Northern Gas Networks

A23.I - NGN RIIO-2

Investment Decision Pack
Pressure Management

we are the network

1. Table of Contents

2. Introduction

This Engineering Justification paper details our proposals for investment on our Pressure Management assets during RIIO-2 and acts as a narrative to be used in conjunction with the accompanying Cost Benefit Analysis. It explicitly follows Ofgem's guidance and is set out in accordance with the headings therein.

Our Pressure Management assets are a critical part of our efforts to reduce leakage and require ongoing maintenance, repair, refurbishment and replacement to ensure we manage increasing environmental risks. During RIIO-1 we have undertaken a programme of works to install remote pressure management on our 26 leakiest networks and apply other pressure management techniques where they prove effective. As assets deteriorate they will require intervention to ensure they continue to be effective and following the successes of this programme we will investigate if our customers and the environment can benefit by growing this leakage reduction strategy.

This engineering paper aims to outline the justification for our proposed RIIO-2 Pressure Management investment, detailing our asset management decision making process during which we analyse risk and value and trade-off between different intervention options. It explains the drivers for investment, the inputs and assumptions used in our Cost Benefit Analysis and how our proposed investment benefits our customers and stakeholders.

3. Equipment Summary

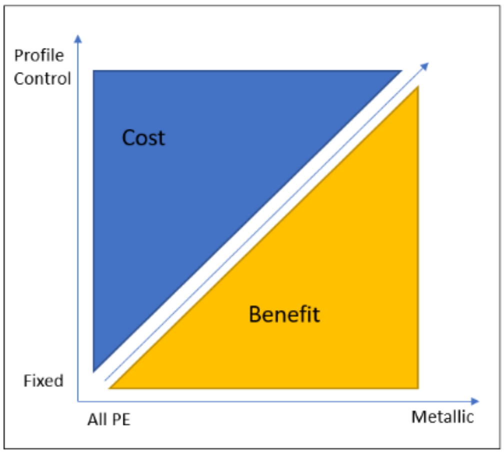
We are committed to reducing our carbon footprint. As a gas transporter, it is well understood that the effects of unburned methane leakage contribute the greatest portion of our overall carbon footprint. The benefits of reducing leakage include reduced carbon emissions and lower number of escapes. This has a benefit to the customer of reduced bills and societal environmental benefits. Leakage is calculated using the industry standard Shrinkage model which supports 3 main methods of leakage reduction:

Replacement - The 30-year program is well underway but is not expected to be completed until around 2032. Currently our networks contain a significant number of metallic mains meaning leakage reduction is still relevant. (Mains replacement is covered in a separate paper)

MEG Treatment - A method of treating gas which helps to close gaps which can open in joints often used in old Iron mains. We will continue to use this method where it is shown to be still viable.

Pressure Reduction - Another approach to leakage control is through managing pressure. By minimising pressure in leaky networks, the volume of gas which will pass through any escape path is reduced and so is a very effective way of reducing methane to atmosphere. This paper details the process we have gone through to determine the optimal ways in which we can manage pressure in our network.

We categorise our networks based upon metallic proportion. Any network or sub-network which has a proportion greater than 5% metal is considered as 'mixed material' and dependent on operating pressure and length will be considered for some form of pressure control. Proportions below 5% are considered as 'All PE' and will be allowed to operate at their full operating pressure all year around as these networks leak much less than networks with metallic mains.



There are different pressure control strategies available to us. The general approach is the more metallic pipes and the higher pressure in the network, the greater the benefit of controlling the pressures in the network.

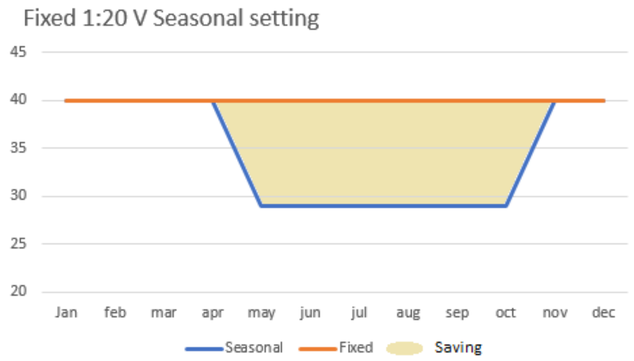
The graph demonstrates there is a place for each type of pressure control strategy and it is not a one size fits all approach.

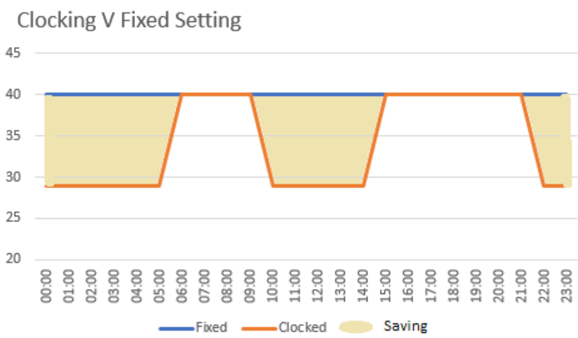
We complete Cost Benefit Analysis on every network to identify the optimal pressure control strategy considering progress of the mains replacement programme (Repex) given the life of the asset.

The Pressure Management strategies available are listed below in ascending order of having no ability to control pressure to having full control of pressure:

Fixed 1:20 settings – this is where we do not control pressures in a network and remain fixed at the 1:20 pressures all year around. This is used for All PE systems and systems which are small in length or operate at low pressures as there is low leakage from these networks.

Seasonal settings – We can manage pressures in a network by visiting site twice a year to manually adjust governor pressures for winter and summer settings. These visits are to simply reduce the pressure setting in summer where demand is low and to raise it again in winter to cover higher demand. This method will be used in any mixed network with a significant operating pressure containing a significant quantity of metallic mains.





Clock Control – This is an effective and simple form of control which allows us to alternate the pressure between peek and off-peek settings within day. The differential in summer would be small so this method is applied only in winter months. This method of Pressure Management although costs more than Seasonal Settings is more effective at reducing leakage as it manages pressure within day rather than within year.

During RIIO-1 our clocking equipment has become difficult to maintain and we are increasingly finding it difficult to find spares and replacements. We are undertaking a project to trial an advanced clock which can be set remotely. We are hoping to have these installed in all clocked sites where the current equipment has become unserviceable within RIIO-1. We will continue this replacement program through RIIO-2. In every case, the viability of clocking will be assessed based upon the remaining material profile and forecast mains replacement.

This means we expect to have all clocks replaced by the end of RIIO-2, but we also expect to have less clocks in our network overall.

Profile control – This is the most effective method of control which allows us to alter the pressure at any time without the need to visit site. The system comprises of three main components:

- **An Actuator** – an arrangement of pneumatic and electrical actuators and related mechanical safety overrides which can be used to control the pressure of the governor.

- **Datalogger and control unit** – this is the brains of the system. The datalogger reads the pressure from the outlet of the governor and compares it to a setpoint profile. It is then able to adjust the actuator to achieve the desired pressure setting.

- **Communications Module –** this is used to control the system remotely. We take a download of the actual pressure data each night and then use a forecast to set a pressure profile to be followed the next day.

Having two-way communication and control of the sites gives the following benefits:

- 24/7 access to pressure data from the control site
- Minimised effects from complex re-enforcements
- The ability to control network pressure to assist with pressure related incidents

This is a more complex system to operate and is more expensive to maintain and repair. To help with this, by the end of RIIO-1, we will have all pressure control sites 100% solar powered reducing the need for regular battery replacements and saving our customers money.

Remote pressure control will remain reserved for our biggest networks where the environmental benefit is clear. We currently use this in 26 of our biggest networks.

For us to be able to manage the networks efficiently, we need to be able to ensure the effects of pressure control are as desired, we use additional data loggers to provide assurance that the correct balance of control and demand has been achieved. We have two types of loggers:

Network loggers - A dedicated pressure control team use loggers connected to the network at strategic points downstream of the governor supply. These 'Network data loggers' are also used to validate the networks. Close monitoring of these network loggers can and has previously given an early indication of developing network issues which if not acted upon could result in customers having poor pressure or loss of supply. Network loggers do not form part of this strategy.

Data loggers - We have loggers fitted to district governors as it is fundamental to our leakage calculations. Over RIIO-1 we have ensured that all loggers are types which can send data remotely over GSM networks. Where we have a profiler fitted we do not need an additional logger as the profiler can undertake this task.

Having a daily stream of data means we can conduct basic health checks on governor control daily. Any control faults with governor control are passed to our maintenance department for resolution as soon as it is identified, previously this was only done during part of a 4-6 weekly visit, during which, the governor may have been relying on safety devices.

In RIIO-2, we will continue this level of monitoring and will look to improve on it further by adopting new types of monitoring devices such as temperature and low-pressure flow when they become available.

4. Problem Statement

Why are we doing this work and what happens if we do nothing?

The main two drivers for pressure control are Safety and Environment:

Safety - by reducing the volume of gas escaping, there will be more time to detect and repair leaks which may be reaching hazardous zones.

Environment - Un-burnt CH_4 is known to be around 25-30 times more damaging as a greenhouse gas than CO_2, so small gas leaks have a relatively big impact on our carbon footprint.

There are other efficiencies which are more difficult to measure such as the reduction of impact by complex replacement and proactive network monitoring which clearly are the right thing to do but have proven difficult to attach value to. In addition, monitoring and data collection of pressure is seen as a pre-curser to smarter gas networks.

All Monitoring and Control equipment on low-pressure systems are battery or solar powered and there are airtime costs associated with the communications. Doing nothing would result in batteries dying and equipment generally failing. The effects of a single site failure are far reaching so the negative effects of failure would be rapid.

As well as the environmental operational costs increasing due to pressures defaulting back to 1:20, we would need to decommission and possibly remove much of the equipment.

If there is no daily monitoring, we would need to return to regular site visits or otherwise rely on customers telling us when our equipment fails.

What is the outcome that we want to achieve?

Our aim is to establish which pressure control method provides our customers with the highest societal benefit on each our 265 low pressure networks, as modelled by our cost-benefit analysis.

How will we understand if the spend has been successful?

The success of each pressure management proposal has been measured by comparing our post implementation shrinkage position to our respective position under the baseline, see graph 2 in this paper for our current projections. Our cost-benefit analysis monetises the shrinkage volumes we expect to save in each scenario using the non-traded CO_2 price stated in the Green book. This is the only valuation structure used in all scenarios in our analysis.

Other measurable success factors include,

- The reduction in the amount of maintenance call outs to reported escapes
- The reduction in the average volume of gas lost per escape incident

The stated factors have not been included in our cost-benefit analysis. This is because the environmental outputs calculated in all scenarios provide adequate payback in year one relative to our baseline position.

It is important to note that certain spend on pressure management equipment is essential. E.g. data loggers must be purchased to ensure that we can calculate the amount shrinkage gas lost in our network.

Narrative Real-Life Example of Problem

Case Study 1 – Huddersfield water ingress

In 2015, a water main burst next to our gas main which resulted in thousands of gallons of water getting into our mains causing loss of supply and poor pressures to hundreds of customers.

After the main incident, the bulk of the water was removed from around the ingress point, but it quickly became clear that some of the water had travelled further into the network creating blockages and restrictions over a wide area.

Using pressure monitoring devices in the area, the location of these pockets was narrowed down which reduced the number of excavations needed to locate the water. As well as greatly reducing the immediate disruption to customers, had this pro-active monitoring not taken place, many customers would have suffered pressure problems the following winter when the demand would be higher.

Case Study 2 – Pressure Management Totex Approach

During RIIO-1 we devised a careful process to ensure the correct approach to increasing capacity is adopted, which takes into consideration the cost of a pipe re-enforcement against the cost of a pressure increase.

The cost of the reinforcement is provided by the design team. The cost of the pressure increase is calculated using network models and analysis tools. If the leakage caused by a pressure increase is sufficiently lower than the cost of the re-enforcement, then the increase is instigated.

In pressure-controlled networks, the effects of the pressure increase are greatly reduced so it is often far better to simply increase the pressure rather than to lay new pipe.

Since this process was introduced, it is estimated that over £10m of reinforcement has been avoided in favour of the equivalent of £230k per annum of leakage which equates to a saving of around £8m over 10 years.

Case Study 3 – Concurrent Controller Faults in Hull

Having access to regular data means we can quickly determine if something is not working as it should in our network.

In March – April 2019, the pressure control team noticed some generally higher than seasonal pressures as we moved into milder weather and lower demand in Hull. Using regular pressure data gathered from monitoring points within the network, we were able to Identify a few suspect sites to be visited.

After some initial visits, it was discovered that several remote pressure management sites within the network had failed in a relatively short time.

When one site fails in a network, the subsequent high pressure is seen across a very wide area. Multiple faults causing multiple interactions makes finding the faulty sites much more difficult to find.

Using careful analysis and checking how the network improved after each repair, the network was quickly brought down to a normal seasonal pressure.

4.1. Spend Boundaries

The boundaries of spend proposed by this justification paper include capital investment on the assets listed in Section 3. It includes all necessary project costs such as design, procurement of materials, construction, commissioning and overheads. It does not include any operational costs such as battery changes or airtime. It also does not include any upgrades to District Governors or any other type of logger such as validation loggers which are situated on the pipelines rather than on the district governors.

5. Probability of Failure

The Probability of Failure (PoF) is the probability an asset will fail at a given point in time. The assets detailed within this strategy were all installed around the same time and are relatively short life assets. An explanation of the types of failure and rate of failure are detailed below:

Types of Failure

- **Clocks** – These devices experience battery and/or mechanical failure. If a clocked site fails, the regulator will default to either it's low or high setting. The low- and high-pressure setting are 80% and 100% of peak 1 in 20.

- **Remote Pressure Management Equipment** – These devices may lose site communication, experience battery failure and/or the solar panel gets damaged / stolen. If a profiled site fails, the regulator will default to its safety mode which is the 1 in 20 setting.

Rate of Failure

- **Clocks** – The clocks we have in the networks are already well beyond their life expectancy and are starting to fail. The manufacturer no longer supports them meaning cables and software updates are also not available and because they are sealed ATEX Units, we are unable to carry out our own repairs. Our CBA assumes that all clocks will need replacing in GD2.

  We are currently looking at some cost-effective alternatives. Among the alternatives, we have done some research with a view to building a clocking device ourselves. At the time of writing this, we have a working prototype which has been mechanically proven. There are some software development to be done, and manufacturing processes will need to be brought up to ATEX standards, but we are hoping to have some fully working prototypes in the network in RIIO-1.

- **Remote Pressure Management Equipment** – Through discussions with other networks, who have greater experience and history of using profilers, we estimate that our equipment will have an 8-year asset life. As the equipment ages, component parts begin to fail. It would be rare to need a complete site re-fit as component parts can be swapped out, so refurbishment of these existing systems will prove to be the most cost-effective solution. The cost of maintaining beyond 8 years will be equivalent to the cost refurbishment and therefore no longer economical.

Therefore, in networks where a pressure management strategy is still beneficial in RIIO-2 we will need to replace or refurbish the existing equipment to ensure it remains operational.

5.1. Probability of Failure Data Assurance

Clocks likelihood of failure: All clocks currently used are at end of life and as such are becoming increasingly difficult to maintain. We have engaged with other manufactures who may be able to provide alternatives, but the options have either been withdrawn or not cost effective. Therefore, we are developing a clock which can be used as a replacement. It is not certain when this will become available, but given the current clocks are at end of life, it is assumed that all clocks will need to be replaced by before the end of RIIO-2.

Profilers likelihood of failure: The proposal for existing profilers is that we will continue to maintain them. Beyond 8 years, this is likely to mean a replacement of many of the parts. The cost of this is estimated to be around half the cost of a new installation.

6. Consequence of Failure

For each pressure management system failure type there is a Consequence of Failure (CoF).

The following consequence measures illustrate the wide-reaching impact of the asset interventions outlined in our RIIO-2 capital expenditure programme,

Environmental risk: The projected reduction in shrinkage gas is the only quantifiable “benefit” used to calculate the present value in all pressure management scenarios stated in our cost-benefit analysis. The agreed industry standard model provides a robust methodology to value the change in risk attributed to each pressure management scheme.

Failure of our pressure systems would mean we cannot mitigate network leakage or minimise the average volume of gas lost per escape.

Customer risk: Our license condition states that to ensure supply assurance in the event of extreme demand surges we must flow gas to meet 1 in 20 peak day requirements. Without pressure management systems in place all network pressures will increase to their 1 in 20 settings. This would increase the likelihood of asset fractures and supply interruptions.

Compliance risk: Without logging equipment we cannot quantify the amount of shrinkage gas lost in our network. Certain settlement transactions with shippers are based on shrinkage volumes. Such purchases form part of our contractual obligation to shippers as stated in the uniform network code.

Financial risk: The volatility of the wholesale market ensures that we’re currently susceptible to price fluctuations when making our mandatory shrinkage purchases.

Not having the appropriate pressure systems in place could also increase the following financial risks,

- Increased maintenance costs in dealing with escapes, including labour and repair
- Complaints and compensation costs associated with supply interruption
- Fines linked to not mitigating the damage caused in the event of us not being able to achieve our escape targets
    - In 2010 we were fined £900k for failing to comply with SSC D10 paragraph 2(g) of our license

Health & safety risk: Being able to maintain low operating pressures when possible will help preserve our assets integrity. This will reduce the number of potentially dangerous escapes that our maintenance colleagues must attend.

7. Options Considered

Types of Intervention

Maintenance and repair – daily monitoring and quick re-active repair to ensure that performance is optimised, and the assets reach their expected life.

Refurbishment – As profile equipment reaches between 5 and 8 years, sites will need to have some new equipment fitted. Where components can be replaced with new technology, this will be considered but only if economical or innovation adds more benefit.

Replacement – installation of a new asset to replace an existing asset, often because of poor condition. This would only be considered reasonable if a new, more efficient / reliable solution became available.

Addition – installation of a new asset on our network to provide extra pressure management capability usually in response to a Cost Benefit Analysis assessment. An example of this would be installation of new pressure profilers throughout a network that previously was managed via seasonal settings or clocks.

Removal – where we no longer require an asset, or we can manage our network in a more efficient manner we decommission the asset from our network.

Future Energy Pathways

We have gone with the default assumption of current assumed proportion of methane CO2 in natural gas projected forwards due to uncertainties in the potential energy pathways and because this is reflective of the current gas quality legislation. However, we acknowledge that significant changes to gas demand or the allowed methane content of gas, for example due to the blending with or conversion to hydrogen, would impact the benefits of our investments.

Arup conducted analysis on the potential benefits of our H21 Programme (see A13 - NGN RIIO-2 Consumer Value Proposition) that showed 45% of the gas in our network is expected to be Natural, 15% biomethane and the remaining 40% hydrogen by 2040; due to a combination of blending and sub-areas of our networks being fully converted. This is consistent with Net-zero by 2050 aligned with the ENA Navigant report.

We have explicitly modelled changes in the methane content of gas in our CBAs as the primary benefit of this investment is to reduce leakage (see Section 7.1.6). This will ensure that our strategy represents a no regrets investment programme that is consistent with net zero and will deliver value to customers whether a hydrogen or electrification pathway is chosen.

Options Analysis

To assess the viability of all considered options, we used the industry standard shrinkage model to estimate the within year leakage emissions when implementing each investment scenario. The feasibility of each project is quantified by estimating our annual emissions under the baseline and comparing them to the relative reduction in emissions estimated under each proposed scenario. All within year projected emissions assume that our gas composition is 77.31% methane. The estimated reduction in emissions have been converted to societal costs using the non-traded price of carbon dioxide, provided by Ofgem.

Repex and MEG saturation have been held constant across all scenarios in the industry standard model used. Subsequently, forecast shrinkage reductions across each scenario can be attributed to each pressure management strategy.

The assumed life of a logger and all pressure control equipment is 8 years under all scenarios which are industry recognised through use. Consequently, this cost benefit analysis is carried out over an 8-year payback period. For information on our expected workload under each scenario refer to the RIIO-2 cost tab in the accompanying cost benefit analysis template.

7.1. Options Summary

The investment options considered are listed below.

7.1.1. Baseline scenario

This scenario assumes that pressure management strategies are not undertaken, including Seasonal Settings. We bypass and remove all clocking and profile equipment and operate at 1:20 pressures. We will continue to replace data loggers when they fail to ensure we are compliant with our leakage calculation requirements. Operational expenditure under the baseline is the cost to cover logger faults across all sites when they occur.

7.1.2. Option 1 - Clocks only scenario

This scenario assumes all sites with profiler in RIIO-1 receive a replacement clock and a new logger is installed. All currently clocked sites receive a replacement clock. All non-profiled sites, in RIIO-1, under this scenario will receive a replacement logger. Operational expenditure under this scenario includes two site visits per year to clocked and seasonally set governors and the costs to cover logger faults.

7.1.3. Option 2 - Pressure Management: Refresh and maintain scenario

In this option we refresh and maintain all existing pressure management equipment. All currently clocked and profiled sites receive a replacement clock and profiler respectively. All sites that currently have a logger receive a replacement logger. Operational expenditure under this scenario includes the cost to cover logger faults, two site visits per year to clocked/seasonally set governors and the cost to visit profiled sites to change batteries etc. plus airtime.

7.1.4. Option 3 - Pressure Management: 10 additional networks

Installation of new profile equipment in 250 (previously clocked) sites across 10 low pressure networks. To ensure maximum customer benefit this work will be carried out in the first and second year of RIIO-2. The remaining sites which had a clock in RIIO-1 will receive a replacement clock.

All sites which had a profiler in RIIO-1 will receive refreshed parts as previously described. All sites which aren't profiled under this scenario will receive a replacement logger. Operational expenditure under this scenario includes the cost to cover logger faults, two site visits per year to clocked/seasonally set governors and the cost to visit profiled sites to change batteries etc. plus airtime.

7.1.5. Option 4 - Pressure Management: 20 additional networks

Installation of new profile equipment in 362 (previously clocked) sites across 20 low pressure networks. All other elements of this scenario are the same as the elements stated in section 7.1.4, the 10 additional networks scenario.

7.1.6 Hydrogen Sensitivity Analysis

In part 4.4 of our business plan we've mapped out our pathway to net zero. This pathway indicates the changes we expect to make to our network through to 2050. Our approach is an increase in hydrogen injection to a maximum of 20% by 2030 and a full conversion of the network to 100% hydrogen in the 2040's. To account for this projected change in our gas composition over time we have re-run each of the stated scenarios and assumed that our gas composition is in line with that stated in part 4.4 of our plan. Section 8.2 provides more information on this sensitivity.

7.2. Options Technical Summary Table

The table below summarises the total number of networks with pressure control equipment under each investment scenario included in our cost benefit analysis.

Option	Strategy	Number of Networks				
		Fixed in 1:20	Seasonal Settings	Clocked	Profiled	Total
-	Baseline	265	0	0	0	265
1	Clocked Only	139	54	72	0	265
2	Pressure Mgt: Refresh & Maintain	139	54	46	26	265
3	Pressure Mgt: 10 additional networks	139	54	36	36	265
4	Pressure Mgt: 20 additional networks	139	54	26	46	265

The table below summarises the total capital costs and outlines the workload required under each investment scenario included in our cost benefit analysis.

Option Title	First year of spend	Final year of spend	CAPEX Workload Volume	Design Life	Total Capex RIIO-2 Cost (£m)
Baseline	2021/22	2025/26	2,177	8 years	£3.45
Clocked Only	2021/22	2025/26	3,500	8 years	£5.71
Pressure Mgt: Refresh & Maintain	2021/22	2025/26	2,703	8 years	£6.40
Pressure Mgt: 10 additional networks	2021/22	2025/26	2,453	8 years	£7.91
Pressure Mgt: 20 additional networks	2021/22	2025/26	2,341	8 years	£8.58

7.3. Options Cost Summary Table

All unit costs are standardised across all scenarios. Any variance in cost between scenarios can be attributed to the differences in required workload under each investment choice.

The table below details the spend associated with each scenario.

Asset intervention	Cost split	Cost Description	Unit cost (inc. overheads)
Replacement / New Loggers	Capex	Cost of logger & install and airtime	£1,586
	Opex	Fault coverage	£138
	Opex	Bypass / remove profile equipment	£140
Replacement Clocks	Capex	Purchase & installation costs	£1,525
	Capex	Remove profiler and install a clock	£1,830
	Opex	2 site visits per year	£138
Replacement Profilers	Capex	Cost of renewal /new install + coms upgrade	£4,271
	Opex	1 battery visit per year + airtime	£285
New Profilers	Capex	Cost of new profiler installation	£9,151
	Opex	1 battery visit per year + airtime	£285
Seasonal Settings	Opex	2 site visits per year	£138

8. Business Case Outline and Discussion

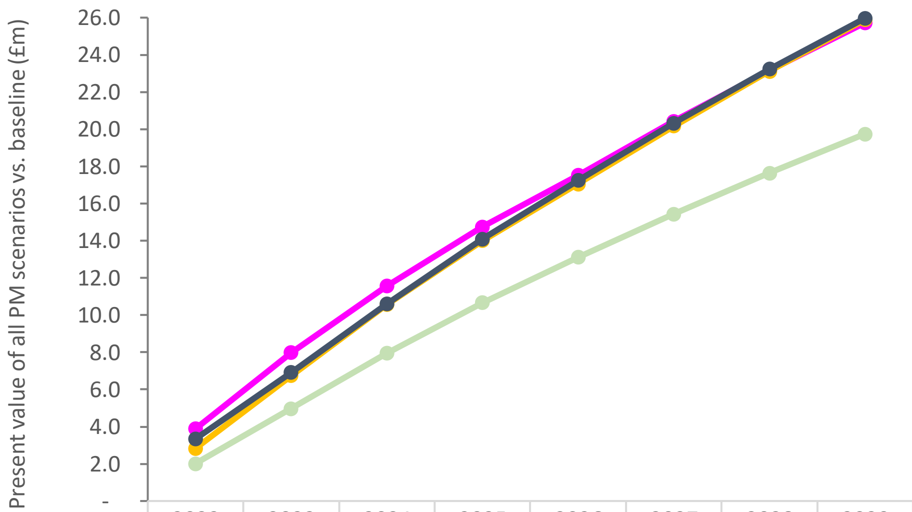
8.1. Key Business Case Drivers Description

We have assessed the present value of each investment scenario over an 8-year payback period. To calculate all present value figures, we have compared the capital and operational costs associated with each scenario and overlaid them against the shrinkage efficiencies we expect each to attain.

All alternative scenarios should be compared to the baseline (graph 1). The baseline position outlines what we expect our annual shrinkage position to be assuming zero pressure control equipment. The present value of each alternative relates to our expected reduction in shrinkage given the funding received under each scenario. To value each of these efficiency gains we have used the non-traded price of carbon dioxide, as quoted by Ofgem.

Estimated shrinkage reduction is the only quantifiable “benefit” used to calculate the present value of each project. The agreed industry standard model is the most robust way to make a valuation assessment. Graph 1 shows that over the 8-year asset life of our profile equipment, the scenario which adds 10 additional profiled networks holds the highest cumulative present value. Compared to the baseline all options show a higher present value in the first year of RIIO-2. This illustrates the high importance pressure management has on operational efficiency.

Graph 1: Net present value of each investment scenario relative to the baseline



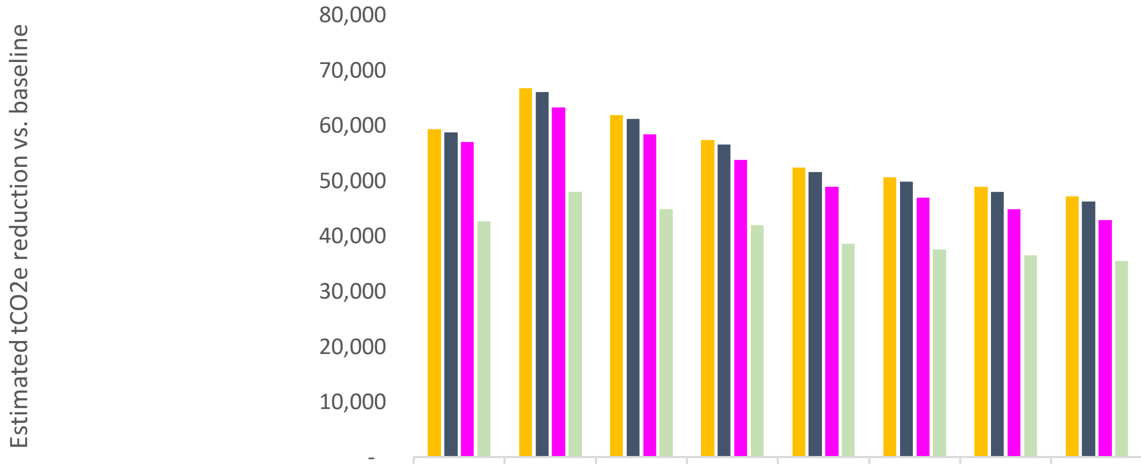
	2022	2023	2024	2025	2026	2027	2028	2029
Pressure Mgt: Refresh & maintain	3.9	8.0	11.6	14.7	17.5	20.4	23.2	25.7
Clocked only	2.0	5.0	8.0	10.7	13.1	15.4	17.6	19.7
Pressure Mgt: 20 additional networks	2.8	6.7	10.6	14.0	17.1	20.2	23.1	25.9
Pressure Mgt: 10 additional networks	3.3	6.9	10.6	14.1	17.2	20.3	23.2	26.0

8 year life of pressure management assets

Graph 2 illustrates the importance our pressure control equipment has on mitigating our business carbon footprint over their asset life. This also has a reputational impact on our company. It is also important to note that, as stated in the uniform network code, we are responsible for purchasing gas to replace the gas lost through shrinkage. Consequently, all shrinkage efficiencies made contribute to a direct cost reduction in shipper purchases.

Installing profilers in 10 additional networks represents optimal value for money as represented by the highest NPV after eight years which is deemed to be the life of the equipment. This is because these additional networks were chosen based on their size and the proportion of metallic main that they currently contain thus maximising the benefits delivered through investment. Adding subsequent profiled networks will result in ever smaller decreases in carbon savings as shown by the additional 20 network option.

Graph 2: tonnes per CO_{2e} saved relative to our baseline scenario



	2022	2023	2024	2025	2026	2027	2028	2029
Pressure Mgt: 20 additional networks	59,243	66,721	61,881	57,264	52,292	50,554	48,816	47,078
Pressure Mgt: 10 additional networks	58,743	65,966	61,105	56,499	51,563	49,768	47,973	46,178
Pressure Mgt: Refresh & maintain	56,982	63,252	58,370	53,785	48,893	46,871	44,848	42,826
Clocked only	42,614	47,987	44,852	41,869	38,542	37,524	36,507	35,489

8 year life of pressure management assets

Pressure Mgt: 20 additional networks   Pressure Mgt: 10 additional networks
Pressure Mgt: Refresh & maintain   Clocked only

The estimated carbon savings referenced are dependent upon our mains replacement programme delivering their forecast replacement and achieving an annual MEG saturation level of approximately 21.4%. All figures above assume that our gas composition is 77.31% methane.

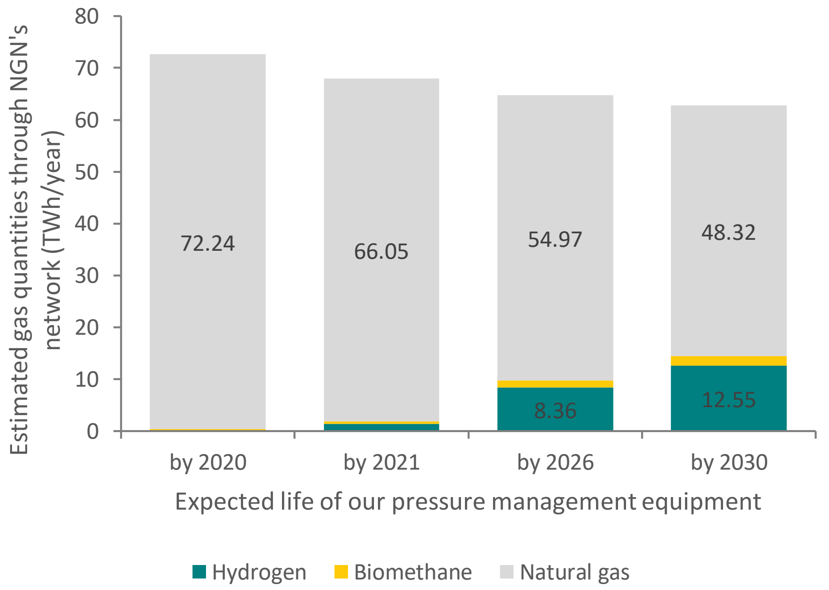
8.2. Hydrogen sensitivity analysis on all investment scenarios

We have recently received innovation funding to support a second phase of research on our H21 programme. This project focuses on research to evidence the conversions of our network to carry 100% hydrogen by 2050.

Over the shorter term, by 2030, our ambition is to achieve a 20% reduction in the amount of methane we transport. To do this we will focus our efforts on blending Hydrogen with natural gas via injection, in addition to experiencing a reduction in the demand for gas because of the onset of renewables and increases in appliance efficiency.

We've mapped out our pathway to net zero in Part 4.4 of our Business plan, which indicates the changes we expect to make to our network through to 2050 to contribute to achieving the UK net zero carbon emissions target. The foundation of our approach is an increase in hydrogen injection to a maximum of 20% by 2030 and full conversion of the network to 100% hydrogen in the 2040's. We have worked with an external consultancy to value the impact of this change and the benefits that will be directly realised or enabled for our customers. Further detail of their assessment can be found in our customer value proposition, see section titled CVP13 – H21. The outputs of this work are illustrated in graph 3 below.

Graph 3: Our estimated future gas composition mix vs. projected life span of our equipment

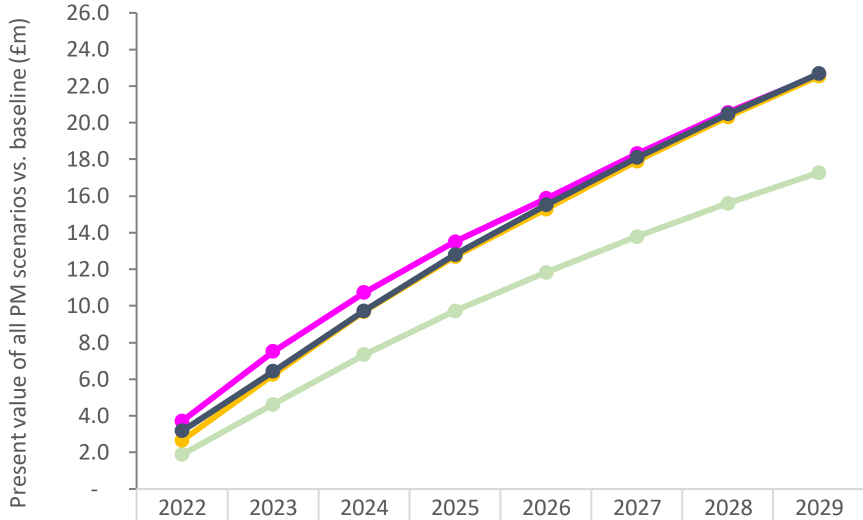


Carbon risk removed is the sole justification used to assess the societal impact of our suggested investment strategies. This is because our cost benefit assessment compares our expected shrinkage position under the baseline to our respective position under each scenario.

The benefits of carbon removed, illustrated in graph 2, will be diminished if these estimated changes to our future gas composition materialise. To account for this, we have applied a Hydrogen sensitivity to each scenario detailed in section 7.1 which follows the logic illustrated in graph 3.

Graph 4 illustrates how we expect the present value of our investments to change relative to our baseline position assuming the gas composition changes outlined above.

Graph 4: Net present value of each investment scenario relative to the baseline



	2022	2023	2024	2025	2026	2027	2028	2029
Pressure Mgt: Refresh & maintain	3.7	7.5	10.7	13.5	15.9	18.3	20.6	22.6
Clocked only	1.9	4.6	7.3	9.7	11.8	13.8	15.6	17.3
Pressure Mgt: 20 additional networks	2.6	6.2	9.7	12.7	15.3	17.9	20.3	22.5
Pressure Mgt: 10 additional networks	3.2	6.4	9.7	12.8	15.5	18.1	20.5	22.7

8 year life of pressure management assets

The table below compares the present values calculated in our cost benefit analysis with the present values calculated in our hydrogen sensitivity. All figures represent present values (£m) relative to our baseline position.

Pressure management scenario	Formula Year 2022			Formula Year 2026			Formula Year 2029		
	Investment CBA	Hydrogen sensitivity	Diff	Investment CBA	Hydrogen sensitivity	Diff	Investment CBA	Hydrogen sensitivity	Diff
Pressure Mgt: 10 additional networks	3.3	3.2	(0.2)	17.2	15.5	(1.7)	26.0	22.7	(3.3)
Pressure Mgt: Refresh & maintain	3.9	3.7	(0.2)	17.5	15.9	(1.7)	25.7	22.6	(3.1)
Pressure Mgt: 20 additional networks	2.8	2.6	(0.2)	17.1	15.3	(1.8)	25.9	22.5	(3.3)
Clocked only	2.0	1.9	(0.1)	13.1	11.8	(1.3)	19.7	17.3	(2.5)

Graph 4 demonstrates that over the short term our investments in pressure management equipment pay back in one year even with the projected uptake in Hydrogen. This is because Hydrogen will only represent a small proportion of our gas composition over the projected life of these assets. The difference column in the table above shows how the projected uptake in Hydrogen will offset the societal benefits we expect to make given the funding we receive under each scenario. This analysis shows that investing in pressure management offers greater benefit to our customers even in the event of a Net Zero future energy pathway. Our strategy therefore represents a no regrets investment programme that is consistent with net zero and will deliver value to customers whether a hydrogen or electrification pathway is chosen.

8.3. Business Case Summary

The table below details the headline business case metrics to allow a high-level comparison of the options:

Option No.	Desc. Of Option			NPVs (relative to baseline, £m)								Preferred Option
		Capex	Opex	2024	2025	2026	2027	2028	2029	2030	2031	
-	Baseline	£3.6	£1.5	-£65.4	-£83.8	-£100.4	-£115.1	-£128.4	-£140.3	-£140.4	-£140.5	×
1	Clocked Only	£5.7	£2.5	£8.0	£10.7	£13.1	£15.4	£17.6	£19.7	£19.7	£19.6	×
2	Pressure Mgt: Refresh & Maintain	£6.4	£2.6	£11.6	£14.7	£17.5	£20.4	£23.2	£25.7	£25.6	£25.5	×
3	Pressure Mgt: 10 additional networks	£7.9	£2.6	£10.6	£14.1	£17.2	£20.3	£23.2	£26.0	£25.9	£25.7	✓
4	Pressure Mgt: 20 additional networks	£8.6	£2.6	£10.6	£14.0	£17.1	£20.2	£23.1	£25.9	£25.8	£25.6	×

9. Preferred Option Scope and Project Plan

9.1. Preferred Option

The preferred option is Option 3 – Pressure Management: 10 additional networks.

9.2. Asset Health Spend Profile

The table below details the intervention workloads and our capital expenditure plans under our preferred RIIO-2 strategy scenario.

Asset	Intervention	Total Workload	Unit Cost	Capital expenditure (£m) 2018/19 prices					
				2021/22	2022/23	2023/34	2024/25	2025/26	Total
Clocks	Replacement	276	£1,250	£0.3	£0.1	£0.0	£0.0	£0.0	£0.4
Replacement Profiler	Refurbishment	797	£3,500	£0.6	£0.6	£0.6	£0.6	£0.8	£3.4
New Profiler	Addition	250	£7,500	£1.1	£1.1	£0.0	£0.0	£0.0	£2.3
Data Logger	Replacement	1,130	£1,300	£0.5	£0.4	£0.5	£0.4	£0.0	£1.8
Total				**£2.6**	**£2.3**	**£1.2**	**£1.0**	**£0.9**	**£7.9**

The total forecast capital expenditure for Pressure Management has been included within this Cost Benefit Analysis and can be referenced back to the following documents:

- RIIO-2 Business Plan – Tables 6.8
- RIIO-2 Business Plan Data Tables – Table 3.05
- A23.I - NGN RIIO-2 Investment Decision Pack – Pressure Management - CBA
- A23.I - NGN RIIO-2 Investment Decision Pack – Pressure Management (Net Zero) - CBA

9.3. Investment Risk Discussion

This is a relatively large asset class. All the existing assets within the network in this asset class have been installed in RIIO-1 and are short life assets, so there is limited risk associated with their failure rates. Unit costs are also low and so hold low risk.