Qnergy
Reliable Remote Power

CAaaS

Compressed Air as a Service

Cost Effective Clean and Reliable Remote Power with Compressed Air that facilitates Methane Emission Reductions.

SUMMER 2020

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About Qnergy

Qnergy is the world's leading clean technology manufacturer of Stirling energy systems. Qnergy provides reliable, remote power generators, for the 500W-10,000W range, to help customers improve operational efficiency, decrease cost, and reduce emissions. Qnergy's Stirling Engines are enclosed systems that require no lubrication, maintenance, or repair, delivering tens of thousands of hours of uninterrupted operation.

Learn more **qnergy.com**

Executive Summary

Background

The natural gas industry is facing an unprecedented combination of pressure to reduce methane emissions, during an overall economic downturn, and with exceptionally low commodity prices. There is a proven and straightforward solution for eliminating about 20% of the industry's vented emissions. These 20% are located at sites with existing pneumatic high-bleed devices combined with remote or unreliable grid electrical power. Traditionally, companies address this type of challenge by investing capital, and buying replacement equipment out of a CapEx budget. However, in the current circumstances, capital expenditure is a barrier, especially with activities that are not core business objectives. Compared with the many options available, the Qnergy power generator and air compressor package, combined with Qnergy's Compressed Air as a Service (CAaaS) financial offering is a clearly superior solution in all aspects of your decision process.

The Problem

A large portion of an operator's GHG emissions are related to bleeding pneumatic devices. These devices use natural gas to activate valves and pumps. Every time a device changes a state, it bleeds-off natural gas, which is mostly methane. Instrument Gas (IG) devices are devices powered by pressurized natural gas that are widely used in the industry, mainly for process control and chemical injection. Familiar examples are pneumatically actuated valves, pressure, and level controllers. These devices vent spent gas (i.e. methane) directly into the air. Many jurisdictions are implementing regulatory requirements to reduce or eliminate venting from these devices.

The Solution

Using unprocessed wellhead gas (saving the typical costs associated with tanked fuel) Qnergy's Stirling-based generator [1], the PowerGen (PG5650), enables the production of clean Instrument Air and utility-grade power. Qnergy has deployed hundreds of its remote power systems in several industrial sectors.

One of many advantages of the Stirling-based external combustion generator is a very low maintenance requirement. Compared to an internal combustion engine the Stirling engine is sealed from the combustion gases and requires no oil changes, filter changes or field overhauls. Qnergy offers a 3-year engine warranty, as part of the compressed air package.

1 Free Piston Stirling Engines https://www.qnergy.com/wp-content/uploads/2019/04/stirling_whitepaper.pdf

The superior system reliability of the Qnergy engine package was not achieved overnight. It is based on the mechanical design that Qnergy's engineers have developed during more than three decades. According to a NASA press release, this design is "the most reliable heat engine ever invented" [2]. The generator drives an air compressor directly and eliminates the need for battery banks, further minimizing conversion losses.

The GHG efficiency of the Qnergy package is outstanding. At a very conservative $5/tCO$_2$e, an IGIA (Instrument Gas to Instrument Air) project with a Qnergy package is one of the most cost-effective GHG mitigation strategies [3]. This cost/tCO$_2$e is second only to leak detection and repair (LDAR), as seen by various marginal abatement cost curve analysis [4].

The Business Case

To address the challenge of limited available capital to manage existing field operations, Qnergy developed the CAaaS program. CAaaS (Compressed Air as a Service) is an accessible, service-based, compressed-air solution that removes the capital barrier, streamlining the path to emissions reduction and regulatory compliance, which in some markets (mainly Alberta) also translate into saleable carbon credits.

The CAaaS solution is built on three layers:

The CAaaS solution is built on three layers:

Qnergy's Compressed Air Pneumatic (CAP3) product line. The CAP3 product line is proven to have the lowest TCO (Total Cost of Ownership) in the industry. Operators can buy and deploy CAP3 as a conventional capital equipment purchase.

CAaaS – A service model with a simple utility-like service agreement that allows customers to shift the cost burden from CapEx to minimal OpEx.

Carbon emission offset credits that in some locations allow operators to turn methane abatement into a cash-positive activity.

The CAaaS approach offloads operational risks to guarantee long-term operational security while ensuring that an operator's internal resources are fully dedicated to the core business. Furthermore, CAaaS agreements are structured to secure long-term, predictable fixed costs, isolating the operator from volatility or price escalations.

CAaaS helps operators adhere to emission reduction regulations, while maximizing the benefits of GHG incentives, without a large upfront capital outlay. This allows Operators to play both 'defense' and 'offense' i.e., to have a flexible strategy that mitigates risks and allows them to meet compliance requirements **while making money**.

2 Stirling-convertor-sets-14-year-continuous-operation-milestone(2020)https://www.nasa.gov/feature/glenn/2020/stirling-convertor-sets-14-year-continuous-operation-milestone

3 See Appendix for a detailed calculation

4 Qnergy ERR (Emission Reduction Ratio) blogpost: https://www.qnergy.com/benchmarking-methane-mitigation-programs-by-emission-reduction-ratio/

Introduction

The energy industry is faced with several not-so-new, as well as new, unprecedented challenges. One of the most significant of these challenges is that of GHG (Greenhouse Gas) emissions management. Industry is aggressively being challenged by an array of stakeholders around the world to reduce the GHG emissions generated by its production processes. Responding to this challenge, many governments are creating regulations designed to incent industry to reduce its emissions through either economic penalty or reward. Adding to the GHG emissions challenge is the position of the industry in the energy business cycle, the disruption caused by various technological advancements, and the global pandemic. These factors contribute to the industry's current capital constrained position at a time when new technology related investments are required to maintain the industry's viability.

This paper will describe how Qnergy enables its customers to reduce the GHG emissions generated at plant facilities that employ natural gas energized pneumatic devices. Employing natural gas to power plant site devices has been a standard, cost effective practice in industry for decades. In energizing the plant devices, this methodology vents natural gas to the atmosphere, producing a significant part of the industry's GHG emissions. Qnergy replaces the natural gas with compressed air using a self-contained electric instrument air system that can provide additional power and heat for use in the plant as required.

The simplicity, reliability and longevity of the Stirling engine technology minimizes total cost of operation and/or ownership (TCO) for instrument air, while significantly reducing GHG emissions. The robustness of the technology enables a Qnergy package to manage operational risk, offering customers commercial options ranging from a 'pay as you go' scheme to outright capital purchase. The 'pay as you go' service model is enabled by the data infrastructure that is built into the operating units. This data ecosystem performs real-time diagnostics while quantifying system duty levels to determine exactly how much service the customer used on location and when maintenance is required.

In addition, the reduction in emissions created by the Qnergy technology can be monetized using region-specific GHG offset protocols, further reducing the total cost of ownership or operation for the customer. Qnergy has created an instrument air offering by adopting proven technology deployed in a simple, state of the art IoT communication package that tells you what the product is doing and how it is performing at all times.

The Challenge

The Billion Dollar Challenge of switching Instrument Gas to Instrument Air (IGIA)

According to the International Energy Agency [5], about 40% of the methane vented by the North American Oil & Gas industry can be replaced with Instrument Air. Qnergy estimates that about half of those installations do not have a connection to a stable grid (about 50% in the U.S. and a larger percentage in Canada), leading to a ballpark estimation of 20% (651 ktCH4) of the industry's vented emissions, that are off-grid and can be addressed with Instrument Air, as Illustrated in Figure 1. According to the same dataset, Canada's off-grid emissions that are replaceable with Instrument Air (I/A) amount to 122ktCH4, which is 27% of the vented emissions in the country.

North America Gas Industry - Methane Emissions (ktCH4)

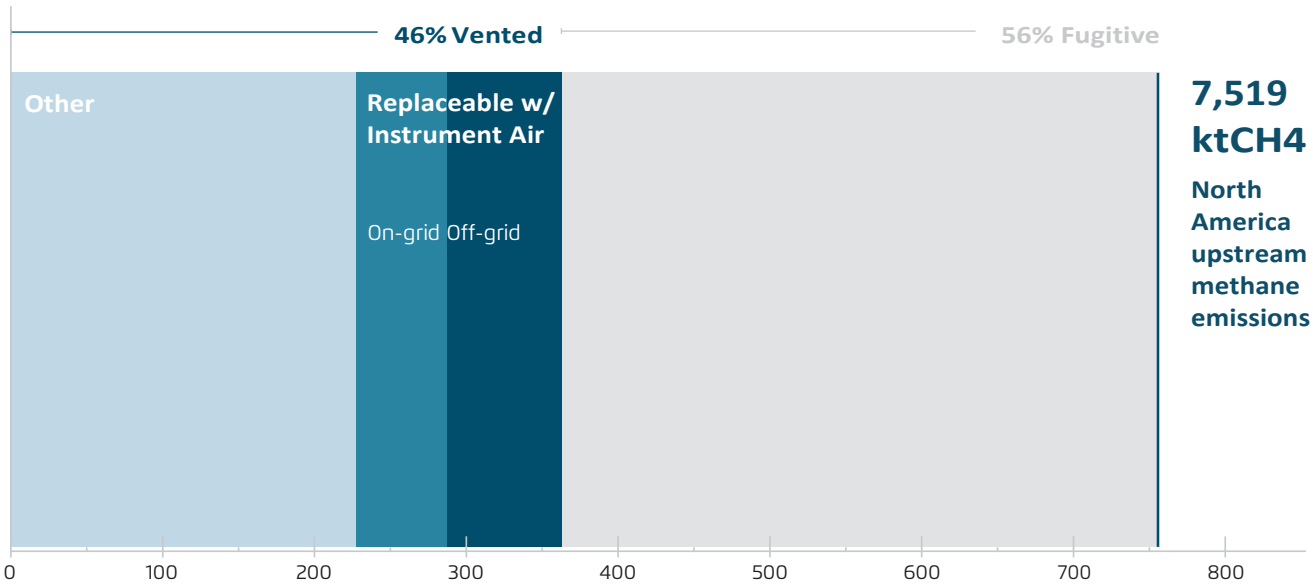


Figure 1. 20% of North America's Gas Industry's Off-Grid Vented Emissions can be Replaced by Instrument Air. The values are based on the IEA (International Energy Agency March 2020: https://www.iea.org/weo/methane/database/) and represent an order of magnitude only.

5 International Energy Agency March 2020 (2019 data): https://www.iea.org/weo/methane/database/

A significant fraction of these emissions is related to bleeding pneumatic devices. These devices use natural gas to activate valves and pumps. Every time a device changes a state it bleeds-off natural gas, which is mostly methane. Instrument Gas (IG) devices i.e., devices powered by pressurized natural gas are widely used in the industry. Mainly for process control and chemical injection. Familiar examples are pneumatically actuated valves, pressure, and level controllers. These devices vent spent gas i.e. methane directly into the air.

Although, each IG device is a relatively small emitter, collectively IG devices comprise a major source of methane emissions since millions of IG devices are used in the oil and gas industry worldwide. There are about 250,000 IG devices in the U.S. alone [6]. IG devices with emissions greater than 6 scfh (standard cubic feet per hour) or 0.17 m3 per hour are considered high-bleed.

The requirement to reduce emissions pose a technical challenge: how to eliminate hundreds of thousands of relatively small emitters that collectively aggregate to a large number.

Operator Specific Challenges:

- How to meet current and future GHG/methane/VOC regulation related to their gas driven pneumatic devices
- How to choose amongst the various technical options available
- How to provide reliable power supply in remote locations
- How to manage spending in a very capital constrained period
- How to reduce manpower and maintenance requirements at remote sites
- How to ensure safe and reliable operations
- How to maximize the potential value of GHG offsets in jurisdictions that include these as a compliance option

6 Natural Gas Flaring and Venting: State and Federal Regulatory Overview, Trends and Impacts (2019) https://www.energy.gov/sites/prod/files/2019/08/f65/Natural%20Gas%20Flaring%20and%20Venting%20Report.pdf

The Qnergy Solution

Qnergy provides a product that:

- is a perfect fit for remote sites with existing pneumatic devices
- has a flexible offering that significantly minimizes cost of ownership
- is simple to install and operate, minimizing complexity and maintenance
- has a 3-year engine warranty
- has been extensively proven in the field
- has the best reliability and ESG performance

The solution is CAP3 (Compressed Air Pneumatics), replacing natural gas as a source of power with instrument air. To fund the deployment of CAP3, Qnergy offers the CAaaS program. Operators that deploy the CAP3 system under CAaaS shift CapEx into OpEx reducing both cost and methane emissions, while retaining capital for activities that help topline growth.

The CAaaS program has no long-term commitment. It can be stopped at any time. The program is typically cash positive with carbon credits. The management of the carbon credits can be handled either by the operator or assigned to Qnergy to manage.

The Critical Missing Component: Utility-Grade Power on Site

Air compression requires power. However, nearly half the sites in the U.S. and a larger percentage in Canada are not connected to a stable grid. With reliable power, the instrument air challenge is readily solved. The CAP3 (Compressed Air Pneumatics) system uses the reliable power provided by Qnergy's PowerGen system to bring to site dry compressed air.

The CAP3 product efficiently combusts unprocessed wellhead gas and provides reliable electric power as well as clean, dry instrument air.

The CAP3 (Compressed Air Pneumatics) concept is illustrated in Figure 2.

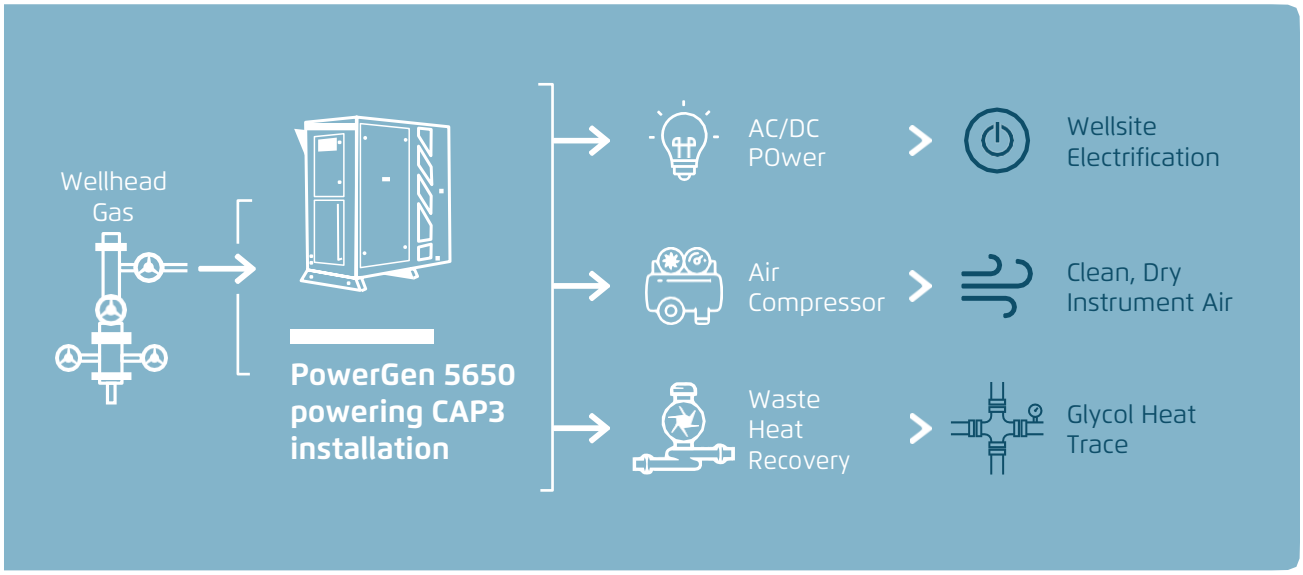


Figure 2. The CAP system brings Utility-Grade power to Site. CAP provides compressed-air, power, and optionally heat to off-grid locations. The fuel is unprocessed wellhead gas.

Using unprocessed wellhead gas (saving the typical costs associated with tanked fuel) Qnergy's Stirling-based PG5650 generator [7] enables the production of clean Instrument Air and utility-grade power.

One advantage of the Stirling-based external combustion generator is the very low maintenance requirement. Compared to an internal combustion engine the Stirling engine is sealed from the combustion gases and requires no oil changes, filter changes or field overhauls.

The superior system reliability was not achieved overnight. It is based on the mechanical design that Qnergy's engineers have developed over the last three decades. According to a NASA press release, this type of engine design could be 'the most reliable heat engine ever invented' [8]. The generator drives a direct AC compressor and eliminates the need for battery banks, further minimizing conversion losses.

The Glycol Heat Trace option uses some excess heat produced by the Stirling engine to circulate a glycol loop throughout the facility, enabling operators to maintain temperature in process lines during cold weather conditions. As tested by an Oil&Gas major in Canada, the overall system efficiency in this configuration exceeds 30%.

The PowerGen is the backbone of Qnergy's Compressed Air Pneumatics (CAP3) solution [9]. CAP3 includes a variety of features that ensure successful deployment. Besides the PowerGen, the system includes a duplex configuration of low maintenance robust compressors; an integrated air dryer; an HMI for local

7 Free Piston Stirling Engines https://www.qnergy.com/wp-content/uploads/2019/04/stirling_whitepaper.pdf

8 Stirling-convertor-sets-14-year-continuous-operation-milestone(2020)https://www.nasa.gov/feature/glenn/2020/stirling-convertor-sets-14-year-continuous-operation-milestone

9 Compressed Air Pneumatics - CAP3 https://www.qnergy.com/wp-content/uploads/2020/04/Qnergy_Instrument-Air-Solutions_2020.pdf

data review and control; Gas flow measurement for mitigation reporting and carbon credit generation; a Gas Conditioning Unit (GCU) to protect against liquids in the gas inlet and air tank (typically 80 Gallon).

The CAP3 system comes in three standard configurations to cover the range of potential uses and different climates. These configurations are illustrated in Figure 3.

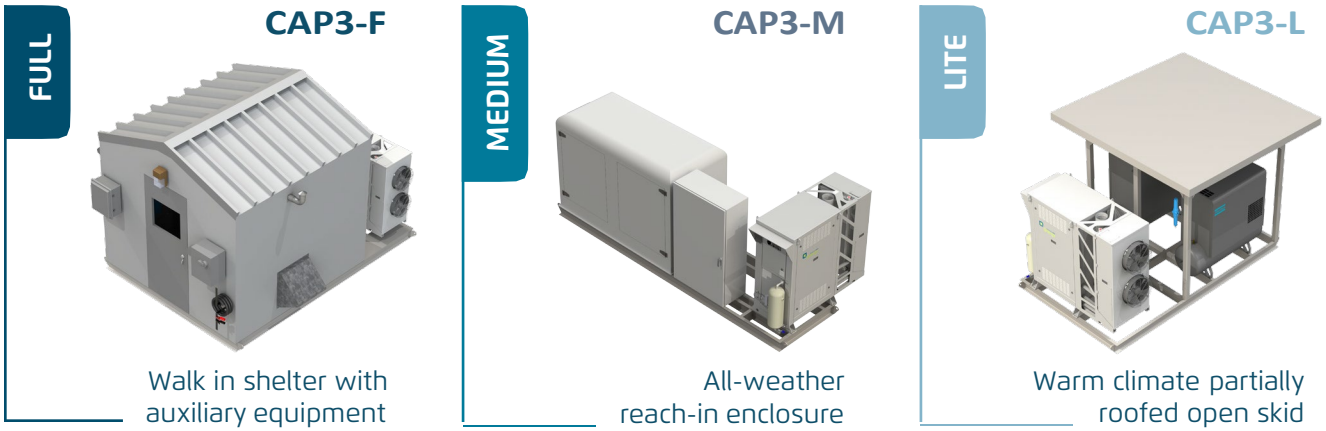


Figure 3. CAP3 Configuration: CAP3-F (Full walk-in shelter with auxiliary equipment); CAP3-M (All-weather reach-in enclosure) and CAP3-L (Warm climate partially roofed open skid)

Figure 4 shows a CAP3 'FULL" installation in Canada. In this specific configuration, the customer specified 500 scfh of instrument air, 1,200 Watt of power and 40,000 Btu/h of heat. All were supplied seamlessly throughout the winter.

Figure 4. Full-skid deployment during winter providing 500 scfh of instrument air, 1,200 Watt of power and 40,000 Btu/h of heat

CAP3 is not the only Instrument Air option, but it is superior in terms of reliability, environmental performance, and Total Cost of Operation (TCO).

Most Instrument Air options fall into one of two categories: low power and high power, while the industry actually requires a medium power solution somewhere in the middle.

On the low-power side, operators find that demand for high airflow and excess power deem the incumbent technologies uneconomical. These technologies include Thermoelectric Generators (TEG) and Fuel Cells in combination with a battery bank and off-grid photovoltaic. TEGs are relatively reliable but low-power

and inefficient (leading to high emissions), while Fuel Cells are efficient, but require tanked fuel and have a short stack life. Both are prohibitively expensive when the power requirements cross the 3-4kW mark.

On the other side of the spectrum are Microturbines, which are both efficient and reliable, but are oversized for most IGIA applications, leading to high cost and high emissions.

Unaware of the possibilities, operators historically would gravitate towards conventional Gas Generators that use Internal Combustion Engines (ICE) with hybrid packages modified for on-site wellhead gas and air compressors. These configurations lead to extensive maintenance visits that make the long-term viability of this approach impractical [10]. From the environmental performance standpoint, Qnergy emits less than 1% of the NOx and CO that characterizes Internal Combustion Engines [11].

Solving the commercial challenge

CAaaS: Utility-Like Service Agreement Without Long-Term CapEx Commitment

The second layer of Qnergy's solution is a simple service agreement that eliminates upfront CapEx commitments. With limited capital resources to allocate, especially during a downturn, many operators are faced with a difficult capital allocation choice. Under CAaaS, the answer to this question is simple: invest in both—reduce liabilities while improving both financial and environmental performance.

Reducing the up-front capital commitment

By shifting from the conventional CapEx approach to an OpEx model, CAaaS enables deployment during a downturn. It allows customers to reap the cost savings and emission reduction offered by air compression, while freeing up capital for other investments central to other aspects of their operation.

Summarizing customer testimonials:

The top ten qualitative advantages of the CAP3 product over repackaged Internal Combustion Engines are:

1. No reciprocating compressor boosts reliability and longevity	2. Superior sour fuel gas capability	3. No solar hybridization required. Superior environmental performance with a small footprint	4. Three years engine warranty
5. No UPS and oversized batteries required	6. No tanked fuel supply required	7. Zero oil changes, low maintenance	8. Continuous service. Available every month of the year (annual inspection and PM when convenient, not when system fails)
9. No frozen fuel gas issues	10. Remote monitoring with early alerts and 24/7 customer support		

10 Detailed TCO, environmental and reliability analysis is available per request from Qnergy

11 See: https://www.linkedin.com/feed/update/urn:li:activity:6683387630023004161/

Appendix

The total cost to industry, as well as methane reduction per tCO_2e, are illustrated in Table 1.

Parameter	Value	Source
Off-grid CH4 Emissions Replaceable with I/A	651 ktCH4/yr	IEA (North America)
CO_2 equivalence	16 $MtCO_2e$/yr	Factor of 25 (IPCC)
Cars of the road	3.4 million	
Abatement per Qnergy system (CH4)	47 tCH4/yr	Qnergy's field data
Abatement per Qnergy system (CO_2e)	1128 tCO_2e/yr	Qnergy's field data
Number of systems needed	**14,000**	
Typical CapEx	$80,000	Volume estimate
Total One-Time Investment	**$1.1 bn**	
Cost of methane reduction per tCO_2e	**$7/$tCO_2e$**	Over 10 years

Table 1. Estimate of cost and GHG benefits of replacing methane emission in bleeding pneumatic devices with instrument air

The CO_2 equivalence for IGIA projects in North America is about 16 million tons of CO_2e per year. Assuming that an average passenger car emits 4.6 tCO_2e per year, the reduction of methane emissions through IG devices would be equivalent to about 3.4 million cars every year.

According to Qnergy's field data, collected from the company's installations in the U.S. and Canada, the average duty cycle of an IGIA skid is 39%, which accounts to about 47 tCH4 abated per unit per year.

This means that the number of systems needed to solve the IGIA challenge in North America is about 14,000. Assuming a capital price per system of $80,000 U.S., which we can use as a ball-park figure at

volume for a standard configuration [12], we obtain a daunting value of more than $1bn that the industry will need to spend to address the IGIA challenge. At $7/tCO2e, an IGIA project is exceptionally cost-effective GHG mitigation strategy.

To make this value more intuitive - the cost effectiveness of the approach is about two orders of magnitudes higher than switching to an electric car. Assuming that an electric car is purely fed by renewable energy (a favorable assumption) the switch would remove about 4.6 tCO2e per year (each electric vehicle replaces a conventional passenger vehicle). A Qnergy CAP3 system abates more than a thousand tCO2e per year (factor of more than 200), and costs roughly twice that of an electric car. There is a factor of 100 improvement between Qnergy's GHG efficiency in Emission Reduction Ratio, or cost effectiveness in $/tCO2e, relative to an electric car!

The daunting challenge remains: how to finance more than a billion dollars during a global recession and with historically low gas prices?

The solution has three layers:

Delivering a proven solution that is best in class in total cost and reliability, as described above.

Frictionless process: making sure that deployment is simple and meets the financial constraints and decision-making process that operators face in an industry downturn.

Maximizing incentives: more relevant to specific customers and territories, the third layer is about maximizing the utilization of emissions reductions, offset credits, and other incentives.

Reducing legal hurdles with a simple utility-like agreement

The fundamental goal of CAaaS is to allow operators to deploy a solution by removing all hurdles and friction points, especially during budget cuts.

One hurdle is the legal agreement. OpEx agreements are often based on a 'lease-to-own' approach that covers both the 'lease' and the 'own' scenarios. These agreements require extensive attention from legal departments, which are typically too busy managing the other challenges associated with a downturn.

The CAaaS approach is different. The agreement is structured like a standard Power Purchase Agreement. Customers can terminate the service agreement at any point. They can also buy the equipment at any point, but equipment purchase is not part of the service agreement. The service T's and C's are very simple, as illustrated in Table 2. The operator only signs a utility-like agreement.

12 The price of a system depends on configuration and volume. For the current analysis we assume $80,000 U.S. per system at volume and $90,000-$100,000 at introduction

Benefits	
Services	Electrical, air and optional heat
Flexibility	Can switch between Instrument Air (I/A) and electricity to meet needs
Carbon Credits	Certified measurement of I/A and emissions to support credit generation
Warranty	Unlimited warranty and guaranteed performance
Remote access	Unlimited remote access through SmartView [13] (IoT platform)
Support	Unlimited 24/7 support through Qnergy's control center
Payments	
Activation fee	Depending on the CAP3 configuration (CAP3-L; CAP3-M; CAP3-F)
Instrument air	Typically, low single digit U.S. cents per scf
Power charge	Typically, less than one USD per kWh
Heat	Glycol heating up to 50,000 BTU/hr can be added to connection fee
Minimal annual fee	Covers the first million scf
Termination	1 y. agreement. Can terminate w/ 60-day notice or automatically renew

Table 2. The simple terms and conditions of CAaaS

Offloading Operational Risk

The CAaaS approach offloads operational risks to guarantee long-term operational security while ensuring that internal resources are fully dedicated to the core business. Furthermore, the agreements

13 Link to SV brochure on website

are structured to secure long-term, predictable, fixed costs, and to isolate the operator from volatility or price escalations.

The operator is completely insulated from operational risks in three keyways:

1 Qnergy guarantees dry instrument air on-site, enabling the operator to meet regulatory compliance

2. The operator only pays their CAaaS fee if the solution performs as guaranteed

3 Operationally, as a backup, operators can always return to their traditional practices

With guaranteed operational performance, operators no longer sink internal resources into securing instrument-air and electricity to site, including asset procurement, operation, and maintenance. Instead, these resources can be dedicated to high-value activities which grow the business.

A Cash-Positive Path to Compliance

The third layer of CAaaS is the combination of compliance with emission reduction regulations, while maximizing the benefits of GHG incentives. The regulations and incentives are highly location dependent. Canada is currently on the cutting edge [14].

Canada Regulatory Environment

Provincial and federal regulators have announced rules that aim to eliminate methane emissions. The overarching goal is to reduce methane emissions in the energy sector by 45% before 2025. These regulations impact the entire sector of upstream oil and gas producers.

On the Federal level, the Canadian Environmental Protection Act (CEPA) includes "Regulations Respecting Reduction in the Release of Methane and Certain Volatile Organic Compounds (Upstream Oil and Gas Sector)."

On the provincial level, in Alberta, Directive 60 requires limiting emissions from pneumatic devices. For practical purposes, we can assume regulatory equivalency i.e. adhering to Alberta's Directive 60 (Venting) and Directive 17 (Measurement) will mean adhering with the Federal regulations [15].

Alberta requires the transition to low-bleed devices in Greenfields by 2022 and in Brownfields by 2023, while B.C. requires transitioning to no-bleed in Greenfields by 2021 and low-bleed in Brownfields by 2022.

An important recent change (May 2020) is the removal of the Alberta GHG Offset Protocol's expiration date. Previously, the Protocol was valid until January 1, 2023. That meant that operators could not gain monetary credit from IGIA conversions after that date. However, now projects that exceed regulatory requirements can gain credits for upto eight years.

14 For government information on Alberta's Directive 60: https://www.aer.ca/regulating-development/rules-and-directives/directives/directive-060 Emissions offset system: https://www.alberta.ca/alberta-emission-offset-system.aspx

15 Alberta Announcement: https://www.alberta.ca/release.cfm?xID=713366C8E89CA-0099-7CA4-A296674CCD258117

Operators can now make money and reduce their methane emissions by converting their instrument gas to instrument air.

Carbon Credit Analysis

Not all incentive programs are available to all operators, for example the Canadian government stimulus package is unlikely to be available to large operators with production that exceeds 60,000 BOE/day. However, carbon credits are available in Alberta irrespective of company size. This section uses public data and Qnergy's field data to estimate the potential value of carbon credits per CAP3 system.

Table 3 details the calculation of credits per CAP system, using Qnergy's field data and following the Alberta Protocol [16]. The level of air consumption changes from case to case and with it the credits. Thus, the values below should be used as an estimation of the order of magnitude and not an exact number.

Parameter	Value	Units	Comments
Max I/A supply	0.449	e3m3/day	11 scfm
Duty cycle	39%		Qnergy field data (average 4.3 scfm)
I/A consumption	0.17	e3m3/day	Effective air supplied to project
Gas Equivalency Ratio / GEF	1.2977		Vol conversion from of air to natural gas
% CH4	80%		Percent methane contained in the fuel gas
Density of Methane (ρCH 4)	0.6797	kg/m3	at 15°C and 1 atmosphere
Global Warming Potential	25	$tCO_2e/tCH4$	25 as per IPCC AR4 100y
Total Abated GHG	**1,126**	**tCO_2e/yr**	
Unit Emissions	**20**	**tCO_2e/yr**	
Credits (Net Reduction)	**1,106**	**tCO_2e/yr**	**= to 240 passenger cars**

Table 3. Carbon Credits. Each CAP system generates about 1,100 credits per year.

16 Quantification Protocol for Greenhouse Gas Emission Reductions from Pneumatic Devices (2020) https://open.alberta.ca/dataset/9f28037a-df38-403a-ac3c-51ed3a53d605/resource/bd3c728a-5cec-42bb-bb9b-f1846cc6d22a/download/aep-quantification-protocol-for-greenhouse-gas-emission-reductions-from-pneumatic-devices-versio.pdf

The air supply depends on customer preferences. The average consumption based on Qnergy's field data is around 4.3 cfm or 250 scfh. This covers 20-50 pneumatic controllers on-site.

The other parameters in Table 3: Gas Equivalency Ratio, percentage of methane in the natural gas, methane density and global warming potential are taken from the Alberta protocol and are consistent with the IPCC calculation and can be readily used for credit submissions.

Overall, each CAP3 unit abates more than a thousand tCO_2e in a year. The direct emissions are about 1% of the abatement [17].

The typical financial value of the credits per unit is illustrated in Table 4.

	2020	2021	2022
Carbon Credit Assumption ($/$tCO_2e$)	$30	$40	$50
Mitigation (tCO_2e /PowerGen /yr)	1,105	1,105	1,105
Annual credit value	$33,164	$44,219	$55,273
Credit mediation fees	$4,975	$6,633	$8,291
Credit value to customer	**$28,189**	**$37,586**	**$46,982**

Table 4. Estimated value of credits in Alberta

The 15% mediation fee is typically paid to environmental companies that analyze the data and submit the credit applications. Operators should consider a small lag time between submitting the information and realizing the credits.

The CAaaS program is designed for full alignment with all of our customer's compliance and reporting needs. There are various implementation options. Operators can own the data and the credits, utilizing the fact that theCAP3 system provides certified values that can be used for reporting and credits. Qnergy is collaborating with environmental companies that support the credit process and facilitate all of our customer's compliance and environmental data needs and can facilitate this process if needed. Alternatively, operators can assign the credits to Qnergy and install the CAP3 system for free.

In both cases operators can use the quantified methane abatement for their internal ESG reporting irrespective of the monetary value of the credits.

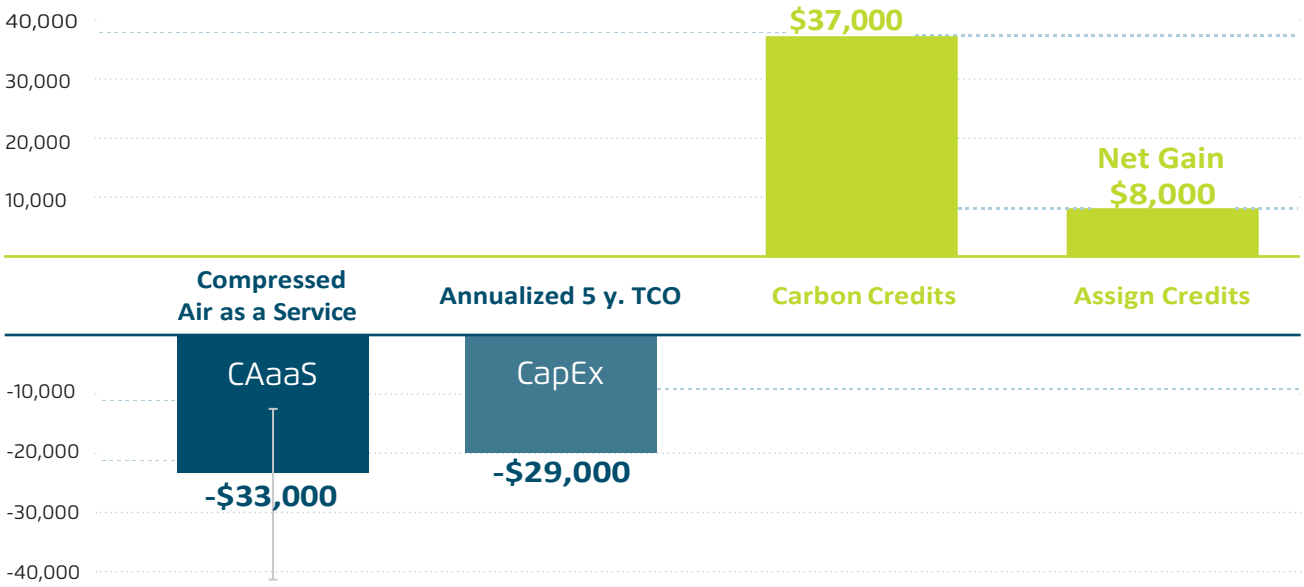
17 For a back of the envelope estimation of the direct emissions, use 5.5 kW with 90% capacity factor and 0.23 tCO_2e/MWh emission factor

CapEx vs. CAaaS [18]

As mentioned, CAaaS shifts CapEx into OpEx. One advantage of this approach is the ability to leverage capital to frontload equipment installation. It allows operators to benefit from the existing credit programs, while keeping the full flexibility to remain in the program or opt out.

Operators can deploy compressed air systems through CapEx or benefit from the low TCO by buying Compressed Air as a Service. Operators that use carbon credits can expect a net gain, Figure 5 illustrates the typical financial values:

CAP3 Financing Examples $/Y



The annualized 5Y TCO is about $29k. The Compressed Air as a Service has a broad range (depending on consumption). It can be as low as $16,000 per year. The typical carbon credits (which also depend on the amount of air used) are $37k, leaving operators with a net gain of about $8k.

In conclusion: the two options can both be cash positive with carbon credits.

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18 Note that the financial values are for illustration purposes only