Jemena Gas Networks (NSW) Ltd

Emissions Meaurement - Picarro

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1. Summary

The implementation of eight Picarro emissions measurement vehicles will provide Jemena Gas Networks a system to enable the measurement of emissions and, therefore, a pathway to a direct and quantified reduction in its fugitive emissions aligning to both its' emission reduction strategies and our customers expectations.

Jemena's Ambition is to reduce Scope1 and 2 emissions to be Net Zero by 2050. The Australian Federal Government has also reformed the Safeguard Mechanism to achieve Australia's emission reduction targets of 43% below 2005 levels by 2030 and net zero by 2050.

Gas leakage is the primary contribution to Jemena Gas Network's (JGN's) emissions, equating to an estimated 98.7%[1] of all JGN emissions.

The ability to directly measure emissions within JGN is a key enabler for the effective implementation of JGN's Emissions Reduction Plan. The default National Greenhouse and Energy Reporting (NGER) methodology currently used to estimate fugitive emissions does not provide the opportunity to reduce emissions as it is linked to gas consumption. Following the success of the pilot trial of Advanced Mobile Leakage Detection using Picarro, JGN's gas leakage emissions calculation methodology can be modified from the default estimation methodology to a direct measurement approach. The move to a higher order direct measurement approach is consistent with the direct of the wider industry.

JGN's trial results align with the international experience. Picarro systems are now being used widely across more than thirty gas networks in Europe and North America for the purpose of identifying, measuring and managing fugitive emissions. Within Australia, other gas network operators are seeking to implement the Picarro system, and JGN is working with these organisations to share its current experience garnered from international networks.

The Picarro technology is also a vital enabler for JGN to measure leakage prior to and post renewal works to accurately determine the reduction in emissions.

JGN purchased two vehicles in 2023. These vehicles are used to leakage survey the Jemena gas networks (JGN) and are committed to surveying 20% of the gas distribution network on a yearly basis, in line with the historical cycle to comply with regulatory obligations. A third vehicle was purchased in Q2 2024 to provide coverage for leakage surveying in areas requiring annual survey (high density community use areas) in accordance with regulatory obligations. Any spare capacity of the third vehicle will enable the measurement of any emissions reductions from some network pressure reduction and targeted mains replacement initiatives.

This Business Case explores four options for enhancing the current use of Picarro's Advanced Mobile Leakage Detection technology for the monitoring and reporting of JGN's emissions. It is anticipated that successful delivery of the accurate measuring and reporting of methane emissions would deliver the following objectives:

- Objective 1: Ensure public safety by reducing the risk of leaks from the gas network.
- Objective 2: Efficiently and effectively meet regulatory obligations for leakage surveillance.
- Objective 3: Provide accurate and timely information to enhance Asset Management decision-making.
- Objective 4: Accurately and consistently measure fugitive emissions to enable reporting against jurisdictional targets for emissions reduction.
- Objective 5: Adopt a financially prudent approach to the management of fugitive emissions.
- Objective 6: Maintain social license by meeting customer expectations and upholding community reputation.

[1] JGN's 2022-23 Scope 1 emissions

This business case reviews four options. Option 3, Advanced Measurement, is recommended as it most effectively addresses all of JGN's objectives. By increasing the fleet to eight Picarro-fitted vehicles through the investment of $0.4M in CAPEX and annual $1.2M in OPEX, JGN can conduct annual emissions monitoring across its entire network. In line with customer expectations, this enables direct emissions reduction targeted on programs including pressure management and asset replacements.

Option 3 allows JGN to accurately and consistently measure fugitive emissions and report against jurisdictional targets for emissions reduction. The advanced measurement approach enhances asset management decision-making and demonstrates JGN's commitment to proactively managing emissions. By taking this proactive stance, JGN will meet its' contribution to the Australian government's net zero 2050 ambitions, as well as the NSW interim target of a 70% cut in emissions by 2035.

2. Introduction

JGN currently faces significant challenges in accurately measuring and reporting methane emissions from its gas distribution network. The company relies on a standardised formula to estimate emissions, which relies on generic emission factors and high level assumptions related to the gas industry's network performance. This lack of direct measurement limits JGN's management of the actual emissions from its network, posing environmental, safety, and regulatory risks to the company and its stakeholders.

To address these challenges, and align with local and international jurisdictions, JGN needs to detect and report emissions accurately, requiring the investment in emission identification and measurement technology. JGN has a responsibility to contribute to the government's net-zero emissions target by 2050. Failing to take action would be a lost opportunity to demonstrate JGN's commitment to sustainability and environmental stewardship.

The release of natural gas to the atmosphere emanates from leaks and operational activities such as venting, purging, and blowdowns, the function of equipment, such as relief valves and instrument gas, and 3rd party damage. This occurs across the distribution and transmission elements of JGN's assets. 98.7% of these emissions are due to fugitive emissions, that is leakage from the distribution network.

Given that these gas network fugitive emissions occur across a large number of mains in various urban and rural locations, the technology of choice is the use of advanced vehicle mounted sensors. referred to as Advanced Mobile Leakage Detection. Over 30 gas distribution businesses around the world have adopted this technology, including Cadent, GRDF, PG&E, National Grid, Snam and Italgas.

JGN has initiated a three-phase approach to implement the use of Advanced Mobile Leakage Detection:

- Phase 1: Trial. Phase 1 was the assessment of various forms of Advanced Mobile Leakage Detection, including a pilot study involving the field testing of the technology. In 2020/21, an Expression of Interest (**EOI**) was conducted to find providers of advanced mobile leakage detection systems. Two vendors were shortlisted. A pilot project in April 2022 focused on assessing methane emissions in a regional NSW area, using the technology of the shortlisted vendors. After evaluating the results, the Picarro solution was selected. At the conclusion of this phase, JGN chose the Picarro system as the most suitable Advanced Mobile Leakage Detection.

- Phase 2: Leak detection. JGN has commenced Phase 2 which is deployment of three Picarro vehicles to replace the existing leakage survey program. Leakage survey programs, as specified in AS/NZS4645.1[2] and supported by legislation, require the leakage survey of the network – 5-yearly for most areas and annually for high density community use areas[3]. The current leakage survey program involves a walking survey which enables the network to be manually surveyed.

  JGN purchased two vehicles in 2023, providing coverage for the 5-yearly component of the leakage survey (~20% of the network). A third vehicle was purchased in Q2 2024 to provide coverage for leakage surveying in areas requiring annual survey in accordance with regulatory obligations[4]. Any spare capacity of the third vehicle will enable the measurement of any emissions reductions from some network pressure reduction and targeted mains replacement initiatives.

- Phase 3: Emission reduction program. Phase 3 of the plan will be executed in the 2025 Access Arrangement period. This phase involves the addition of five vehicles equipped with Picarro Advanced Mobile Leakage Detection tools, bringing the total fleet to eight vehicles. With this expanded fleet, JGN will be able to survey its entire network annually, providing direct measurements of gas leaks and confirming the impact of pressure management, asset replacement and other programs on emission reduction.

2 Refer to AS/NZS4645.1-2018 cl6.5

3 High density community use areas include areas where buildings of four or more storeys are prevalent, major shopping centres, schools, hospitals, aged care facilities, major sporting and cultural facilities.

4 Final approval from the NSW Technical Regulator (Department of Climate Change, the Environment, Energy and Water) is pending, to move from manual survey to vehicle based survey

This Business Case is a gate or hold point to confirm the options for Phase 3 of the program for direct emissions management.

2.1 Financial Treatment

JGN's initial assessment of the Picarro was based upon the capitalisation of the equipment, however, a more detailed review by JGN's finance team identified that, with the exception of the vehicles themselves, the majority of the costs are operational expense, based upon the core elements (including software) being supplied by Picarro on a 'subscription model' basis. This means JGN cannot take possession of the software and access is contingent on continued payment. As there is a prepayment component of the subscription, this is recognised as prepayments on the balance sheet and amortised.

3. Objective

JGN faces a critical challenge in accurately measuring and reporting methane emissions from its gas distribution network. The current reliance on a standardised formula for estimating emissions, combined with the lack of direct measurement capabilities, limits JGN's ability to understand the true extent of leakages and their environmental impact. This limitation exposes the company to significant risks, including environmental damage and safety concerns.

To align with local and international jurisdictions and contribute to the government's net-zero emissions target by 2050, JGN must invest in advanced technology to accurately detect, measure, and report methane emissions from its network. Failure to do so would result in a lost opportunity for JGN to demonstrate its commitment to sustainability and responsible environmental stewardship.

This Business Case explores four options for enhancing the current use of Picarro technology (Phase 3). It is anticipated that successful implementation of the accurate measuring and reporting of methane emissions would deliver the following objectives:

- Objective 1: Ensure public safety by reducing the risk of leaks from the gas network.
- Objective 2: Efficiently and effectively meet regulatory obligations for leakage surveillance.
- Objective 3: Provide accurate and timely information to enhance Asset Management decision-making.
- Objective 4: Accurately and consistently measure fugitive emissions to enable reporting against jurisdictional targets for emissions reduction.
- Objective 5: Adopt a financially prudent approach to the management of fugitive emissions.
- Objective 6: Maintain social license by meeting customer expectations and upholding community reputation.

3.1 Objective 1: Safety of the Network

The safety of the public and JGN's employees are non-negotiable. Customers agree that safety is paramount and expect JGN to ensure the gas network remains safe, environmentally-responsive and reliable. Enhancing the safety of the JGN gas distribution system is a key consideration for any activity. AS/NZS4645.1 requires that:

> *Management of gas distribution networks shall result in an acceptable level of risk with respect to the safety of personnel, the public (including customers), property, or the environment.*

Loss of containment is identified as one of the key hazards.[5] A significant risk to any gas distribution network is the ignition of leaking gas, potentially leading to injury, death, or property damage. Gas distribution systems inherently leak, and as assets age, deterioration leads to increased leakage in both number and size. Each leak is a source of fugitive emissions from the network.

Gas distribution companies use several methods to monitor and manage these leaks:

- Leakage survey (refer to Objective 2): Conducted every five years for most of the system and annually for high density community use areas, offers limited benefit in mitigating safety threats from leaks.
- Public reporting of leaks: JGN responds to an average of 24,000 public reported leaks per year. Initial triage and field investigation classify leaks, but accuracy in location, source, and size is limited. Quantification is not possible, even for gas technicians using current equipment.

[5] AS/NZS4645.1-2018 cl 2.3.3

- Other technological solutions: JGN has invested in the Picarro system (see "The Picarro System" call-out box), which enables detection, location, and quantification of leaks across the entire network. When used yearly, it has been shown to reduce public reported leaks by being proactive[6] instead of reactive. Picarro detects leaks from any source and is also useful for services and meters considered disconnected or abolished but still in place.

The Picarro System

The Picarro Gas Surveyor 2.0 Ethane System is an advanced leakage detection system, intended to be installed on a mobile platform such as a car. The leakage detectors quantitatively measure gas leakages and emissions from the network.

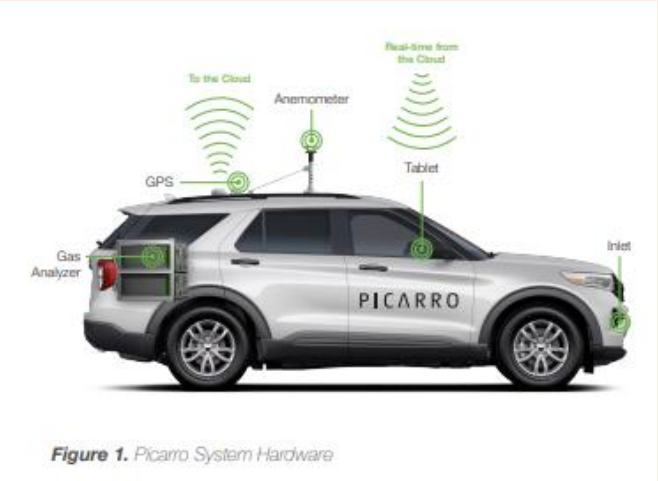
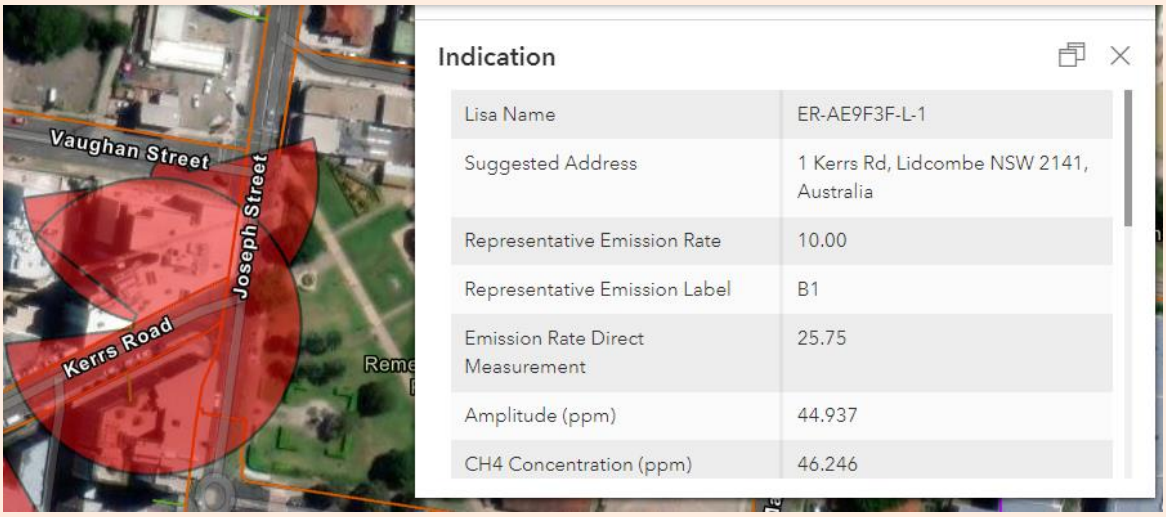


Figure 1. *Picarro System Hardware*

The system provides precise leakage quantification and maps these geographically via GPS locations, enabling highly targeted rehabilitation and repair. The technology facilitates regular comparative studies to measure the gas leakage and emissions pre- and post-repairs to determine the reduction of emissions.



Further information as to the Picarro System can be found at http://picarro.com/gas

AS/NZS4645.1 requires that gas distributors to develop processes for:

[6] Source….

Systematic monitoring and management of leakage to mitigate the risks from gas leaks. These processes should ensure an adequate and timely response to gas leak detection, assessment and repair, and should provide information to monitor deterioration within the gas distribution network.

Leakage surveillance is a key process that achieves multiple outcomes, including safe management of leaks, reduction in unaccounted for gas (UAG), and provision of evidence and information.

JGN's leakage surveillance program, documented in the JGN Safety and Operating Plan (SaOP) and accepted by the NSW technical regulator, Department of Climate Change, the Environment, Energy and Water (NSW DCCEEW), requires five-yearly surveys across the gas distribution system and annual surveys in High Density Community Use Areas (HDCA).

With the purchase of three Picarro systems, JGN is currently transitioning from manual surveys, where a gas service technician walks with a handheld detector, to surveys using the Picarro vehicle-mounted system. As of May 2024, JGN has completed a review of the Picarro system and is awaiting final endorsement from DCCEEW[7] to update the SaOP to reflect the use of this technology.

The benefits of the Picarro system compared to the historical leakage survey process include:

- Accuracy – sensitive enough to detect all meaningful emissions and geospatial reference the location
- Quantification – able to quantify leak size accurately enough to assess emissions with high confidence
- Sensitivity – 1000 times more sensitive than the hand held devices currently in use
- Repeatable – independent on quality of personnel doing traditional foot surveying.

3.2 Objective 3: Enhanced Asset Management Decision Making

Decisions as to the management of the JGN assets are made through the Jemena Asset Management System (AMS)[8]. Two of the key elements outlined in Jemena's AMS policy are to:

- *Facilitate innovation and continual improvement in the safety and performance of the assets, through the establishment, maintenance and governance of effective asset and safety management systems*
- *Develop and maintain asset information systems which support asset management decisions and activities throughout the asset lifecycle*

Accurate and contemporary information is intrinsic to these elements. Appendix A contains a summary of the risks associated with some of the Asset Management decisions where information provides a mitigation to the risks.

The operational, maintenance and capital activities related to the management of leakage or fugitive emissions form a significant part of the overall asset management program for JGN. Seeking to optimise the planning and delivery of these activities will:

- Reduce the risks associated with gas leakage
- Optimise expenditure
- Enhance customer experience.

[7] Verbal confirmation as to an approval has been received

[8] The Jemena AMS is certified to ISO 55001:2014.

3.2.1 Targeted Network Repair And Rehabilitation

Collecting more accurate and up-to-date leakage information can significantly enhance the targeting of repair and rehabilitation programs.

JGN has included a program of planned mains rehabilitation in the Capital and Operational Works Plans (COWP) under its Asset Management Agreement (AMA)[9] and as part of the 2025 Access Arrangement. Historically, areas of the network deemed to have higher than normal integrity issues have been considered for planned rehabilitation.

The Picarro technology is an enabler to be able to survey the network, then analyse and target the locations of the network that have been found to have gas leaks, called Leak Indication Search Areas (LISA's)[10]. A threshold for the size of the leak can be set to target the largest leaks and prioritise for investigation. The investigation requires a technician to go the location of the LISA and definitively find the location and asset on which the leak is occurring, usually a gas main, service to the customer or the meter set.

From this investigation the LISA will then progress to be repaired (for a leaking meter or customer regulator) or rehabilitated (for a main or service). This provides a means to be able to optimise the current planned rehabilitation program, and also moves from being reactive to a proactive approach in reducing leakage in the network.

Upon completion of the works in the LISA, an evaluation survey would identify the success of the works including a quantification of the reduction in emissions attributable to the works.

3.2.2 Pressure Reduction

JGN is developing a program in areas where the pressure in that part of the network can be optimised in order to reduce emissions. The rate of leakage is proportional to the pressure in the mains, and thus a reduction in pressure will lead to a reduction in gas lost through leakage. Some of these areas have been deemed to have higher than average integrity issues where publicly reported leaks and levels of mains repairs are higher than other parts of JGN (i.e. leading to higher emissions). The initial program has been a review of those systems with pressure higher than 210kPa, future phases will review the potential to reduce emissions through pressure management in those network segments with pressures of 210kPa or lower.

In the initial phase, the plan is to reduce those sections of the network where pressure is higher down to 210kPa. This will be either a permanent reduction if minimal capex is required to maintain network capacity, or may be applied seasonal during summer months where significant levels of capex would be required to maintain capacity during the winter period.

The benefit of using the Picarro technology is being able to measure the emissions from the area at a higher pressure. The network area pressure is then reduced at the supply point to a level that still maintains sufficient capacity for customers and the Picarro vehicles are used again to measure emissions at the lower pressure and the results are compared. This approach was tested in a small pocket in the Blue Mountains where the pressure was lowered in September 2024 resulting in emissions reduction of 30%.

[9] See attachment JGN - RIN - 4.21 - Related party agreements - 20240628 – Public.

[10] Refer to Appendix C– Picarro Technology Information for further information

3.3 Objective 4: Measurement of Fugitive Emissions

JGN's Emissions Reduction Program has identified a critical opportunity to significantly reduce Australia's greenhouse gas emissions through two key strategies. The first strategy relates to the introduction of renewable gases. The second strategy relies on the accurate measurement and reporting of emissions, as highlighted in the call-out box below.

JGN Emissions Reduction Program - Strategies

1. **Reduce customer emissions by enabling access to renewable gases.** We will facilitate the introduction of 8 PJs of renewable gases by 2030. This will reduce greenhouse gas emissions by 500,000 tCO2e a year by 2030, delivering 0.6% and 1.4% of the emissions reductions needed to achieve the NSW and Australian government's 2030 emission reduction targets.
2. **Move to direct emission measurement for our fugitive greenhouse gas emissions**, which account for 98.7% of our emissions, and away from generic and likely inaccurate benchmark emission factors. This will allow us to:
   - Report accurate emissions **–** by ensuring that reported emissions reflect our actual emissions, rather than an estimate based on generic emission factors and high-level assumptions of our network performance.
   - Reduce actual emissions **–** as it provides sufficiently granular data to identify the size and location of leaks and development of an optimised repair program.

   Moving to direct emissions measurement is essential to enable the achievement of emission reduction targets for our network, is consistent with global good industry practice and the goals of the Global Methane Pledge.

The current NGER reporting framework offers three levels of maturity for reporting emissions, ranging from standardised benchmarks to measurement-based reporting using engineering estimates. JGN currently uses the default NGER Method 1 methodology, which is based on fixed assumptions about the UAG rate and the proportion of UAG assumed to be methane emissions. This method does not facilitate emissions reduction, as the only way to reduce emissions under Method 1 is to decrease the network length (transmission) or reduce gas consumption (distribution).

The use of generic assumptions for estimating fugitive emissions likely results in underestimating actual emissions. Both Method 1 (and Method 2) may unintentionally incentivise JGN to continue releasing methane into the atmosphere and offsetting it with carbon credits. The underestimation of emissions has been raised by academics who have conducted partial atmospheric methane mapping in Sydney[11] and think-tanks that have compared reported emissions against satellite observations.

Rod Sims, Chairman of Superpower Institute, which manages the Open Methane satellite monitoring program, wrote an article in *The Australian Financial Review*[12] highlighting that satellite data indicates companies are underreporting their emissions by up to 60%. He emphasises, "*If we can just cut our methane emissions, that makes an enormous contribution to greenhouse gases. And if we can't measure them, then how can we manage them?"*

Sims advocated for a "*proper system of measurement on the ground, upwind and downwind from the methane source*" was required so that "*whichever way the wind's blowing, what the extra emissions are over that site*" will be known. He suggested that satellite measurements[13] could be used to verify on-the-ground measurements, providing greater assurance on emissions levels.

The Picarro technology fulfills the requirements for direct measurement of fugitive emissions. If deployed to enable annual surveillance, it can advance the maturity pathway to a 'Measured' approach. Picarro's direct emissions measurement approach aligns with international regulatory emissions reporting requirements and emerging standards such as Veritas and OGMP 2.0 (see Appendix C for more information).

[11] O'Malley, N. (2020, September 13). *Sydney awash with leaks as research shows the climate cost of gas,* Sydney Morning Hearld. Available here. We note that one of the areas surveyed was an area of cast iron mains we have since replaced.

[12] Financial Times article by Ben Potter, April 30 2024. Accessed at < https://www.afr.com/policy/energy-and-climate/coal-mine-methane-twice-official-disclosures-sims-20240429-p5fnfv>.

[13] JGN has reviewed the use of satellite technologies – refer to Option 4 in section 4.4. The satellite technology quoted by Professor Sims is primarily utilised for mapping large gas basin emissions, whereas Advanced Mobile Leakage Detection are more suitable for urban areas. This does not change the conclusion as to potential underreporting.

Appendix D outlines the Picarro system's capability in terms of network coverage. The distance travelled while identifying emissions depends on various factors, including optimal speeds, weather, and driver management. The vehicles typically operate at night to minimise weather and traffic effects.

The accurate measurement and accurate reporting of emissions, though 'direct measurement' is essential in enabling to JGN to:

- Track, plan and respond in order to meet internal targets[14]
- Track, plan and respond in order to meet jurisdictional targets. Refer to JGN's Emission Reduction Program for further information.

3.4 Objective 5: Financially prudent approach

To ensure a financially prudent approach to managing fugitive emissions through implementing Picarro technology, JGN has evaluated the cost-benefit of each Option and then to account for the uncertainty in the actual level of emissions (as opposed to the 'mandated 37.5% of UAG),for Option 3 three scenarios: low, medium, and high actual emission have been analysed. Considering multiple scenarios, acknowledges the uncertainty in current emission levels and demonstrates the robustness of the investment.

In each scenario, we quantify the potential emissions reduction improvements against the cost of implementation. This comprehensive analysis provides a clear picture of the financial viability of the Picarro technology investment across a range of potential emission levels.

We estimate that even in the low emission scenario, the long-term benefits will outweigh the initial investment costs, with even greater returns in the medium and high emission scenarios. This approach ensures that the decision to invest in Picarro technology is grounded in a thorough understanding of the financial implications, considering the uncertainty surrounding current emission levels. By demonstrating the cost-effectiveness of the investment across multiple scenarios, we can confidently move forward with a financially prudent strategy for managing fugitive emissions.

3.5 Objective 6: Retain social licence

Failure to effectively manage fugitive emissions will hinder JGN's ability to maintain its social license for the continued operation of the gas distribution system. To retain customer trust and community reputation, JGN must understand and meet their expectations. Through customer consultation processes, JGN customers expressed their belief that organisations should take greater responsibility for environmental sustainability[15] and strongly supported:

- The direct reduction of emissions as opposed to purchasing Australian Carbon Credit Units (ACCU) or Safeguard Mechanism Credits (SME)
- The direct measurement of emissions to ensure accurate reporting and proactive management.

An objective measure of community expectations is the cost the community has assigned to fugitive emissions. Australian state governments have set benchmarks to determine the community cost of emissions. In determining this cost, JGN has adopted the AER's value of emissions reduction (VER) mechanism.

Customers were also consulted on proposals related to the use of Picarro technology. A snapshot of their feedback is contained in the call-out box "Customers Opinion on Picarro". Appendix B contains information presented to customers at one of the customer forums.

[14] In March 2021, Jemena announced our ambition to achieve net-zero (Scope 1 and 2) emissions by 2050.

[15] This was particularly evident in the Youth forums, where sustainability and support for vulnerable customers were highlighted as topics of concern.

Investing in Picarro demonstrates JGN's commitment to accurate emission measurement and reduction, aligning with evolving regulatory expectations. Accurate emission data empowers JGN to:

- Engage transparently with regulators, stakeholders, and the public, building trust and credibility
- Avoid accusations of not doing enough (there have been international cases where airlines and oil and gas companies have been accused of not doing enough)
- Recognise that buying ACCUs is not a sustainable long-term strategy.

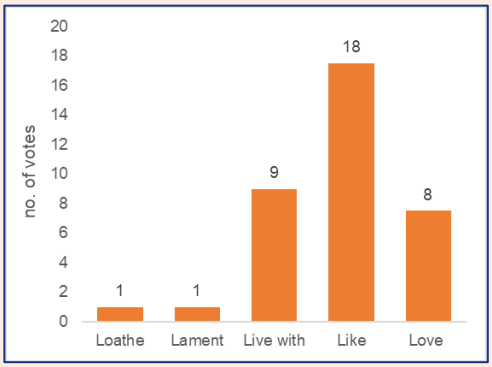
By implementing cutting-edge technology, JGN positions itself as an industry leader, setting a positive example for peers and contributing to the overall decarbonisation efforts of the energy sector and Australia.

Customers Opinion on Picarro

In response to their feedback, the March 2024 customer forum provided more insight into JGN's investments to address emissions and climate change. The forum also presented the bill impacts associated with the cost of Picarro-fitted cars to ensure that customers were comfortable with the potential bill impacts resulting from our emission reduction plans.

Participants were encouraged to use the Human Library of experts for any questions or further clarification. After discussions, the group voted using L-scale ("loathe", "lament", "live with", "like", "love") cards on whether JGN achieved the right balance between Picarro and ACCUs. They were asked to provide reasons for their vote and to describe any challenges they faced in making their decision. The figure below shows the number of customer votes on the degree to which they supported Picarro.

Customer voting for Picarro



The group voted strongly in favour of Picarro, with comments supporting concrete efforts to genuinely reduce carbon emissions in the network rather than relying on carbon credits.

They have also indicated that JGN should have been more proactive in gas detection and that the incremental cost of purchasing an additional five (5) Picarro units and vehicles is acceptable, considering the anticipated impact on emissions reduction.

Verbatim comments from customers included the following:

"Positives outweigh negatives"

"Actual action to stop leaks is vastly better than ACCU (reducing emissions somewhere random). Cost, if any, are small, accounting for all costs/savings."

"Fix leaks early and safely"

"No reliance on carbon credits is better."

"Address the source by investing in technology"

Further information as to the Customer Consultation Process can be found at

Appendix B – Customer Forum Mar 24

4. Options

The following options were identified:

- **Option 1: Status quo (Phase 1).** This option allows for the completion of the 5-yearly leakage survey for the majority of the network using three Picarro vehicles and an annual survey for high-risk areas, in compliance with AS/NZS4645.1. This effectively replaces the manual (walking) leakage survey. Additionally, the third vehicle enables a limited amount of additional emissions survey measurement in selected segments of the network.
- **Option 2: Enhanced coverage (Phase 1A)**. Acquire two additional units, increasing the fleet to five Picarro vehicles. This option continues the activities outlined in Option 1, with added targeted emissions measurement in more network segments. While this does not support higher-order emissions measurement, it will enable targeted measurements before and after network maintenance activities, such as pressure reduction and rehabilitation programs.
- **Option 3: Advanced measurement and reporting (Phase 2).** Acquire five more vehicles, totalling eight Picarro vehicles. In addition to the benefits of Option 2, this option supports advanced emission measurement and reporting capabilities. This will allow JGN to accurately measure and report on its progress towards emissions reduction targets set by various jurisdictions.
- **Option 4: Alternative technologies.** This option explores the potential of integrating or substituting Picarro technology with other emerging gas leakage detection technologies. Alternative technologies may include:
  - Drone-based leak detection: Utilising drones equipped with advanced sensors to perform aerial surveys, which can access hard-to-reach areas and cover large sections of the network more efficiently than ground-based methods.
  - Satellite Monitoring: Implementing satellite technology to monitor emissions on a macro scale, providing broad coverage and frequent updates on leakage patterns and trends.

In the sections below, each of these options are explained in detail.

4.1 Option 1: Status quo

Option one ceases the program at Phase 2. The current three Picarro vehicles allows leakage survey compliance obligations and supports limited emissions validation for targeted pressure reduction and mains replacement initiatives.

The benefits and limitations of Option 1 are detailed below:

Option 1 : Phase 2 - Status Quo – 3 Vehicles					
Number of vehicles	**3**	**CAPEX**	**No additional**	**OPEX**	**$2.07M pa**
Objective			**Indication**	**Commentary**	
Objective 1: Safety of the public, through reduction in the risk of leaks from the gas network;			✓	Leaks identified during leakage survey are prioritised for investigation and repair	
Objective 2: Efficiently and effectively meeting the regulatory obligations for leakage surveillance;			✓	The use of Picarro technology still meets leakage surveillance requirements but sensitivity of equipment 1000 times better	

Option 1 : Phase 2 - Status Quo – 3 Vehicles					
Number of vehicles	**3**	**CAPEX**	**No additional**	**OPEX**	**$2.07M pa**
Objective			**Indication**	**Commentary**	
Objective 3: Provision of accurate and timely information to enhance Asset Management decision making;			●	Targeted information is only limited to locations identified for pressure reduction and mains replacement – not whole of JGN	
Objective 4: Accurate and consistent measurement of fugitive emissions to enable reporting against jurisdictional targets for emissions reduction;			✘	Does not provide whole of JGN emissions reduction – specific to small scale initiatives	
Objective 5: Financially prudent approach to the management of fugitive emissions;			✘	Does not provide whole of JGN emissions reduction – specific to small scale initiatives only	
Objective 6: Retain social licence through meeting customer expectations and community reputation.			✘	The customer expects JGN to fast track reducing emissions in line with government targets	

(1) Note the OPEX costs are the total costs, not the incremental costs. Note the CBAM uses the incremental costs in order to do the options comparison.

4.2 Option 2: Enhanced coverage

This option involves adding two more Picarro-equipped vehicles, bringing the total to five. This enhances the network coverage for leak detection, providing a broader view of emissions across JGN. However, five vehicles would only be able to survey approximately 60% of the network, still falling short of achieving 100% annual network leakage detection.

Like Option 1, this option allows JGN to meet its basic safety and regulatory obligations but only supports limited asset management decision-making. Additionally, Option 2 does not support proactive emissions management or the accurate and consistent measurement of fugitive emissions. Option 2 would not enable the introduction of a higher order measurement system. Consequently, it does not significantly contribute to the Australian government's net zero ambitions by 2050.

The benefits and limitations of this Option are detailed below:

Option 2 : Phase 2A – Additional Two Vehicles					
Number of vehicles	**5**	**CAPEX**	**$160k (one-off)**	**OPEX**	**$3.45M pa**
Objective			**Indication**	**Commentary**	
Objective 1: Safety of the public, through reduction in the risk of leaks from the gas network;			✓	Leaks identified during leakage survey are prioritised for investigation and repair	
Objective 2: Efficiently and effectively meeting the regulatory obligations for leakage surveillance;			✓	The use of Picarro technology still meets leakage surveillance requirements but sensitivity of equipment 1000 times better	
Objective 3: Provision of accurate and timely information to enhance Asset Management decision making;			●	Targeted information is only limited to locations identified for pressure reduction and mains replacement – not whole of JGN but more than for Option 1 and at least half of network	

Option 2 : Phase 2A – Additional Two Vehicles					
Number of vehicles	**5**	**CAPEX**	**$160k (one-off)**	**OPEX**	**$3.45M pa**
Objective			**Indication**	**Commentary**	
Objective 4: Accurate and consistent measurement of fugitive emissions to enable reporting against jurisdictional targets for emissions reduction;			✘	Does not provide whole of JGN emissions reduction – specific to small scale initiatives only	
Objective 5: Financially prudent approach to the management of fugitive emissions;			✘	Does not provide whole of JGN emissions reduction – specific to coverage of the 5 vehicles	
Objective 6: Retain social licence through meeting customer expectations and community reputation.			●	The customer expects JGN to fast track reducing emissions in line with government targets – this option goes part way to doing this	

(2) Note the OPEX costs are the total costs, not the incremental costs. Note the CBAM uses the incremental costs in order to do the options comparison.

4.3 Option 3: Advanced measurement and reporting

This option involves advancing to Phase 2 by purchasing five additional Picarro-fitted vehicles, increasing the total fleet to eight vehicles. This enhancement will enable annual leakage surveys across the entire JGN network.

Utilising Picarro vehicle technology, this expanded fleet will facilitate targeted leakage reduction programs focused on system operating pressure reductions and specific asset replacements.

This option meets all the objectives – it enables JGN to meet its safety and regulatory obligation, undertake a higher order measurement approach and enhances asset management decision making[16].

Importantly though it allows JGN to accurate and consistently measure fugitive emissions and reporting against jurisdictional targets for emission reduction. This option also provides a social licence to JGN. By proactively managing emissions, we will avoid accusations of greenwashing and assisting the Australian government reach its net zero 2050 ambitions, as well as the NSW interim target of a 70% cut in emissions by 2035.

The benefits and limitations of this option are detailed below:

Option 3 : Phase 3 – Additional Five Vehicles					
Number of vehicles	**8**	**CAPEX**	**$400k (one-off)**	**OPEX**	**$5.52M pa**
Objective			**Indication**	**Commentary**	
Objective 1: Safety of the public, through reduction in the risk of leaks from the gas network;			✓	Leaks identified during leakage survey are prioritised for investigation and repair	
Objective 2: Efficiently and effectively meeting the regulatory obligations for leakage surveillance;			✓	The use of Picarro technology still meets leakage surveillance requirements but sensitivity of equipment 1000 times better	
Objective 3: Provision of accurate and timely information to enhance Asset Management decision making;			✓ ✓	Provides whole of network view to ensure all large emissions can be prioritised	

[16] Italgas has moved to surveying 150% of their gas networks within 1 year, in order to accelerate the targeted reduction in fugitive emissions and realise earlier benefits from the Italian regulatory model.

Option 3 : Phase 3 – Additional Five Vehicles					
Number of vehicles	**8**	**CAPEX**	**$400k (one-off)**	**OPEX**	**$5.52M pa**
Objective			**Indication**	**Commentary**	
Objective 4: Accurate and consistent measurement of fugitive emissions to enable reporting against jurisdictional targets for emissions reduction;			✓	Enables emissions benchmarks for whole of JGN and against targets	
Objective 5: Financially prudent approach to the management of fugitive emissions;			✓	Provides whole of network view to ensure all large emissions can be prioritised. Enables higher order measurement approach.	
Objective 6: Retain social licence through meeting customer expectations and community reputation.			✓	The customer expects JGN to reduce emissions in line with government targets	

(3) Note the OPEX costs are the total costs, not the incremental costs. Note the CBAM uses the incremental costs in order to do the options comparison.

4.4 Option 4: Alternative technologies

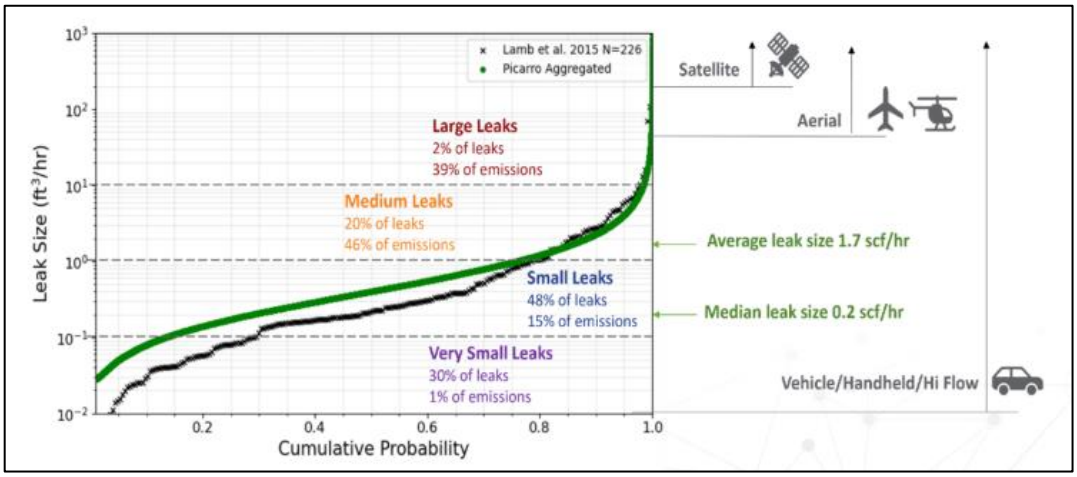
JGN has evaluated the technologies used by other pipelines and networks and concluded that satellite detection is only suitable for identifying large leaks due to its lack of sensitivity for smaller ones. Additionally, aerial or drone-based detection, as utilised in APA's climate transition plan, [17] is more appropriate for large transmission pipelines or production field and not for a gas distribution network like JGN in NSW. While these technologies are not currently suitable for our needs, we will continue to monitor their development and potential benefits for future use.

The chart below shows the distribution of gas leak sizes by cumulative probability and highlights the detection capabilities of different technologies. The chart shows the distribution of gas leak sizes (in cubic feet per hour) by cumulative probability, based on data aggregated by Picarro. The chart categorizes leaks into four sizes:

- Large Leaks: 2% of leaks, contributing to 39% of emissions.
- Medium Leaks: 20% of leaks, contributing to 46% of emissions.
- Small Leaks: 48% of leaks, contributing to 15% of emissions.
- Very Small Leaks: 30% of leaks, contributing to 1% of emissions.

[17] APA Group, 2023. Climate Report 2023. [online] Available at: https://www.apa.com.au/globalassets/about-apa/sustainability/climate-report-2023.pdf

Figure 4.1: Gas leak size distribution and detection capabilities by technology



The chart also indicates the detection capabilities of different technologies:

- Satellite: Suitable for detecting only large leaks.
- Aerial (e.g., drones): More appropriate for medium to large leaks, typically used in transmission pipelines.
- Vehicle: Capable of detecting very small to medium leaks, suitable for detailed distribution network surveys.

This analysis underscores the need for appropriate technology selection based on leak size and network requirements, with satellite detection being suitable for large leaks, aerial detection for medium to large leaks, and vehicle/handheld detection for very small to medium leaks.

The benefits and limitations of this Option are detailed below:

Option 4 : Alternative Technology – Satellite					
Number of vehicles	**3**	**CAPEX**	Undetermined	**OPEX**	Undetermined
Objective			**Indication**	**Commentary**	
Objective 1: Safety of the public, through reduction in the risk of leaks from the gas network;			●	The data from satellites is not as granular as on the ground and may not be able to pinpoint location of leaks, particularly if there is more than one leak close to each other	
Objective 2: Efficiently and effectively meeting the regulatory obligations for leakage surveillance;			●	While AS/NZS4645 does not specify appropriate technology to use for surveying, satellite is not ground based and may not be accepted as a means of detection	
Objective 3: Provision of accurate and timely information to enhance Asset Management decision making;			●	The use of satellite is out of JGN control and therefore not as reactive as use of Picarro.	
Objective 4: Accurate and consistent measurement of fugitive emissions to enable reporting against jurisdictional targets for emissions reduction;			●	Data is not granular and useful for top down reporting. Difficult to differentiate between biogenic methane sources and natural gas at satellite level	

Option 4 : Alternative Technology – Satellite					
Number of vehicles	**3**	**CAPEX**	Undetermined	**OPEX**	Undetermined
Objective			**Indication**		**Commentary**
Objective 5: Financially prudent approach to the management of fugitive emissions;			●		Initial investigations indicated costs for high data quality were compatible to Picarro costs.
Objective 6: Retain social licence through meeting customer expectations and community reputation.			✓		Jemena is seen as being proactive In identifying methane emission sources

(4) Note the OPEX costs are the total costs, not the incremental costs. Note the CBAM uses the incremental costs in order to do the options comparison.

5. Options Comparison

5.1 Cost Benefit Comparison

The first element of the comparison is the cost-benefit analysis which has been conducted with a focus on the amount of emissions reduced and the value of those reductions. This analysis has been done on the incremental costs and the benefits obtainable by each option.

The NPV analysis is largely based on assumptions relating to reducing emissions, which are detailed in Costs and Benefits Analysis Model (CBAM) in the tab "*inputs for IFM.Picarro*". This inputs tab provides the following key information:

- Forecasts on the dollar value per tonne of avoided greenhouse gas emissions (VER)
- Forecast Australian Carbon Credit Units (ACCUs)
- Percentage of fugitive emissions reduced per annum, in each option.

For each option, the value of reducing emissions is estimated with and without the Picarro technology (i.e. direct measurement). To calculate the value of reducing emissions, the estimated reduction in emissions for each option is multiplied by the corresponding VER and ACCU forecasts provided in the Excel file.

The CBAM provides a comprehensive analysis of the value and costs associated with reducing emissions. The model incorporates the following key components:

- Value of reducing emissions: The "*inputs for IFM.Picarro*" tab sets out the value of reducing emissions based on the assumptions discussed above
- Capital and operating costs: The CBAM details the capital expenditure and operating expenditure for each option being considered
- Enhanced leak detection and repair: The model accounts for the step increase in leak detection and repair efforts due to the use of direct emission measurement techniques (i.e. Picarro). This is represented as an operating expenditure line item.
- Additional mains replacement: The CBAM also includes the cost of additional mains replacement required for each option, which is represented as a capital expenditure line item.

The CBAM integrates these components to provide a comprehensive financial analysis of the various options for reducing emissions. By doing so, the CBAM considers the following trade-offs:

- Advanced measurement techniques vs. status quo reporting: The CBAM assesses the financial implications of adopting advanced measurement techniques (i.e. Picarro) for reducing emissions compared to relying on standardised benchmarks for reporting emissions, which is the current status quo.
- Purchasing ACCUs vs. repairing high-leakage areas: The model also evaluates the trade-off between continuing to purchase Australian Carbon Credit Units (ACCUs) to offset emissions and investing in repairing high-leakage areas. Repairing these areas can lead to long-term savings on ACCUs by directly reducing emissions at the source.

By considering these trade-offs, the CBAM provides valuable insights into the long-term financial and environmental benefits of each option, enabling informed decision-making on the most effective strategies for reducing emissions.

A summary of the CBAM analysis is shown in Table 5-1. As the costs for Option 4 (alternative technologies) are not easily determined, no cost benefit has been performed for this scenario, however, as indicated in Table 5-2, this scenario does not achieve the other objectives.

The table below summarises the three key options that JGN has considered – do nothing, enhanced coverage of gas leakage detection, or advanced measurement. The results demonstrate that Option 3 – advanced measurement – has the highest Net economic benefit of $815.6M.

Table 5-1: Summary of cost-benefit analysis of options ($2023)

	Option 1 Do nothing	Option 2 Enhanced coverage	Option 3 Advanced measurement
No. of Picarro cars	3	5	8
Methane emissions %	37.3% Constant over time	37.3% Reduces over time	37.3% Reduces over time
Reduction in emissions, p.a.	0%	4%	10%
Incremental capital cost ($M)	0	2.5	7.2
Incremental operating cost ($M)	0	-20.2	-77.5
NPV INCREMENTAL total cost ($M)	**0**	**-17.8**	**-70.3**
NPV economic benefits ($M)	0	165.9	745.3
NPV NET economic benefits ($M)	**0**	**183.6**	**815.6**

As an explanation of Table 5-1 above:

- Methane emissions. The methane emissions under Option 1 remain constant at 37.5% as JGN continues to rely on standardised NGER benchmarks for reporting. In contrast, the methane emissions under Option 2 and Option 3 start at 37.5% but decrease over time, reflecting JGN's ability to reduce emissions through advanced measurement monitoring. The reduction in methane emissions for Option 3 is based on a forecast of a 10% per annum reduction with the full eight cars, equivalent to a 4% per annum reduction with five cars, as the first three cars (or their equivalent) are used to meet leakage survey requirements. These 10% and 4% reduction rates are carried through in the assumptions regarding emissions reduction.[18]

- Incremental capex cost. The incremental capex cost represents the additional mains replacement for each option. In option 1 (status quo, do nothing), there is $0 of capex relating to mains replacement, as we would not know what parts of the highest-leaking network to repair. For options 2 and 3, it is assumed that advanced measurement results in $1M p.a. in additional mains replacement.

- Incremental operating cost. The incremental opex costs vary across the options. For Option 1 (status quo, do nothing), the only opex costs are the ACCUs required to offset excess emissions. Options 2 and 3 incur additional opex costs, including the cost of Picarro technology and the incremental increase in leak detection and repair costs. The cost-benefit model is structured to compare the tradeoffs between implementing Picarro, which leads to higher leak detection and repair costs but long-term ACCU savings, and the status quo/do nothing option, which does not result in any additional opex line items besides ACCUs.

- Economic benefits. The VER is treated as a negative benefit to be minimised. The CBAM is set up to estimate all costs and benefits relative to the base case. As an example, if the base case has a VER of -$10, and option 3 has a VER of -$5 then the benefit is $5 (=-$5- (-$10)). The $5 represents the difference in the value of the VER between doing nothing and implementing Picarro.

[18] Refer to "Inputs for IFM Picarro" worksheet in the Costs and Benefits Analysis Model for the Picarro business case.

- NPV.
    - The *NPV INCREMENTAL total cost* represents the incremental operating cost and incremental capital cost of each option.
    - The *NPV economic benefits* represents the VER, i.e. the social value gained in reducing emissions, by implementing Picarro technology.
    - The *NPV NET economic benefits is the aggregation of both incremental costs and incremental benefits.* It represents the net economic benefit of each option relative to the base case.

5.2 Option 3 Scenario Analysis

To address the uncertainty in the actual emission levels (as opposed to the mandated 37.5% of UAG), Option 3 has been analysed under three scenarios: low, medium, and high actual emissions. By considering multiple scenarios, the analysis acknowledges the uncertainty in current emission levels and demonstrates the robustness of the investment decision across a range of potential outcomes.

The financial benefits of Option 3 are subject to the actual level of emissions, which cannot be obtained without the vehicles and thus the analysis for this option has been undertaken through use of a scenario analysis based upon the variability of the potential level of emissions. Three scenarios have been utilised to acknowledge the uncertainty in current emission levels and demonstrates the robustness of the investment. The scenarios under Option 3 are:

- High scenario – JGN's actual emissions are higher than currently reported for NGERs
- Medium scenario – JGN's actual emissions are similar to currently reported NGERs
- Low scenario – JGN's actual emissions are lower than currently reported for NGERs

In each scenario, the reduced emissions are quantified in the same manner as Option 3 above. The only difference is that the startling level of methane emissions is different for the high, medium and low scenario.

As seen in table 5-2, the results show that even in the low emissions scenario, the long-term benefits outweigh the initial investment costs, with even greater returns in the medium and high emission scenarios.

Table 5-2: Summary of Option 3: Scenario cost-benefit analysis (incremental to Option 1)

	Option 3 – Advanced measurement		
	High emissions	**Medium emissions**	**Low emissions**
No. of Picarro cars	8 cars	8 cars	8 cars
Methane emissions %	55%, reduces over time	37%, reduces over time	28%, reduces over time
% reduction in emissions, p.a.	10%	10%	10%
Incremental capital cost ($M)	7.2	7.2	7.2
Incremental operating cost ($M)	-26.9	-77.5	-105.5
NPV INCREMENTAL total cost ($M)	**-19.7**	**-70.3**	**-98.3**
NPV economic benefits ($M)	615.3	745.3	817.2

NPV net economic benefits ($M)	**635.0**	**815.6**	**915.5**

As an explanation of Table 5-2 above:

- Methane emissions. The methane emissions under Option 3 vary. The high scenario assumes that JGN's methane emissions are 53% of its UAG. The medium scenario assumes that it is 37.5%, and the low scenario assumes 28%. Despite differences in starting points, in all three scenarios, the methane emissions reduce over time, as Picarro technology is used to detect leaks. The reduction in methane emissions for all scenarios in Option 3 is based on a forecast of a 10% per annum reduction with the full eight cars.
- Incremental capex cost. As per table 5-1 the incremental cost of capex is held constant, reflecting mains replacement. The only difference in each of the three scenarios are the starting point for the proportion of methane emissions in the UAG.
- Incremental operating cost. As detailed above, the opex costs for Option 3 are ACCUs, the cost of Picarro technology and the increase in leak detection and repair costs. The cost-benefit model is structured to compare the trade-offs between implementing Picarro, which leads to higher short-term leak detection and repair costs but long-term ACCU savings, and the status quo/do nothing option, which does not result in any additional opex line items besides ACCUs.

- NPV.
  - The *NPV INCREMENTAL total cost* represents the incremental operating cost and incremental capital cost of each option.
  - The *NPV economic benefits* represents the VER, i.e. the social value gained in reducing emissions, by implementing Picarro technology.
  - The *NPV NET economic benefits is the aggregation of both incremental costs and incremental benefits.* It represents the net economic benefit of each option relative to the base case.

5.3 Options Benefits Comparison

Table 5-3 summarises and compares the four options considered in this Business Case against the objective of success for the program.

Table 5-3: Summary of Options

Options Comparison				
	Option 1 Phase 2 Status Quo	**Option 2 Phase 2A Enhanced Survey**	**Option 3 Phase 3 Emissions Management**	**Option 4 Satellite Technology**
Ranking	**3**	**2**	**1**	**4**
Number of vehicles	3	5	8	3
Objective			RECOMMENDED	
Objective 1: Safety of the public, through reduction in the risk of leaks from the gas network;	✓	✓	✓	●

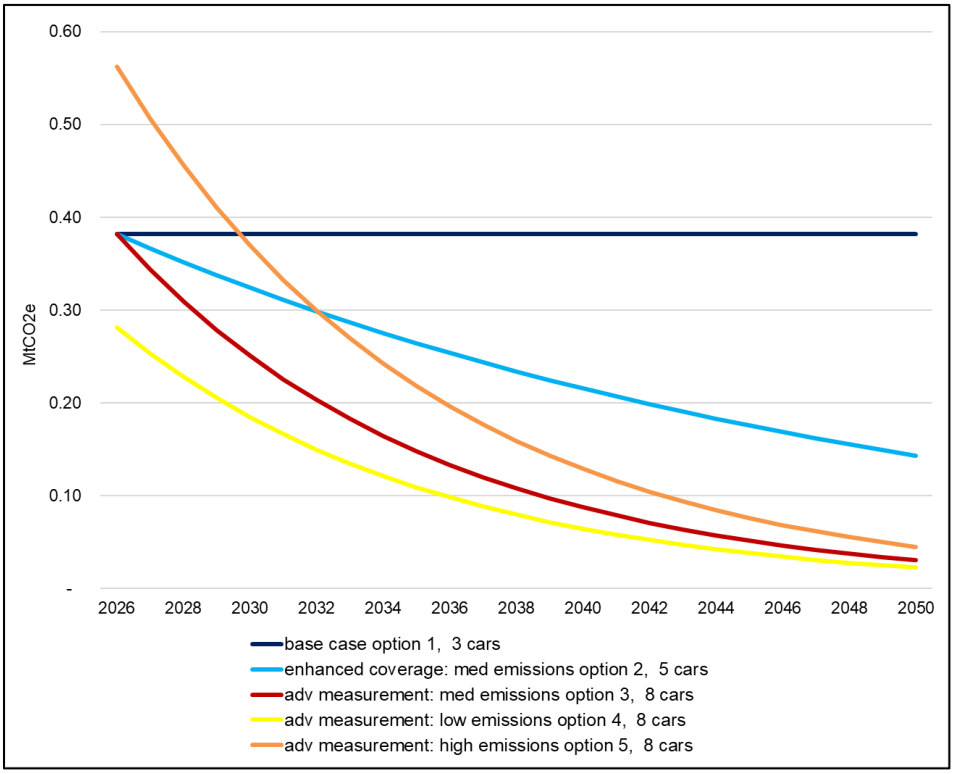
Options Comparison				
	Option 1 Phase 2 Status Quo	Option 2 Phase 2A Enhanced Survey	Option 3 Phase 3 Emissions Management	Option 4 Satellite Technology
Ranking	**3**	**2**	**1**	**4**
Number of vehicles	3	5	8	3
Objective			RECOMMENDED	
Objective 2: Efficiently and effectively meeting the regulatory obligations for leakage surveillance;	✓	✓	✓	●
Objective 3: Provision of accurate and timely information to enhance Asset Management decision making;	●	✓	✓ ✓	●
Objective 4: Accurate and consistent measurement of fugitive emissions to enable reporting against jurisdictional targets for emissions reduction;	✘	✘	✓	●
Objective 5: Financially prudent approach to the management of fugitive emissions;	✘	✘	✓	●
Objective 6: Retain social licence through meeting customer expectations and community reputation.	✘	●	✓	✓

- Option 1 – Do nothing: The Picarro-fitted vehicles would be deployed for compliance purposes only, as there are insufficient units for emissions reduction. Consequently, JGN would not reduce its emissions and would continue to rely on purchasing ACCUs to offset its excess emissions.
- Option 2 – Enhanced coverage: There is a slight improvement in the VER and required ACCUs in this option. However, JGN would not be able to fully transition to direct measurement or reduce its largest leakages, due to lack of information on emission sources. .
- Option 3 – Advanced measurement: Assessed in three scenarios. In the high emissions scenario, the proportion of methane emissions out of UAG is assumed to be 55%, higher than the fixed assumption of 37% required by NGER scheme reporting in Methods 1 and 2. With Picarro, the proportion of methane emissions would gradually decrease over time. Even when JGN's emissions are lower than the NGER assumption, there is a long-term benefit as Picarro would detect leak locations and help reduce emissions, contributing to Australia and NSW's net zero ambitions.
- Option 4 Alternative technologies, while being monitored for future benefits, currently fails to meet the required regulatory obligations, enhance asset management decisions, and measure fugitive emissions accurately for a distribution network. It results in a fail overall.

In conclusion, the absence of the additional five Picarro vehicles would prevent JGN from identifying the specific areas of the network responsible for emissions, significantly impairing our capacity to implement effective emission reduction strategies. This holds true regardless of whether JGN's actual emissions prove to be higher than, lower than, or equal to the assumptions made by NGER.

Figure 5–1, which shows the emissions reduced in each scenario over time, demonstrates that regardless of whether JGN's actual emissions are higher or lower than estimated (i.e. reported) emissions, implementing Picarro technology would result in a net benefit by lowering emissions. Picarro provides visibility of the highest leakages on the network, enabling JGN to proactively reduce its emissions. Notably, option 2 (5 cars), while enabling some degree of emissions reduction, would not enable a material enough level of emissions to be reduced by 2050 to meet net zero.

Figure 5–1: Emissions reduction over time, with direct measurement



Without Picarro, JGN would not be able to effectively reduce its emissions over time and would continue to rely on standardised benchmarks and purchase Australian Carbon Credit Units (ACCUs) to offset excess emissions where required.

6. Recommendation

It is recommended that Option 3 be implemented, that is Purchase of additional five (5) vehicles. This option best meets the Objectives and provides the most certainty with respect to the benefits.

7. Realising the benefits

The benefits of Option 3 have been mapped as a schedule in Table 7-1. The increase in number of vehicles will enable the realisation of benefits in a staged manner:

1. **Leakage surveying for regulatory compliance** – The current fleet of three vehicles is adequate to meet regulatory obligations. Adding five more vehicles will maintain the current level of service without any negative impact.

2. **Repair** – The existing three vehicles already enhance repair work due to the increased sensitivity and more precise locations provided by the Picarro system. Expanding the fleet to eight vehicles will further boost repair capabilities. By the end of the current access arrangement period, we anticipate a substantive uplift in repair-related costs, although this remains unpredictable. As such, no changes to forecasts have been made. The need for repairs is expected to continue as our assets continue to age

3. **Pressure Reduction Programs** – Three vehicles can provide a limited understanding into emission reductions through pressure reduction programs. By increasing the fleet to eight Picarro-fitted vehicles, our capacity to confirm and quantify emission reductions will improve substantially. The initial two years will focus primarily on baseline measurements, with tangible benefits quantified in later years.

4. **Targeted replacement / rehabilitation** – The current three vehicles provide some insight into emission reductions through targeted replacement/rehabilitation programs, but their use must be balanced between various activities (e.g. against leakage surveying for compliance purposes vs. monitoring in high risk areas). Expanding to eight vehicles will significantly improve our ability to confirm and quantify emission reductions. The first two to three years will focus on baseline measurements and planning for replacement/rehabilitation programs, with benefits quantified later. As more asset management decision-making information becomes available towards the end of the access arrangement period, our approach to rehabilitation will become more targeted, potentially leading to increased activity.

5. **Realisation of emissions reductions**. To confirm or validate the emissions reductions, at least two full appraisals of the gas distribution system will be required following the pressure reduction and targeted programs. JGN will only be able to confirm the full benefit and understand which benefit scenario has been realised, or is in the process of being realised, by RY29.

6. **Other benefits.** Other benefits, such as reductions in public reported leaks, may not be immediately realised. The ongoing deterioration of the assets may not be matched against the programs being increased or prioritised to meet the information becoming available from the Picarro system. However, JGN expects that the introduction of the eight vehicles in RY26 will establish the conditions for the above and other benefits prior to the next access arrangement period

Table 7-1: Option 3 Benefits Schedule Summary

	RY2025	RY2026	RY2027	RY2028	RY2029	RY2030	RY2031
Vehicles	3	8	8	8	8	8	8
Survey	✓	✓	✓	✓	✓	✓	✓
Repair	✓	✓	✓✓	✓✓	✓✓	✓✓	✓✓
Detailed pressure reduction program	●	●	✓	✓✓	✓✓	✓✓	✓✓
Targeted replace / rehabilitation	●	●	●	●	✓	✓	✓

	RY2025	RY2026	RY2027	RY2028	RY2029	RY2030	RY2031
Vehicles	3	8	8	8	8	8	8
Realise emissions reduction				●	✓	✓	✓
Reduction in public reported leaks	●	●	●	●	●	✓	✓

● - limited realisation; ✓ - full realisation of benefits ✓✓ - potential for increased level of benefits

.Emissions Monitoring - Picarro

8. Appendices

8.1 Appendix A – Risk Assessment

A risk assessment was conducted to determine the level of risk severity of the untreated risk. The table below shows the summary of results and then the treated risk summary for each option. It is considered that since Option 2 (5 total vehicles) does not fully address the 'Financial' risk, it is the same risk rating as per Option 1. The risk assessment was undertaken in accordance with the Jemena Risk Manual JAA MA 0050 Revision 9 (31/05/2021).

Risk Title	Risk Consequence Category	Risk Consequence - Description	Untreated Risk			Risk Mitigation	Treated Risk		
			Consequence	Likelihood	Risk Rating		Consequence	Likelihood	Risk Rating
Not implementing the Picarro Technology (8 vehicles) to undertake measurement within JGN	Financial	**Financial** – Inability to measure fugitive emissions reductions, limiting the choices as to emissions measurement mechanisms - Increase in Australian Carbon Credit Units (ACCU's) purchase costs to offset exceeding emissions above the JGN baseline. **Financial** - By not reducing the level of UAG%, the cost savings can't be passed on to the customers.	Serious	Likely	Significant	Implementing Option 3 – Moving to Phase 2	Serious	Unlikely	Low
	Brand / Reputation / Stakeholders	**Brand/ Reputation/ Stakeholders -** Losing the trust of our customers and meet their expectations due increased costs and failure to invest in new technology. **Brand/ Reputation/ Stakeholders** - increased adverse media scrutiny. **Brand/ Reputation/ Stakeholders -** Risk of greenwashing – not directly addressing emissions and purchasing ACCU's	Severe	Possible	Significant		Severe	Unlikely	Moderate
	Health, Safety & Environment	**Public Safety -** Continuing to be reactive in identifying the leaks and rehabilitating them which increases the likelihood of public being exposed to leaks as the assets deteriorate.	Serious	Possible	Moderate		Serious	Unlikely	Low
	Employee	**Employee -** Employees losing trust on the company due to lack of investment in emission reduction initiatives resulting in them exiting the business.	Minor	Possible	Moderate		Minor	Unlikely	Low

8.2 Appendix B – Customer Forum Mar 24

The following slides were presented to customers at the March 2024 forum.

Why are we checking in with you again?

Young voices
Young individuals want us to be proactive in environmental responsibility, while being mindful of cost-of-living pressures.

How we meet net zero
JGN has to cut emissions by 30% by 2030. We aim to meet government emissions targets through operational changes rather than purchasing carbon credits.

What you supported last year
In 2023, you supported our targeted mains replacement program, which uses digital tools to prioritise repairs. We need to draw out the environmental implications of this.

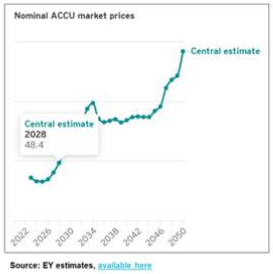
JGN is required to reduce emissions year on year

With over 25,000 km of pipelines, manually surveying the network for emissions would take years.

Without actual emissions data, we lack visibility to target and reduce leaks.

Accurate emissions data is needed to repair leaks contributing the most to emissions.

How can Australia's market for ACCUs facilitate decarbonisation?



Source: EY estimates, available here

If JGN cannot meet its emissions reduction targets set by the government, we can purchase carbon credits to "offset" our emissions.

Remember Picarro?

A highly trained sniffer dog for gas leaks but in car form!

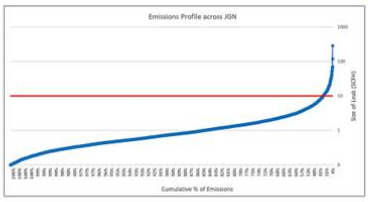
Picarro is a provider of sensor technology that can measure gas levels accurately

Picarro can enable us to patch up the leakiest parts of the network

Targeted mains rehabilitation to reduce emissions

The red line marks the threshold for the largest 2-3% of leaks.

This small number of major leaks accounts for a disproportionate 30% of total emissions from the network.



Summary

Picarro will also quantify the reduction in emissions, following pipeline repairs

1. Picarro emissions detection technology — Leakage survey of the entire network in 1 year
2. Targeted mains repair and rehabilitation — Reveals highest-leak areas for priority repair
3. Emissions reduction — Cutting "fugitive" gas leaks

Investing in emissions-detection technology

Relying on carbon credits to offset emissions

- Survey **20%** of the gas network annually to detect emissions
- **Minimal change** to mains repair & rehab
- **Minimal impact** on actual network emissions
- **In the long-term, strong reliance** on carbon credits to offset actual emissions
- Lack of visibility on actual emissions for reporting
- 3 Picarro-fitted cars

Long-term bill impact skewed towards purchasing carbon credits to offset emissions

Indicative average bill impact: $0.90 p.a

Investing in technology to cut network emissions

- Survey **100%** of the gas network annually to detect emissions
- **Proactive & planned** mains repair & rehab
- **High reduction** in actual network emissions
- **In the long-term, minimal reliance** on carbon credits to reduce actual emissions
- High transparency & accuracy in emissions for reporting
- 8 Picarro-fitted cars

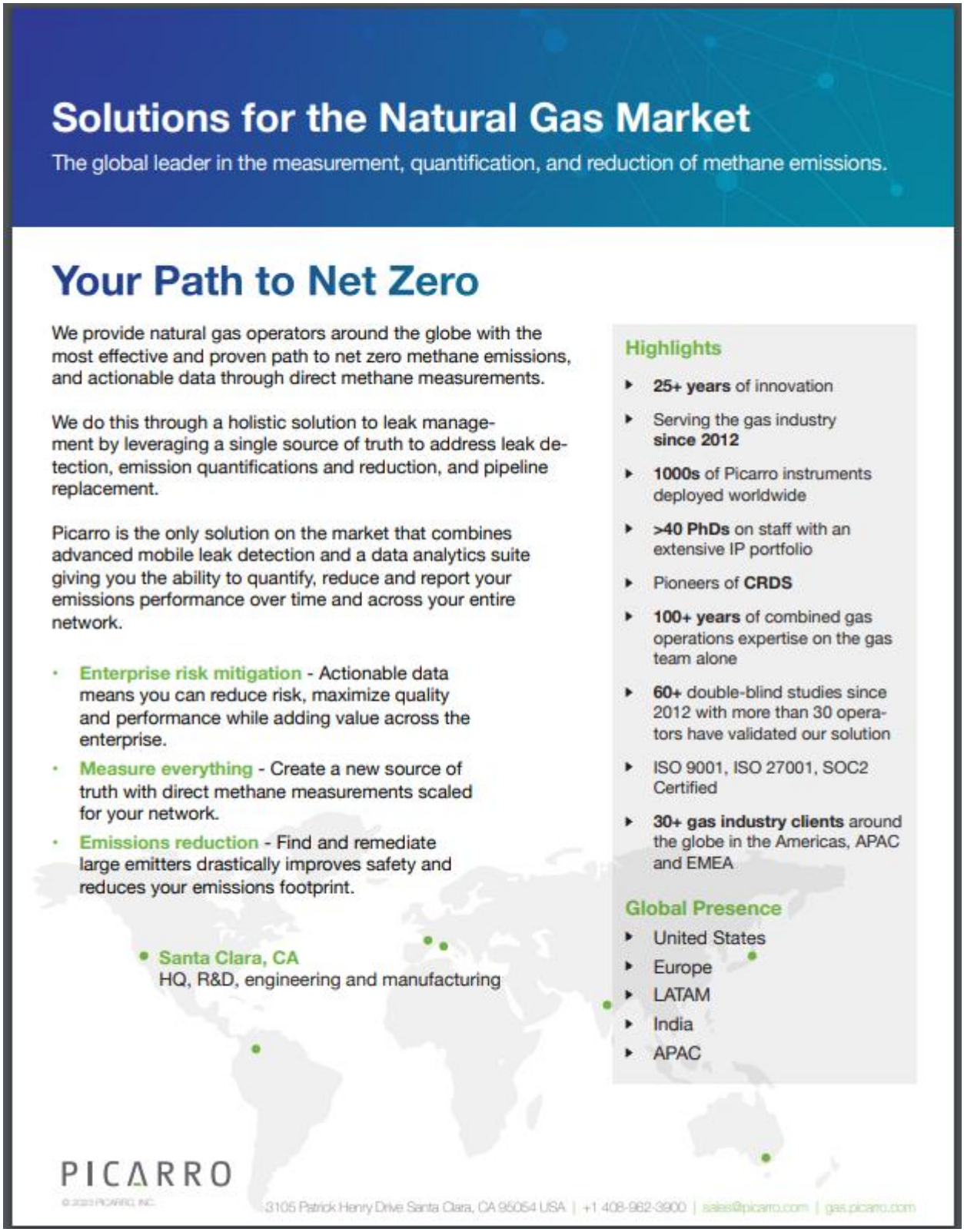
Option included in the Draft 2025 plan

Long-term bill impact skewed towards proactive mains repair to cut actual emissions

Indicative average bill impact: $2.40 p.a.

8.3 Appendix C– Picarro Technology Information

Refer to Picarro's website for additional information which can be found here [Picarro Technology Brief | Picarro]



8.4 Appendix D – Calculation of Driving Distance

In determining the number of vehicles required to survey the total length of the Distribution assets in JGN, two approaches were taken. The first is a 'Top Down' or theoretical approach to establish a ball-park figure on how many vehicles are required, And a 'Bottom Up' or actual approach based on the current driving rates of the two vehicles since fully operational since Jun 2023.

The recommendation from Picarro is that surveying should be undertaken in the night to reduce the effects of solar radiation, with an additional benefit of also encountering reduced traffic. It is also suggested that for emissions data gathering, six passes should be undertaken as a minimum, i.e. the vehicle must pass the same section of mains six times, over three different session. It is preferable to conduct two surveys on one night (4 passes) and the third session (2 passes) on a separate night and the vehicles can be driven in moderate rain and wind conditions,

The three vehicles currently in use for leakage surveying are 2 x Forester and 1 x Rav 4 hybrids. Jemena has considered using electric vehicles and this was also raised during the customer forum. Practical considerations need to be factored in if Jemena heads towards electric vehicles. These may be suitable where vehicles are within metro areas (Sydney, Newcastle, Illawarra) but becomes more complicated when out in the country areas. The need to be able to plug in at hotels/motels where drivers stay overnight may not be available.

Top Down Calculation (Theoretical)

The table below provides the top down calculation when initially determining the number of vehicles required to survey 100% of JGN within 1 year.

Average speed of vehicle	15	km/hr	Limited by nature of driving a pattern between streets
Driving time	5.5	hr	Limited by to and from return to depot and night time fatigue
Driving km per night (for 1 vehicle)	82.5	km	per night of mains
6 Passes required for emissions	14	km	Picarro recommendation to ensure quality outcome
Driving nights per week	5	days	
Driving weeks per year	48	weeks	
Total driving days	230	days	Working nights of year available
Total Mains km travelled (6 passes)	18,975	km	
Total Mains km travelled	3,163	km	
Length of network to be surveyed	26,100	km	Divided by Total Mains km travelled
No. of vehicles required	**8**		

Bottom Up Calculation (Actual validation)

The table below provides the calculation for the requirement of eight vehicles to survey JGN on a yearly basis.

This is based on actual driving distances covered by leakage surveying (As at 1 May 2024). The 'Mains km travelled' is inclusive of the requirement to conduct 6 passes for higher accuracy of emissions data.

The total length of the JGN Distribution network covered by leakage surveying is approx. 26,100km.

Based on current driving rates, eight vehicles are required to cover just over the minimum distance of JGN, which included operational issues such as vehicles servicing, breakdowns and drivers annual leave.

Month	Mains km travelled	
Jun	608	
Jul	689	
Aug	478*	Month where short periods of leave taken by drivers
Sep	312**	One vehicle was out of operation due to gearbox issues
Oct	500**	One vehicle was out of operation due to gearbox issues
Nov	761	
Dec	497*	Month where short periods of leave taken by drivers
Jan	717	
Feb	948	
Mar	781	
Apr	453*	Month where short periods of leave taken by drivers
Total Mains km Driven	**6,744**	
Months of surveying	11	
Monthly Avg for 2 vehicles	613	
Monthly Avg per vehicles	307	
Monthly distance of 8 vehicles	2,453	
Total distance for 8 vehicles per year	**26,978**	Equivalent to extent of network