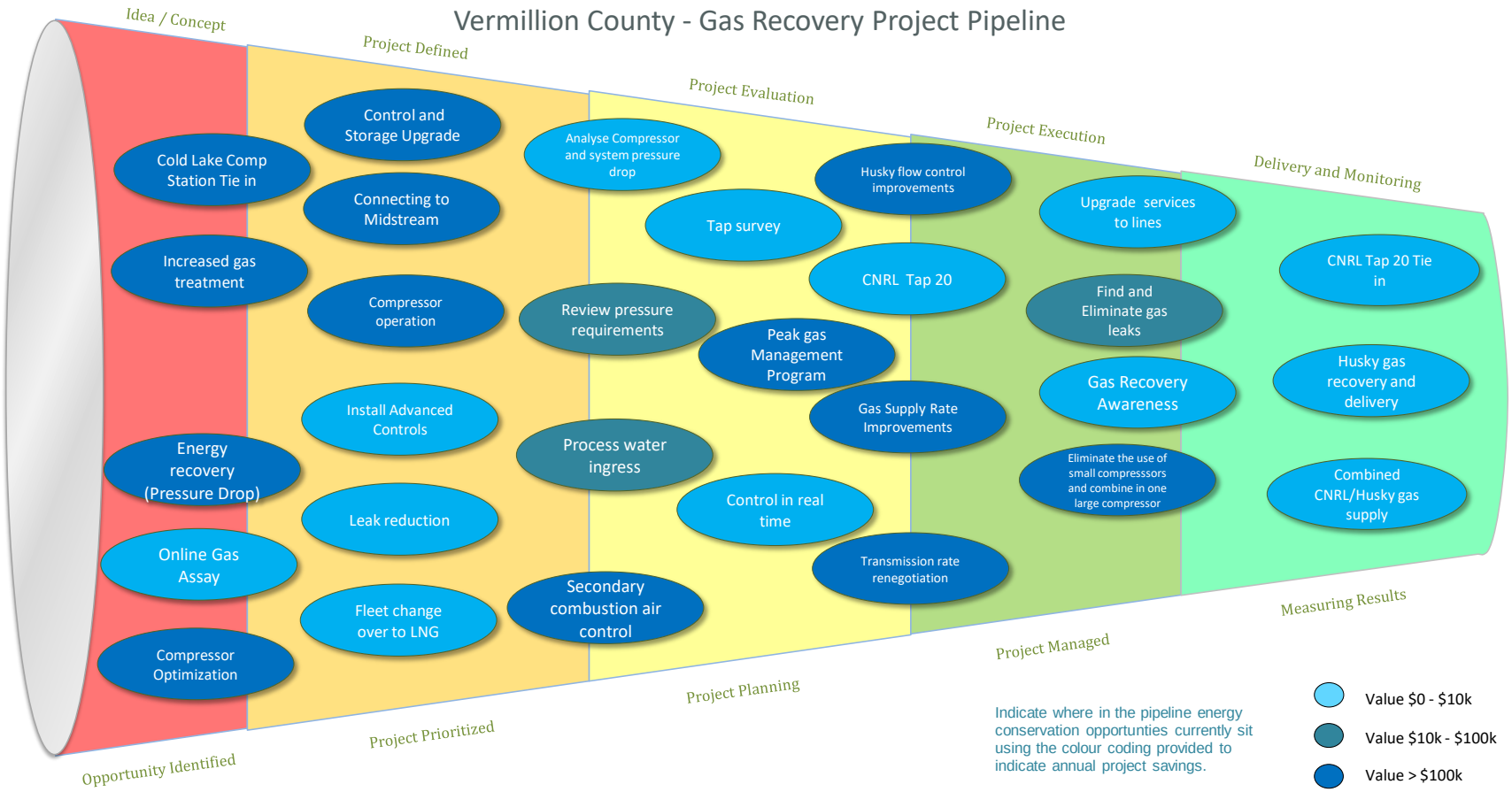

Figure 8 - Project Pipeline example

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APPENDIX A

Overview of Vermillion Gas Services

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Appendix A: Overview of County of Vermillion River Gas Utility

CVR River Gas Utility is a member of the Federation of Alberta Gas Co-ops. The Federation is an umbrella organization comprised of 81 natural gas utilities. The Federation coordinates and provides centralized services such as training, operational guidelines, government relations, insurance, odorant delivery, the rural gas grant, and gas measurement assistance.

CVR Gas Utility maintains an extensive pipeline system of nearly 4,400 kilometres of pipe. The distribution system uses industry standard piping and controls for transportation of gas. The overall system efficiency is considered standard for a distribution system of this size. CVR Gas Utility provides a wide variety of gas services including rural residential/farm, urban, grain dryers, commercial, and oilfield. Services are constructed in several ways based on customer needs primarily:

- Rural services are often serviced by long, small-diameter pipelines. Gas is supplied to a meter installed at the location required by the customer. Rural service pressures are typically 5-20 psi.
- Urban services within hamlets and villages are constructed to operate on low pressure (0.25 psi). Urban centers are served by regulating stations and the lines are typically installed in the streets or alleys.
- Grain dryers require a high volume of gas. Gas supply services are constructed with sizing considerations for the required volume being the main difference. These grain dryers have an intermittent demand which creates supply challenges.
- Oilfield services vary greatly depending on customer requirements. Some of the oilfield services installed include:
    - Small service to single oil well or facility,
    - Large service where numerous wells and facilities are served behind the meter,
    - Large service to batteries, plants and linked fields,
    - Sale/Transportation services where a producer supplies a portion of their own gas and the CVR Gas Utility sells gas to supplement,
    - Transportation-only services where producer uses CVR Gas Utility pipeline system to transport gas for own use or sale to another company,
    - Vent Gas tie-ins where CVR Gas Utility purchases customer's excess gas for use on the county system,
    - Sale/Vent Gas tie-ins where CVR Gas Utility purchases excess gas and sells gas to the customer when no excess gas is being produced.
    - Construct systems that allow companies to utilize their own vent gas to operate their wellsite equipment (typically burners and motors) and sell the excess gas onto the CVR Gas Utility system, or a combination of the two. Vent- gas gathering provides numerous benefits to Vermillion River County in reduction of vented methane, construction revenues, and purchase of gas at a reduced price.

CVR Gas Utility uses over 3,300 gas meters to accurately track gas wholesale purchases, sales to customers, and for system balancing/gas loss detection. CVR Gas Utility installs and maintains purchase and sales meters in accordance with Measurement Canada regulations. In 2012-2013 CVR Gas Utility installed automated meter reading (AMR) devices on nearly all sales meters. AMR reads are collected by

flight monthly, and by drive-by as needed to collect read data for system balancing, switching to backup sources, and other maintenance/repair projects. AMR improves accuracy in monthly bills and system balancing/gas loss detection.

CVR Gas Utility maintains an excellent preventative maintenance program guided by regulatory commitments and agencies. CVR Gas Utility utilizes cathodic protection systems on metallic pipelines which are inspected on a minimum yearly basis.

The CVR Gas Utility system maintains tap stations as they are critical to operation of the system. The inspection of tap stations occurs on a weekly basis and includes:

- Checking proper operation of line heater
- Checking odorant level and arrange refills
- Checking inlet and outlet pressures
- Collecting meter reads
- General inspection for leaks, overpressure/relief, and other issues.

Customer services are fully inspected on a five-year rotation. Yard inspections provide benefit to customers in verification that the system at point of customer connection is operating properly. Customer inspections generally involve the following:

- Leak detection
- Ensuring above-ground piping is installed to code
- Repairing utility leaks on.
- Notifying and—if requested—repairing apparent leaks or deficiencies on customer-side.
- Obtaining cathodic readings on customer risers and replacing anodes if necessary.

CVR Gas Utility operates an extensive Supervisory Control and Data Acquisition (SCADA) system. Due to the scale and nature of the system it is critical that it is monitored 24/7/365. Numerous SCADA sites have been established throughout the system, to provide near real-time data on system pressures, alerts for potential issues, and full reporting on gas flows for system balancing and leak detection. SCADA sites typically operate off solar-power and report via radio or cellular connections. Checking meters are tied to the SCADA system and are used to confirm volumes, isolate portions of the system for balancing, and identifying potential areas of concern with regards to gas loss.

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APPENDIX B

Case Studies

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Appendix B: Case Studies

1 Case Study 1: Oil Producers Compressor Vent Gas Recovery and Interconnection

Project Overview:

In 2016, CVR Gas Utility reached an agreement with Producer and Gas Alberta for recovery and sale of gas from an Oil Producers Compressor to the CVR Gas Utility distribution network at tap 20. The project involved the connection of a skid-mounted Regulate, Monitor, Odorize (RMO) unit connected to an pre-existing Oil Producer compressor. This connection to the Oil Producer was obtained and constructed in December 2016 and has become a major supplier of gas onto CVR Gas Utility' Tap 20 system (CVR Gas Utilities main high-pressure infeed point).

By pressure, this source now takes priority over the ATCO supply. In the winter months ATCO supplies 75,000 GJ/month and the Oil Producer supplies 25,000 GJ/month. In the summer months ATCO supplies 13,000 GJ /month and Oil Producer supplies 25,000 GJ/month. Tap 20 is a main service point for the network served by the ATCO transmission line and is the highest volume tap served by Gas Alberta. The project required installation of 6,200 meters of 4" steel pipeline and a tap facility.

Technical/Economical and Environmental Evaluation of Case Study 1:

1. Technical challenges:
    - The volume of methane available in this project required connection to CVR Gas Utility's high-pressure backbone infrastructure. Due to the distance covered from the gas source, size of the infrastructure, and volumes required, it was required to operate on the high-pressure backbone at 400 PSI. Gas needs to travel a long distance on this tap from the gas inlet and there are several large customers at the furthest point from the Tap 20 high pressure inlet:
        - Approximately 30km north of the Oil Producer source, CVR Gas Utility has a 2,900m 50mm Aluminum Line serving the Husky Marwayne Battery, which sees max loads of 15 MCF/h and requires a high pressure to accommodate demand.
        - Another 7 km north a Hutterite colony in the same area is served off a 38mm aluminum pipeline.
        - North of the North Saskatchewan River another 15km of 50mm Aluminum system that operates at 300 PSI and typically sees flows of 5-7 MCF/h, but as much as 17 MCF/h must also be serviced. This system serves numerous low-pressure residential and industrial systems north of the river.

2. Operational Challenges:

- Use of recovered gas impacts CVR Gas Utility's purchasing of firm gas supply service commitments made through the contracted ATCO gas supply thereby increasing the risk of incurring higher rates for gas from ATCO.
- Increasing contributions of gas onto Tap 20 in the summertime required CVR Gas Utility to supply other taps to deal with excess gas.

3. Technical Benefits:
    - Integrating the Oil Producer gas on Tap 20 improved the gas available on the line and reduced the requirements for bringing additional gas from connected taps.
    - Additional gas supply is available from this compressor and can help to meet the growing demands on Tap 20.

4. Economic Benefits:
    - Establishment of dedicated high-pressure compressors is typically not feasible/economical for producers for smaller volumes of vent gas., In this case the compressor was in use for a similar service: the sale of recovered gas to ATCO. The project allowed the producer to continue to operate the compressor at a profit even with low gas throughput (operating at 30% of capacity).
    - If CVR Gas Utility were able to acquire the Village of Kitscoty franchise and infrastructure from ATCO, it could add a major customer base/volume boost on Tap 20 and therefore have a more consistent use for the gas available from the Compressor.

5. Environmental Benefits:
    - The 25,000 GJ of gas that is recovered and used in the CVR Gas Utility distribution effectively offset 1,265 tCO_2E of carbon emissions from gas that would have been flared on the well. Although this gas is eventually combusted in residential homes and industrial facilities, the recovered gas offsets gas that would otherwise have to be produced from conventional wells.
    - Because the Oil Producer compressor is currently underutilized, it could be used to add additional gas to the system. This provides an opportunity to economically recover gas from several producers within the vicinity and reduce the amount of flaring and venting in the region (Lloydminster to the North Saskatchewan River).

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2 Case Study 2: Grouped Oil Wells Vent Gas Recovery and Interconnection

Project Overview:

In 2016 an oil producer contacted CVR Gas Utility looking for possible solutions to an estimated 18,000-19,000 m^3/day of excess gas being vented from a group of oil wells within the Vermillion River County franchise area. The value of the gas was estimated at $ per year. The wells had been in operation for 10-20 years, and the CVR Gas Utility has had a pipeline system in place between the wells since 2001. The existing utility pipelines allowed the oil producer to utilize vent gas generated from the connected wells to operate equipment (burners, engines, etc.) on the well sites. Presumably any gas in excess of what the wells had been using was vented to atmosphere as there was no flare.

The oil producer requested that CVR Gas Utility look at either:

1. Constructing a pipeline system to move the gas to an existing facility owned by the oil producer that was a "high-volume" user on CVR Gas Utility gas system; or
2. Moving the gas to a point where CVR Gas Utility could purchase and use the gas on the CVR Gas Utility general distribution network.

As the facility was not a high enough gas user to accept all of the gas, CVR Gas Utility looked for a solution that would allow the oil producer to sell onto the utility distribution system. The utility was able to come up with a plan that would allow the oil producer to supply both the utility's general distribution network and their own facility.

The proposed solution involved the following:

- Construction of 7,000 m of HDPE pipeline at an estimated cost of <$300,000[1]
- Tying into another existing pipeline system, owned by a third party, to move the gas to a compressor that fed gas onto CVR Gas Utility's distribution system. The oil producer would supply and operate the compressor.
- Establishing contracts for purchase of the gas and associated tariffs

The pipeline owner was contacted regarding the proposed project and immediately responded favourably. In addition to the quote for construction of the pipeline, CVR Gas Utility provided the oil producer with a scenario and projections for payout of the proposed project, as follows:

- The gas would be added onto a component of the utility's distribution system on which the oil producer currently uses approximately. 20,000 m3/day.
- For all the gas added onto the system up to their total monthly usage. the oil producer would pay only transportation tariffs totalling $1.00/GJ rather than purchasing the gas (as they currently do) for an average price of $3.57/GJ.

[1] Estimated cost was for construction of the pipeline only (riser to riser) and did not include any cost for onsite compression, tie-in, etc.)

- The oil producer would buy any additional gas they used from CVR Gas Utility at the standard rates. In the event that the oil producer added more than their usage, CVR Gas Utility would purchase from the oil producer at wholesale rates.

Overall, the plan was that the oil producer would use the CVR Gas Utility distribution network as a transportation system to move their own vent gas to their sites that were currently using gas purchased rom other suppliers and sell any additional gas to the utility for profit.

The projected savings (based on current use rates paid to CVR Gas Utility) for the oil producer were approximately $45,000/month less the small processing fees that would be payable to the third-party pipeline owner for utilizing their pipeline and compressor.

Instead of carrying out the project, the oil producer elected to construct their own pipeline to a new flare and burn off the excess gas. They indicated that they may want to pursue this project at a later date.

Technical/Economical and Environmental Evaluation of Case Study 2:

This project was a clear example of the opportunity to effectively collect associated natural gas and use it to both reduced carbon emissions and create value for both the producer and the utility. The project offered multiple challenges/benefits to both the producer and the gas utility, including:

Technical Challenges

- Intermittent supply could cause distribution system imbalances and operational challenges,
- The recovered gas may require treatment before being distributed commercially (for instance, H2S removal, water removal, addition of odorant)
- Low gas supply pressure,

Economic Challenges:

- Cost of natural gas is low, so the payback period is long.
- Oil producers have limited interest in applying capital to non-core and long payback projects.
- The project investment risk is high. Potential return is based on long-term vent gas production and oil well economic viability.
- On peak demand days, tap 20 exceeded the firm service commitment resulting in additional tariffs/penalties to Gas Alberta.
- Investment and agreement on gas recovery projects between multiple producers can be challenging,
- Carbon offset credits were not pursued as they were deemed as not applicable, because the gas supply sources were over the 900 m3/day maximum Directive 60 requirements,
- Although there is a large carbon benefit to capturing and using natural gas versus flaring the gas. There is no carbon pricing mechanism that provides incentives for capturing and using vent gas over flaring vent gas.

Environmental Challenges:

Technical Benefits:

- Currently there are inadequate backup sources of gas for customers on Tap 20, so failures that could potentially result in loss of service to many customers. The additional gas supply would provide backup to Tap 20.
- High-quality vent gas is available, and the gas supply is readily useable by utility customers.

Potential Economic Benefits:

- Long-term income opportunity for the oil producer.
- Additional revenue stream for all three parties
- The oil producer would otherwise have to invest in group combustor infrastructure. The infrastructure investment would likely have been similar with exposure to OPEX costs.
- Use of existing natural gas transmission infrastructure reduces implementation costs,
-

Environmental Benefits:

- The oil wells are a large source of carbon emissions for the oil producer.
- CVR Gas Utility has past success with the use of recovered vent gas from compressor stations and has identified further opportunities.
- Significant greenhouse gas reduction and air quality improvement in the region.

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3 Case Study 3: Excess Gas Sale to Oil and Gas Producer

Project Overview:

CVR Gas Utility has many industrial operators that consume a large amount of gas on a consistent basis throughout the year. This consistent use of gas helps to ensure an even demand on CVR Gas Utility's system. Increasing the number of industrial customers on CVR Gas Utility's system would help considerably in ensuring a consistent gas demand for recovered gas.

One potential industrial off-taker is closely located Oil and Gas Producer. The Oil and Gas Producer is a large consumer of natural gas. Due to its age and relatively small production, the producer has a higher carbon emissions intensity than other oil producers in the province as illustrated in Figure 9. Utilization of recovered natural gas could have a significant impact on the overall carbon emissions of the Oil and Gas Producer if the recovered gas could be shown to have a lower carbon intensity.

Conceptually, CVR Gas Utility could deliver recovered natural gas to the Oil and Gas Producer through Oil and Gas Producer's own pipeline system that starts in the NW, Elk Point, area of the utility's distribution network and terminates at the Oil and Gas Producer. This pipeline is currently underutilized and crosses all the County's major high-pressure systems. In addition, the Oil and Gas Producer has indicated they have a large amount of stranded gas in the region.

This type of industrial user is ideal for connection with large recoverable natural gas sources; however, the potential opportunities, challenges and risks of this project are significant. CVR Gas Utility has experience with the takeover of natural gas pipelines, in 2012 the utility took over the Christopher Lake Pipeline from Devon to supply industrial customers and, potential future residentials, and for system backup for Tap 20. This project has been a success for CVR Gas Utility both financially and technically, currently CVR Gas Utility sells around 30,000 GJ/Month through this pipeline.

Technical/Economical and Environmental Evaluation of Case Study 3:

This project would provide a large demand for recovered natural gas from CVR Gas Utility and illustrates the opportunity available with the identification and development of demand opportunities in the region. The project offers multiple benefits/challenges to both the producer and the utility, including:

Technical Challenges

- Coordinating a "varying recovered gas supply" with a "varying Oil and Gas Producer demand" between multiple producers.
- Gas supply pressure to the Oil and Gas Producer requiring investment in and operation of additional compressors.
- Gas contracting for a large industrial consumer requires a more coordinated effort to balance the distribution system.

Economic Challenges:

- The oil and gas producer is a valuable customer for ATCO and may have corporately-negotiated rates that could be challenging for CVR Gas Utility y to compete with, even with recovered gas.

- Gas contracting for a large industrial consumer could require more coordination.
- The cost of natural gas is low making capital investments for purchasing and upgrading the Oil and Gas Producer's pipeline challenging.

Environmental Challenges:

- Carbon offset credits are likely not available as the gas supply sources are likely over the 900 m3/day maximum, Directive 60 requirement.
- Although there is a large carbon benefit to capturing and using natural gas versus flaring the gas, there is no carbon pricing mechanism available at this time that will provide the Oil and Gas Producer an economic advantage to using the vent gas over flaring that same vent gas.

Technical Benefits:

- Provides a large consistent industrial gas user to take an majority of recovered natural gas.
- In the past ATCO has had challenges with peak usage on their transmission line that supplies both CVR Gas Utility and the Oil and Gas Producer. Using other Gas Producer's recovered natural gas through the Oil and Gas Producer's pipeline could solve this peak capacity issue for ATCO.
- Provides a secondary source for gas to the large industrial facility.
- Gas quality is less of concern for the large industrial facility than for retail customers. The Oil and Gas Producer does not require the same specifications as sales gas, so a variety of vent gas may be used.

Economic benefits:

- Long-term investment opportunity for the Oil and Gas Producer and CVR Gas Utility.
- Connects an underutilized existing natural gas pipeline to a potentially lower cost gas source.
- The Oil and Gas Producer likely will need to invest in infrastructure to combust vent gas sources anyway – this project provides infrastructure investment that may have much better economics.
- Based on the federal carbon-pricing backstop requirements, reduction in carbon emissions from production sites could have a value of as much as $50/tonne when the carbon price is implemented for oil and gas producers in 2023.

Environmental Benefits:

- Oil and Gas Producer is a large producer in the area and these production sites are a large source of carbon emissions. This project could effectively eliminate a large amount of carbon emissions from the production sites.
- CVR Gas Utility has excellent track record in pipeline monitoring and leak repair. If the utility takes over the Oil and Gas Producer pipeline it will be maintained and managed.
- This project provides significant greenhouse gas reduction and air quality improvement in the region.

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4 Case Study 4: Use of Recovered Gas to Help Supply Neighboring Gas Utilities

Through discussions with neighboring utilities, CVR Gas Utility has identified that gas supply to the northeast of their service territory has supply limitations. Though there are some distance/topography challenges, CVR Gas Utility could, with additional supply of recovered gas, supply these neighbouring utilities. This would likely require CVR Gas Utility to make investments in transmission infrastructure to move gas up to that area.

One transmission investment available to supply gas to the north end of the existing distribution system is the purchase of an unused Devon pipeline. This pipeline could provide the following potential benefits:

- Potential to reduce pressure on the Tap 20 backbone system. Lower pressure on this system would significantly increases the amount of vent gas recovery options as the high-pressure compressors are typically the largest capital and operating costs. A lower- pressure backbone system makes a number of vent gas locations throughout Tap 20 economical.
- This pipeline would provide backup for customers north of the North Saskatchewan River who are currently supplied from a pipeline source (attached to the Lea Park HWY 897 bridge).

Technical/Economical and Environmental Evaluation of Case Study 3:

This project would be a win/win solution in that it would provide additional supply to the neighboring utilities and increased demand for recovered natural gas from Vermillion River County. This project offers similar benefits/challenges as interconnection with the Oil and Gas Producer pipeline. Only the additional key points are illustrated in the analysis below.

Technical Challenges

- Neighboring utilities share the same challenge of low summer demand and may not improve the “oversupply” challenge of using recovered gas in summer months.
- Gas quality is a concern for the residential customers and may require additional infrastructure to ensure that the recovered gas meets sales gas specifications.

Economic Challenges:

- The lower quantity of natural gas supplied to the northern utility, compared to the Oil and Gas Producer example, may make the capital investment more challenging.
- Utility customers pay the same carbon levy for recovered natural gas.

Technical Benefits:

- Increasing the size of the distribution system will help even-out the supply and demand balance for the overall distribution system.

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5 Case Study 5: Application of CNG and LNG

In an effort to offer lower carbon intensity fuel and increase natural gas utilization, the County of Vermillion River has embarked on a pilot project to convert the county vehicle fleet to natural gas. The county believes that conversion of the county vehicle fleet to compressed natural gas and bi-fuel would provide a significant cost savings and a greatly reduced environmental impact over the present gasoline/diesel fleet (Figure 9).

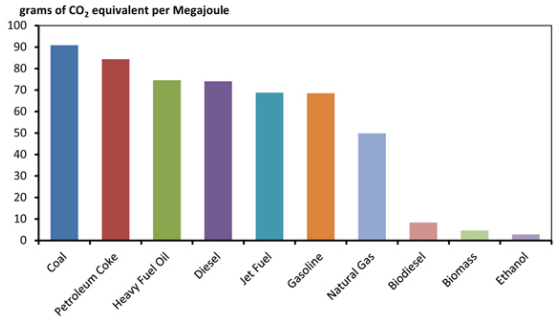

Figure 10 - Carbon Intensity Comparison of Various Fuel Types ("Canada's Energy Future" NEB 2016)

In 2017, Council approved a pilot project for conversion of two light trucks to bi-fuel and purchase of a time-fill natural gas compressor. The County of Vermillion River has scheduled four more vehicles to be converted in 2018 and is reviewing conversion of their gravel haulers. The pilot is scheduled as a three-year project, managed and monitored by the CVR Gas Utility. The results are regularly reported to Council throughout the project, with a full report and recommendation provided to Council at the end of each of the three years. Reporting will highlight the success or failure of the pilot project by comparing actual data against the assertions presented in this business case.

Figure 11 - Current County CNG Infrastructure

Economic Challenges:

- CNG and LNG have a variety of additional capital and operating costs to be considered. The primary challenge is the cost of compression vs. the savings in the fuel costs. With this type of investment capital costs remains constant and fuel cost savings can vary significantly (Figure 15).
- Achieving the required utilization of CNG/LNG volumes is another key challenge. Due to many factors the utilization of CNG/LNG at certain times may not be high enough to justify the county's CAPEX/OPEX spend on the CNG/LNG facilities.

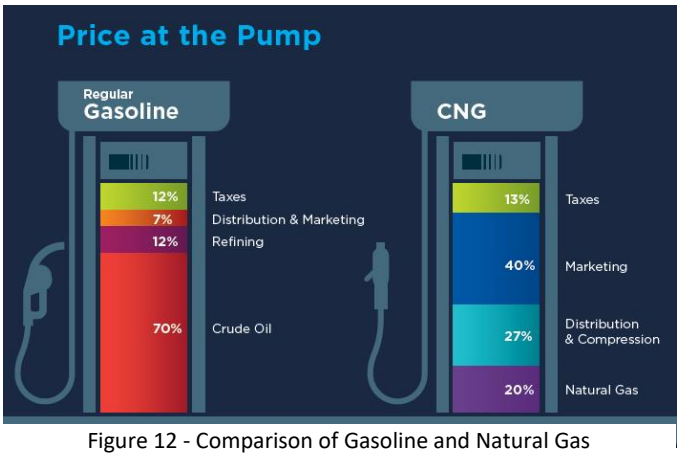

Figure 12 - Comparison of Gasoline and Natural Gas

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- LNG facilities are generally not economical at a small scale. The county's smallest options for LNG are likely in the 20,000 GPD range. This challenge is not easy to overcome as the county must secure contracts for the LNG before construction of an LNG facility. Fortis and Gaz Metro utilize incentive funding to secure off takers for LNG.
- Large capital infrastructure is required which also requires a long- term investment horizon,
-

Environmental Challenges:

- Some CNG/LNG infrastructure has faced social criticism regarding the safety of the technology and requires public engagement to illustrate the hazards.
- Air quality monitoring around the CNG/LNG terminals is required.

Technical Benefits:

- The CNG/LNG facility can be connected to large sources of recovered natural gas and provide a large and consistent gas user the recovered natural gas year-round.
- The project develops knowledge of the technology and internal capacity for operating CNG/LNG generation within Vermillion River County.
- Addition of CNG/LNG storage can be used as a "gas reservoir" to help balance the system for peak supply management.
- CNG/LNG is a proven technology that has numerous applications worldwide providing fuel option for industrials and centrally dispatched, short-haul trucking and vehicle fleets.
- CNG/LNG can be used as a "virtual pipeline" offering a fuel supply for large off- grid energy-consuming clients,
- Oil producers are well suited to use CNG/LNG for use in a variety of applications including:
    - Fuel supply for remote operations, well development and fracking,
    - Mobile equipment fleets,
    - Power generation,
    - Potential application of LNG as a fracking fluid,
- Other potential large off takers include Industrials, greenhouses, and seasonal grain drying,

Economic benefits:

- CNG/LNG is typically sold on a value-added long-term supply contract that produces revenue from both the commodity and infrastructure.
- Strong long-term business case for investment in CNG/LNG gas fuel supply due to long term "low price" stability vs diesel.
- Reduces industrial GHG emissions therefore lowering corporate carbon tax.
- Tax breaks and Incentives for businesses investing in low- carbon energy infrastructure.
    - Alberta Capital Investment Tax Credit (CITC)
    - Federal Accelerated Capital Cost Allowance (ACCA)

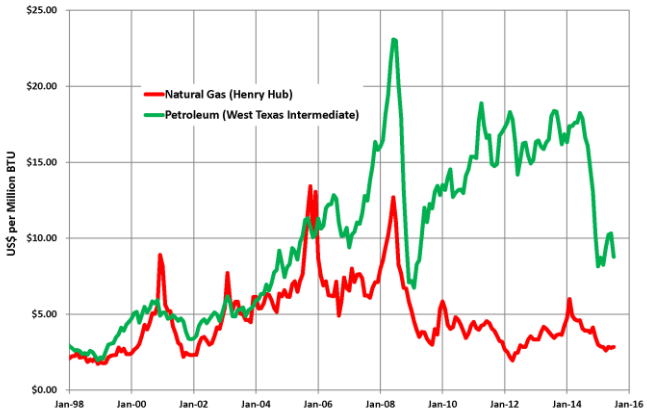

Figure 13 - Cost Comparison on an equivalent energy basis

- Historically, when compared to diesel, compressed natural gas (CNG) and liquefied natural gas (LNG) users save 25% to 50% in fuel costs (See figure 15).
- Presents a long-term investment opportunity for the County of Vermillion River.
- Based on the federal carbon pricing backstop requirements, the reduction in carbon emissions from production sites could have a value of as much as $50/tonne when the carbon price is implemented for oil and gas producers in 2023.
- Opens additional markets for sale of natural gas including:
    - Filling stations for temporary gas supply demands (pigging)
    - Low-cost diesel replacement for remote oil and gas producer sites (wells, drill rigs, etc.)

Environmental Benefits:

- Natural gas is the cleanest burning of all the fossil fuels. Burning of gasoline produces 5.178 lbs of CO2 per liter. The energy equivalent of natural gas produces only 3.915 lbs of CO2.
- It is estimated that converting only 15 vehicles could provide 50 tCO_2e/yr in carbon reductions over the standard diesel/gasoline vehicles. Converting a larger system, such as the frack spreads, could reduce carbon emissions by reduce thousands of tonnes per year.
- Reduced particulate, NOx and other air emissions versus gasoline/diesel combustion.
- This project provides significant greenhouse gas reduction and air quality improvement in the region.

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APPENDIX C

Energy Efficiency Opportunities

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Appendix C Energy Efficiency Opportunities

SysEne recommends that Vermillion County consider implementing the following system efficiency projects.

1. Improved SCADA for system measurement and reporting

CVR Gas Utility currently has approximately 65 sites which report pressure and flow information to their SCADA server, as well as generating alerts based on industry standard thresholds. Most of the SCADA sites operate off solar power and/or batteries. The utility is beginning to the assess the benefits and implications of moving to increased use of SCADA for control of the distribution system, including actuation of valves and regulators. SCADA is an important tool to ensure the successful integration of recovered gas as it is a real-time control to deal with fluctuations in flow and pressure as recovered gas supply increases. Improved metering and analysis with the SCADA can provide system leak detection which will reduce gas losses.
A majority of the CVR Gas Utility's SCADA communicates via unlicensed radio frequency (the remainder communicates via cellular). CVR Gas Utility plans to move to a licensed band, which will increase the reliability of communication.

Figure 14 - Fired Heater

2. Ensure best practices being followed for fired heaters

CVR Gas Utility currently has eleven line heaters in operation. Six of the line heaters use a heating system called Cold Weather Technologies – Heat Driven Loop heaters. These heaters, which are quite efficient, use the steam-to-vapour reaction in a vacuum to heat the coil through which the gas line travels (see Figure).
Five of the line heaters are the glycol bath-style. The burners on these heaters have been upgraded to Kenilworth U 0.25 PHM heaters to meet current code. Burners are solar/battery powered (see Figure .)

Figure 15 - Natural Gas Fired Heater

SysEne

3. Energy recovery from pressure letdown

Gas letdown generator are a potentially economical solution to recovering energy from applicable to natural gas pressure reduction stations. The energy recovery occurs in an engine the recovers the waste energy from the pressure drop and converts it into electricity. The technology for pressure letdown energy recovery is well developed; modules use off-the-shelf turbine components that have a proven history of reliable, robust, low-maintenance performance. However, they require a capital investment as well as annual maintenance costs, and may not be able to handle fluctuations in flow rates and pressure.

Figure 16 - Pressure Letdown Energy Recovery Turbine