Northern Gas Networks

A23.B - NGN RIIO-2

Investment Decision Pack

Offtakes

we are the network

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2. Introduction

This Engineering Justification paper details our proposals for investment on our Offtake 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 Offtake assets are a critical part of our gas transportation service and require ongoing maintenance, repair, refurbishment and replacement to ensure we manage increasing risks associated with asset health. During RIIO-1 we have undertaken a programme of works to upgrade the worst condition assets on these sites. During RIIO-2 as the other assets deteriorate we will implement a more robust maintenance and refurbishment strategy to extend their life and ensure our gas transportation service continues to function safely and reliably whilst representing value for our customers.

This engineering paper aims to outline the justification for our proposed RIIO-2 Offtake 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

Offtakes are above ground sites which mark the start of our Local Transmission System and are where we take gas, typically at 70 bar, from the National Transmission System (NTS) which is owned and operated by National Grid. The sites primary roles are to record the volume and quality of gas taken from the NTS, to inject odorant to give the gas a distinctive smell and at all but two of our Offtakes to reduce the pressure of the gas to feed either high, intermediate, medium or low-pressure networks. We own and operate 23 Offtakes each with different characteristics in terms of capacity, velocity, pressure cut and footprint but in the most part they all contain similar equipment, albeit by varying manufacturers, which undertake the same functions. The equipment on these sites are considered critical due to the high pressure of the gas and the significant numbers of customers these sites feed and so are designed, operated and maintained to strict regulations, policies and procedures. The following equipment at Offtakes are considered as primary assets:

Filters – Removes debris from the gas stream thereby protecting downstream assets from damage

Meters – Record the volume of gas that flows into our network, allowing accurate billing and management of the network capacity, meters are supplemented by auxiliary control systems such as a flow computer and FWACV

Preheaters – Heats the gas prior to pressure reduction to overcome the temperature loss created as natural gas is reduced in pressure, this is known as the Joules Thompson effect. This will prevent critical downstream assets such as regulators and associated control systems from freezing, thus protecting the assets. These assets are complemented with a control system that ensures the preheating functions as it should.

Pressure Control – This system consists of regulators whose function is to reduce the pressure of gas in the network and Slamshuts, whose function is to protect the downstream network and customers from any over-pressurisation that could occur. These assets are supplemented by a control system that senses and controls the primary assets to ensure that they function correctly.

Odorant Injection System – This system Injects a distinctive smell to the gas, so leaks can be readily detected as natural gas has no smell. Odorisation is one of our main obligations as a gas transporter.

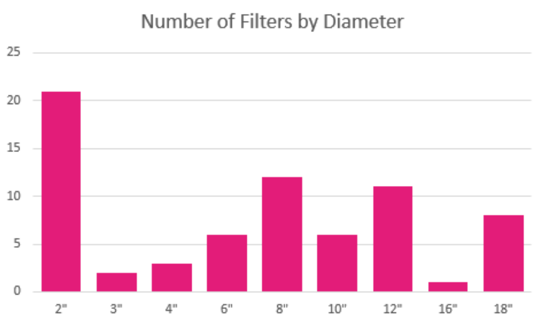
The following equipment at Offtakes are considered as secondary assets:

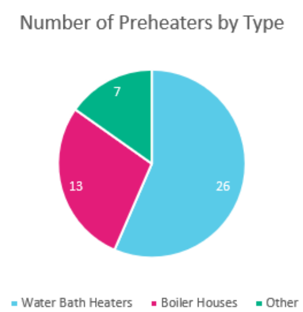
Electrical, Instrumentation & Telemetry – Sites have an electrical supply used to provide power to assets e.g. control system for a boiler or site lighting. Instrumentation equipment is used to monitor site metrics and telemetry systems relay this information to system control to allows faults and alarms to be picked up in real time.

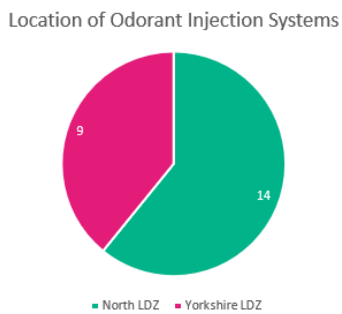
Civils – Civil infrastructure is used for safe access onto and around the site. Buildings are used to house certain equipment to provide security and protection from the elements

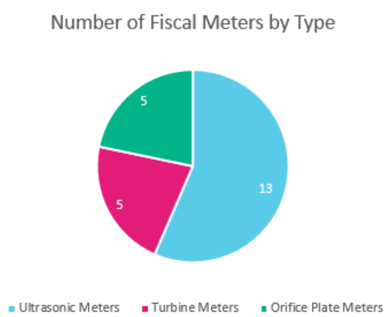
Associated Pipework – above and below ground pipework transports the gas around the site and strategically positioned valves allow the control of flow through the site, cathodic protection is used to mitigate against the effects of corrosion on below ground pipework

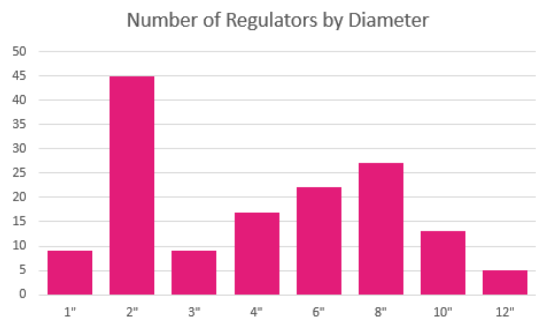
The graphs below provide asset information for the key components of our Offtake sites:







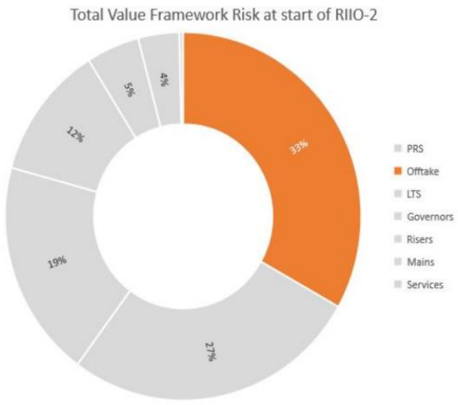




4. Problem Statement

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

We have developed a Value Framework which we use to calculate the risk we hold on our assets as well as to understand how the risk changes over time as our assets deteriorate. Offtake assets account for 33% of our total network risk and include five primary asset classes: Preheating, Filtering, Pressure Control, Metering and Odorant. Within our Value Framework we report on risk in five categories: Compliance, Customer, Environmental, Financial and Health & Safety (further explained in Section 6 of this document).



The table below shows the risk profile of our Offtake assets at 2021 split by secondary asset class and risk category:

Risk profile @ 2021	Compliance Risk £m	Customer Risk £m	Environmental Risk £m	Financial Risk £m	Health & Safety Risk £m	Total Risk £m	%
Preheating	£0.4	£51.8	£0.0	£0.1	£0.1	£52.5	84%
Filters	£0.1	£0.0	£0.1	£0.1	£0.0	£0.4	1%
Pressure Control	£0.2	£0.1	£0.1	£0.1	£0.1	£0.5	1%
Metering	£3.3	£0.8	£0.0	£1.2	£0.1	£5.3	8%
Odorant	£0.6	£1.7	£0.0	£1.2	£0.1	£3.7	6%
Offtake Total	**£4.7**	**£54.3**	**£0.2**	**£2.7**	**£0.5**	**£62.3**	**100%**
%	8%	87%	0%	4%	1%	100%	

Of the five asset classes within Offtakes, Preheating holds most risk at 84% and is predominantly made up of customer risk. Metering holds the second highest risk with 8% however unlike Preheating this is predominantly made up of compliance risk. Odorant assets hold 6% of Offtake risk and is predominantly made up of customer risk. Filters and pressure control hold the lowest risk with 1% and like Metering it is compliance risk which makes up the largest element of risk within this asset class.

Customer risk is by far the highest risk category within total Offtake risk holding 87% of the total risk. This is predominantly driven by Preheating assets. Customer risk refers to the risk of a loss of supply incident and considers the number of properties affected, the costs associated with rectification, reconnection, GSOS payments and other costs such as the provision of electric fan heaters, hot food, shower facilities etc. Compliance risk is the next largest risk category within Offtakes holding 8% of total risk and includes the risk of incurring fines or penalties, this is mainly driven by the potential for regulatory fines due to meter errors, which would impact shippers and customer bills. Environmental, Financial and H&S risks are all relatively small, totalling only 5% of total risk when combined.

Due to the complexity of some of our assets, failure could result from a magnitude of different circumstances. A few examples are detailed below:

Failure in preheating on site leading to low outlet temperatures – This may result from cracking of fire tubes, corrosion of the burner boxes, flues or outer shells, pump failure, heat exchanger failure and boiler failure and will lead to a variety of outcomes such as integrity issues with downstream pipework, detrimental effects on pilot control systems, or hydrate or liquid formation which could influence the operation of pressure reduction equipment and other downstream assets. In the event of one or more of these failures, we would expect to see a loss of supply incident.

Failure in pressure control leading to low/high outlet pressures – This may result from failure of the regulators to control, potentially due to the soft parts perishing, failure of the pilot regulators or a complete failure of the regulator, failing either in the open or the closed position. This would lead to the primary protective device, the slam shut valve functioning which would stop gas supply and result in a loss of supply event, if the slam shut valve failed to function it would result in high outlet pressure which increases the risk of an explosion in the downstream network.

An emerging problem that we are beginning to encounter is that our Preheaters must comply with the Medium Combustion Plant Directive which states that any existing combustion plant with less than 5MW of thermal input must comply with a NOx limit of 250mg/Nm3 by 1st January 2030. Approximately half of our water bath heaters have the potential to fall outside of this limit and will need upgrading to ensure they are compliant by this date.

Without intervention, over the course of RIIO-2 risk increases predominantly due to deterioration of the assets, affecting metrics such as expected number of supply interruptions, but also due to other effects such as the rising cost of carbon. The table below details this without intervention change:

Offtake risk change over RIIO-2 w/o intervention	%
Preheating	39%
Filters	46%
Pressure Control	48%
Metering	88%
Odorant	63%
Offtake Total	**45%**

Over the course of RIIO-2, without intervention we will see total risk within this asset category increase by 45%. It is the Metering category which sees the largest percentage risk increase with 88% however all other asset classes see sizable increases in risk ranging from 39-63%.

Our Decision Support Software allows us to understand various service measures associated with each asset and how these change over time with and without investment. For our Preheaters and Odorant assets, the key service measure is the total expected number of supply interruptions (SI). The table below shows the impact on this service measure over RIIO-2 without investment.

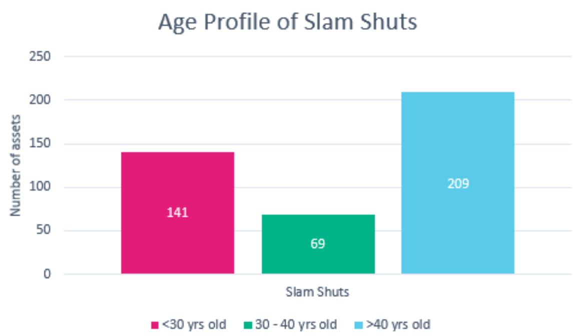
Offtake service level change over RIIO-2 w/o intervention	%
Preheating	51%
Filters	52%
Pressure Control	53%
Metering	85%
Odorant	62%
Offtake Total	**52%**

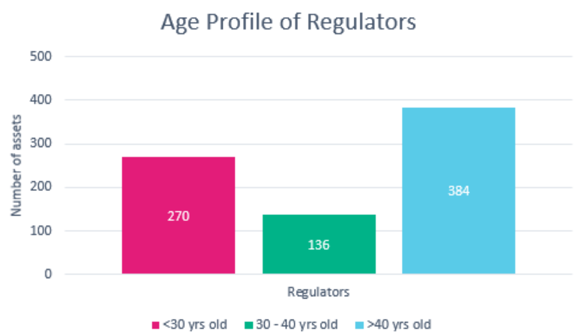
Without intervention in RIIO-2 the total expected number of supply interruptions will increase by 52%. This increase will result in a forecast of at least one loss of supply incident per 2 years during RIIO-2 due to Offtake asset failure. When you consider that these assets form a critical part of our transportation service and asset failure on an Offtake may affect tens or hundreds of thousands of customers, this would be a catastrophic loss of supply event resulting in customers off gas for a considerable length of time. We deem this not to be a tolerable level of risk.

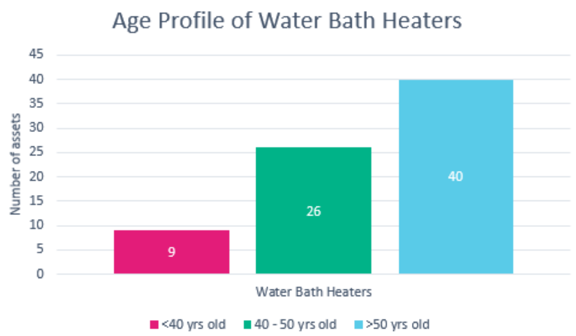
Some additional asset information to consider and which highlights some of the problems we are encountering with our asset populations is to understand their health, age and fault trends, all of which is some of the data used in the calculation of asset risk. The below table highlights the health of our assets as reported in our Regulatory Reporting Pack. This shows that over one third (37%) of our assets have a health score of six or worse which will continue to worsen over time without investment.

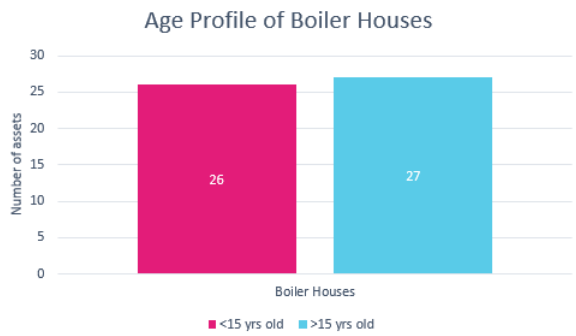
Asset Class	Health (Nr)									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Offtake Filters	0	0	0	8	7	2	4	1	0	2
Offtake Slamshut/ Regulators	0	0	0	4	6	0	1	3	1	8
Offtake Pre-heating	0	1	5	3	1	2	2	1	0	2
Odorisation & Metering	0	0	1	24	10	6	2	1	1	2

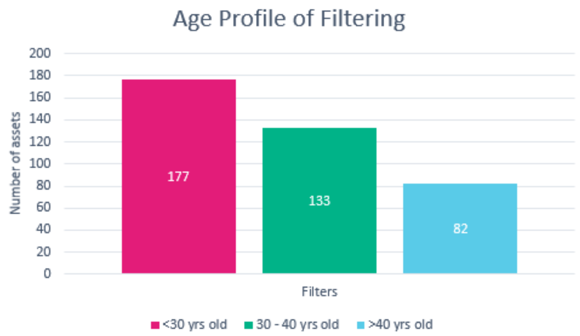
The charts below summarise the age profile of all our assets (both on PRS sites and Offtakes) with the light blue bar representing the expected design life of the equipment. Although on its own age is not a reason to intervene, it can be viewed as a leading indicator to condition and faults. This analysis shows that our slam shuts, regulators, water bath heaters and boiler houses will all have at least 50% of their populations beyond their design life at 2026 without intervention. It also shows that all our odorant systems are over their asset life, the remaining Meters not yet replaced are over their asset life and 20% of our filter assets are over their asset life. If we were to only consider age, we would be intervening on nearly 800 assets in RIIO-2 which would be a considerable cost to our customers.

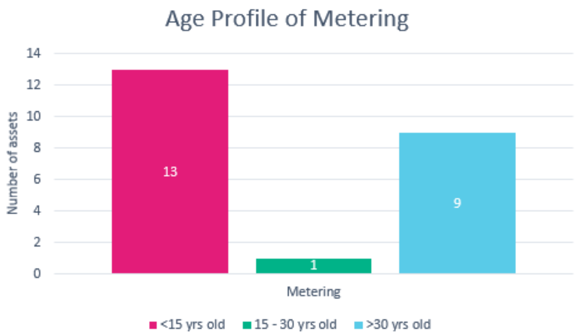


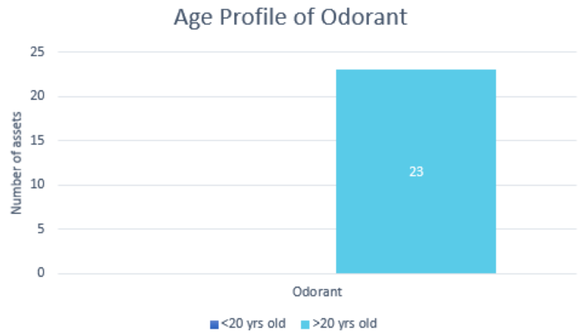




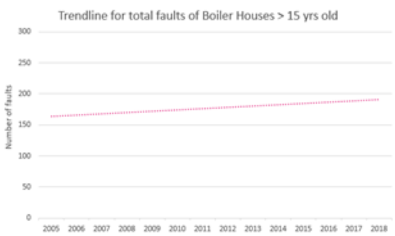


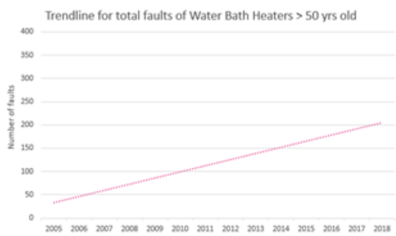


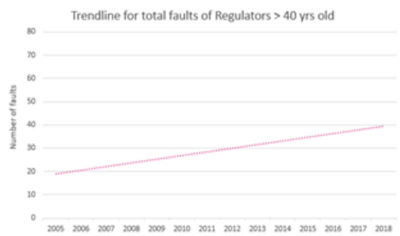


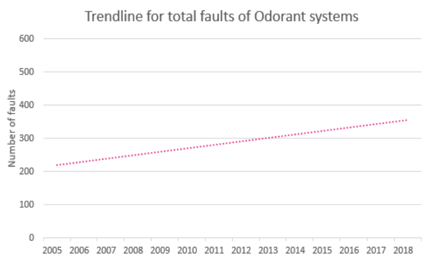


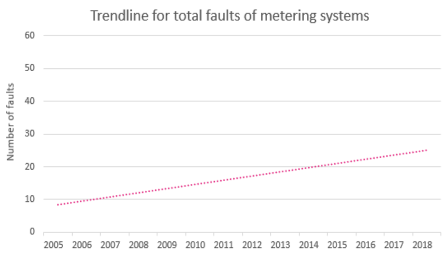
The graphs below show the numbers of faults over time for the assets which will be beyond their expected design life in RIIO-2. This analysis shows a steady increase in faults despite well targeted capital expenditure throughout the RIIO-1 period. Without investment in RIIO-2 these trends would be expected to worsen, and the number of faults logged and fixed would increase more rapidly.











What is the outcome we want to achieve?

From our stakeholder research we know that health and safety, reliability and cost remain our customers key priorities and we are seeing increasing importance placed on the environment. From the risk analysis in Section 4 of this document, for this group of assets, customer risk is the main risk driver and so our objectives will focus around reliability rather than health and safety or the environment, however interventions will have an impact in these areas. We also know that our customers expect value for money and that we make the right investment decisions for both our existing and future customers. We have proposed four objectives covering risk, cost, service and uncertainty. These will be used to determine how successful each option considered is at delivering against our customers' expectations.

We want to manage total risk – We know that our customers value safety and reliability as their number one priority and without intervention total risk will increase by 45% within the RIIO-2 period. In addition, we want to manage increasing risks to provide a safe working environment for our operatives and avoid loss of supply events. We will aim to maintain risk throughout RIIO-2 however we understand the need to balance this ambition with service and cost constraints.

Objective = to maintain total risk to the same level as the starting position of RIIO-2

We want to ensure efficient costs – We know that our customers expect us to invest their money wisely and efficiently to enable a reduction in their bills. To do this we need to make sure we maximise value from our existing assets before we replace them, however, we must understand the whole life cost of the decisions we make to ensure we are doing the right thing both now and in the future. As risk is rising sharply in RIIO-2 it is expected that we will need to intervene on more assets than we have during RIIO-1 to meet our objectives around managing total risk. To avoid escalating costs we therefore need to think of pioneering solutions to ensure we are delivering value for money for our customers.

Objective = to invest no more each year than our average annual RIIO-1 spend (£6.1m/yr.)

We want to continue to provide exceptional service – The key service measure for our Offtake assets is the total expected number of supply interruptions. From the analysis in the section above we understand that supply interruptions are increasing by 52% within the RIIO-2 period to a point where we would be expecting at least one supply interruption every other year from a failure of our Offtake assets. Our RIIO-2 investments need to target this service measure and reduce it back down to a more acceptable level.

Objective = to maintain supply interruptions to the same level as the starting position of RIIO-2

We will protect our customers from future uncertainty – To ensure the investments we make in RIIO-2 are right for both our existing and future customers, and to avoid the risk of asset stranding we must ensure that our investments offer a payback before either the asset life or a point in time where future uncertainty could reduce the forecasted benefits, whichever is the smallest time period. Evidence shows that 20 years is a reasonable timeframe in which we expect minimal changes to large infrastructure in our network, meaning that any new or refurbished equipment that pays back within this time frame will be deemed suitable for investment.

Objective = to ensure our investments pay back within 20 years

How will we understand if the spend has been successful?

This asset class is covered within the NARMS methodology and we have set a relative risk target on which we will annually report performance against.

In addition to the NARMs target, we would expect to keep the number of supply interruptions from Offtake asset failure at a manageable level, ideally at the same level seen during RIIO-1. During the price control period we would also expect to see a reduction in the numbers of faults and remedials picked up during routine maintenance and PSSR inspections.

4.1. Narrative Real-Life Example of Problem

Case Study 1 – Meter replacement

During RIIO-1 our fiscal meter strategy has been driven by reducing the number and impact of meter read errors. This has resulted in upgrading meters at 13 sites due to condition and criticality. These upgrades have also been prioritised due to compliance and financial risks around meter read errors. At one of our Offtakes, Saltwick, during our value engineering design process we were able to rationalise the network to reduce the number of supplies from the NTS and subsequently reduce the numbers of fiscal meters on site from two to one. This has saved our customers money, reduced risk and reduced our operational requirements at this site.

Case Study 2 – Volumetric Regulator replacement

The pressure control system at Towton Offtake was in poor condition and we were experiencing increasing faults in operation of the remote-control valves causing issues for System Control operating our network. In addition, the regulators were housed within a large bund which created operational difficulties and posed an increased risk of injury due to their condition and access and egress arrangements. The decision was taken to replace the regulators with newer and quieter equipment which allowed us to remove the regulator streams from the bund. Faults reduced, remote control was once again reliable, and the removal of the bunds allowed for improved working conditions during maintenance and operational tasks.

Case Study 3 – Odorant refurbishment

The odorant injection system is a critical asset with many component parts such as the expansion tank, controllers, pumps, filters, velometers, pipework, electrical, instrumentation and telemetry systems. The controllers on our assets were beginning to fail and as they had become obsolete and faults were difficult to resolve quickly. During RIIO-1 we decided to replace the controller component of the system to reduce faults and the risk of a health and safety incident that could occur from leakage of un-odorised gas. The refurbishment of the system was a cost-effective solution to the increasing risk we were holding on this asset class and enables us to extract the maximum value out of this piece of equipment by extending its asset life beyond our initial expectations.

4.2. 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 costs associated with LTS pipelines. For further detail see section 7.3 of this document.

5. Probability of Failure

The Probability of Failure (PoF) is the probability an asset will fail at a given point in time. When justifying our RIIO-2 Capital Investment, our Cost Benefit Analysis uses the NARMS methodology to calculate the PoF of our Offtake assets (with exception to two elements which are discussed later in this section). The NARMs methodology algorithm used to calculate the PoF for each Failure Mode is:

PoF = Initial Failure Rate x (exp[(Effective Age – Default Age) x Deterioration Rate]) x Coastal Factor x Housing Factor x FS Factor x Flood Factor

This section discusses how we have used the NARMS methodology to understand the types of failure of Offtake assets as well as the rate of failure, or deterioration, which is a function of the assets attributes and age and condition.

Types of Failure

A failure in an asset is defined as the inability of an asset to fulfil one or more of its intended functions to a standard of performance that is acceptable and gives rise to a detrimental outcome. In the NARMS methodology these failures have been categorised into Failure Modes, and for this group of five primary assets, can be split into the following three categories:

- Odorant & Metering
- Pre-heating
- Filtration & Pressure Control

Odorant & Metering

Failure Modes have been developed by modelling the outcomes rather than components of which there are many. This avoids the need to accurately identify root cause which can often be difficult to diagnose. The Failure Modes consist of:

Over / Under or No Meter Reading – meter read errors where the readings are higher, lower or not being read at all and in addition meter read errors affect the measurement of odorant being injected into the system

High or Low Odorant – where levels of high or low odorant are injected into the gas supply

Release of Gas – failure of a pressure containing component of the system such as site pipework

Release of Odorant – failure of containment of odorant such as corrosion of the odorant tank

General Failure – relating to other failures not leading to a safety, environmental or gas supply consequence such as failure of instrumentation or telemetry systems

Pre-heating

Failure Modes have been developed by modelling the consequences rather than specific component failures such as the burner ignition or control systems. This is because of the variances in heater designs and the complex relationships between components. The Failure Modes consist of:

Release of Gas – failure of a pressure containing component of the system such as the heat exchanger shells

High or Low Outlet Temperature – where failure in the preheating system results in erroneous heat input for the gas flow through the site resulting in high or low outlet temperatures

Capacity – where the system has insufficient capacity to meet a forecast 1:20 peak day downstream demand

General Failure – relating to other failures not leading to a gas release, high or low temperatures or capacity failures such as water level alarms or exhaust flue adjustments

Filters & Pressure Control

Failure Modes have been developed by modelling the outcomes rather than components of which there are many. This avoids the need to accurately identify root cause which can often be difficult to diagnose. The Failure Modes consist of:

Release of Gas – failure of a pressure containing component of the system such as filter bodies

High or Low Outlet Pressure – where concurrent failure of both regulators and the slam shuts result in either over pressurisation or partial or total loss of the downstream system

Capacity – where the system has insufficient capacity to meet a forecast 1:20 peak day downstream demand

General Failure – relating to other failures not leading to a safety, environmental or gas supply consequence such as failure of instrumentation or telemetry systems

Rate of Failure

The Failure Rate for an asset is the frequency of failures at a given point in time, typically measured as the number of failures over a year. We use the Initial Failure Rate from the NARMS methodology which has been elicited through structured and formal workshops and adjust it by age, asset attributes and condition to achieve a more accurate estimate for the initial likelihood of failure for an asset. These scaling factors are:

Condition Risk (Effective Age) – this is the modified default age of an asset according to its condition

Location Risk – a multiplication factor is applicable for assets within 3km of the coast

Housing Risk – a multiplication factor is applicable depending on the condition of the housing

Fencing / Security Risk – a multiplication factor is applicable depending on the condition of the fencing and security

Flood Risk – a multiplication factor is applicable depending on the flood zone the asset is located

The tables below show the Failure Rates of each primary asset at 2021/22 and 2025/26 without intervention and the rate of failure over the RIIO-2 period:

Filters			
Failure Mode	Total Expected no. of Failures		RIIO-2 Failure Rate
	2021/22	2025/26	
Capacity	0	0	0
General Failure	2	3	1
High Outlet Pressure	0	0	0
Low Outlet Pressure	0	0	0
Own use gas	16	16	0
Release of Gas	1	1	0
Total	**20**	**22**	**2**

Preheating			
Failure Mode	Total Expected no. of Failures		RIIO-2 Failure Rate
	2021/22	2025/26	
Capacity	0	0	0
General Failure	15	26	12
Heating Gas	353	353	0
High Outlet Temp	2	4	1
Low Outlet Temp	43	72	29
Release of Gas	0	0	0
Total	**412**	**455**	**42**

Pressure Control			
Failure Mode	Total Expected no. of Failures		RIIO-2 Failure Rate
	2021/22	2025/26	
Capacity	1	1	0
General Failure	3	5	2
High Outlet Pressure	4	5	2
Low Outlet Pressure	3	4	1
Own Use Gas	17	17	0
Release of Gas	0	1	0
Total	**28**	**33**	**5**

Odorant			
Failure Mode	Total Expected no. of Failures		RIIO-2 Failure Rate
	2021/22	2025/26	
General Failure	6	9	4
H_odorant	2	4	1
L_odorant	7	11	4
Power gas to verometers	16	16	0
Release of gas	0	0	0
Release of odorant	0	0	0
Total	**31**	**40**	**9**

Meters			
Failure Mode	Total Expected no. of Failures		RIIO-2 Failure Rate
	2021/22	2025/26	
Over meter reading	3	6	2
Power gas to verometers	18	18	0
Under meter reading	25	48	22
Total	**46**	**71**	**25**

The above tables show the number of expected failures split between different failure modes, these are specific to asset classes. These failures will result in a response from our maintenance team and could result in a loss of supply for our customers. The number of failures is a leading indicator in understanding the condition of these assets. The tables show that without intervention in RIIO-2 the failure rate of our Offtake assets will increase by 16%.

Changes to the NARMs Methodology

In the NARMS methodology, the Initial Failure Rate is multiplied by a function of the asset's attributes. When used in practice, we have seen this caused spurious PoF results, for example, if we only replace the housing of a pressure control system the Housing Risk function halves the PoF for that asset. This is an unrealistic representation of how the intervention affects the assets PoF and therefore we have revised the NARMS asset attribute function for the purposes of justifying our RIIO-2 capital investments. Instead of the asset attribute function affecting all the asset's PoF, our revised calculation assumes that 70% of the Initial Failure Rate is unaffected by the asset attribute function and 30% is affected. When we optimise in our decision support software the result is less weighting towards building and fence interventions.

The Deterioration Rate of an asset estimates how the Failure Rate changes over time and is used to forecast the number of future failures each year over a planning horizon. When calculating the future probability of failure of our assets to inform our RIIO-2 capital programme, we have revised the NARMS methodology deterioration curves. The NARMS methodology uses a bathtub model for deterioration assessment and applies an exponential rate of deterioration. We have seen this type of curve produce spurious results, for example, where we see no change in the failure rate of an asset for c.30 years and then see a sudden steep increase in failures. When justifying our RIIO-2 capital programme we have replaced our Offtake asset's deterioration curves with a more gradual deterioration curves taken from industry approved models (SEAMs) which better represents the behaviour of our Offtake assets.

The net effect of these two alterations to the NARMS methodology give a more realistic representation of the benefits from intervention and result in lower benefits than if we were to stick with the current approved NARMs models used in Regulatory Risk Reporting. This results in more credible NPV's, pay back periods and investment justification.

5.1. Probability of Failure Data Assurance

With exception of the above two points, the data used in our probability of failure calculations comes directly from the NARMs methodology. The failure models are based on various industry standard guidelines (see GDN Asset Health Risk Reporting Methodology document) and the failure rates have been statistically derived using actual asset information such as age or material and historic failure data taking into consideration other influencing factors such as weather or temperature.

Our **Core Asset Data** for Offtakes includes location, fault data, health bandings, customers, capacity, obsolescence and maintenance costs. Each year we update the fault data within our systems as a requirement for Regulatory Reporting therefore this data is up to date as of 2018/19. Our Core Asset Data is scored as green within our Data Improvement Plan for NARMS which means our data is robust and complete.

Our **Asset Health and Failure Data** includes design specification, age, condition, duty, capacity, location and environmental health factors. We have recently undertaken condition surveys on c.65% of our PRS sites during 2016/17 with the remaining sites being last surveyed during 2012/13. All other factors within this category are static and are only updated when we install new assets. Our Asset Health and Failure Data is scored as amber within our Data Improvement Plan for NARMS which means there are some data gaps and assumptions have been applied. This includes some default data applied to kiosk condition and no condition data for fences or control systems. We are developing a smarter field-based Work Management System to resolve this.

Our **Financial Data** includes all the financial data held in the core system that is used within the risk models. We have recently updated all the interventions costs within the system to ensure with the unit costs derived from our Unit Cost Database (See section 7.3). Our Financial Data is scored as amber within our Data Improvement Plan for NARMS which means there are some data gaps and assumptions have been applied.

For the data used within our CBA's we have submitted an update to our Data Improvement Plan which outlines how we intend to improve our data so that the Monetised Risk is reflective of our network assets and current maintenance regimes.

6. Consequence of Failure

For each failure there may be a Consequence of Failure (CoF) which can be valued in monetary terms. In the NARMS methodology the CoF is calculated as the Probability of Consequence (PoC) multiplied by the quantity and Cost of Consequence (CoC) and are linked directly to Failure Modes which categorise the asset failure.

Types of NARMs Consequence

The NARMS methodology sets out the Consequence Measures for each Failure Mode categorised into four risk groups: Customer Risk, Health & Safety Risk, Carbon Risk and Other Financial Risk. These are detailed below for Offtake assets:

Customer Risk

Offtake Site Failures – a failure of the site resulting in loss of supply to downstream domestic, commercial or industrial consumers. Linked to the following Failure Modes: Low Odorant, Under Meter Reading, Low Outlet Temp, High Outlet Temp, Capacity, High Outlet Pressure and Low Outlet Pressure.

Ground Heave – a preheater failure resulting in damage to structures, roads and other assets due to low outlet temperatures. Linked to the following Failure Mode: Low Outlet Temp.

PRE-Odour Release / High Odour – an increase in Public Reported Escapes due to an odour release either near the Offtake or downstream of the network because of a failure of the odorant injection system. Linked to the following Failure Modes: Release of Odorant, High Odorant, Under Meter Reading and Over Meter Reading.

Health & Safety Risk

Explosion – an explosion at either the asset itself or in the downstream network resulting in death, injury or property damage. Linked to the following Failure Modes: Release of Gas, Low Odorant, Low Outlet Temp and High Outlet Pressure.

DS Undetected Gas Escapes / DS Gas Escapes – an increase in gas escapes in the downstream network resulting in an explosion or loss of gas. Linked to the following Failure Modes: Low Odorant, Low Outlet Temp and High Outlet Pressure.

Carbon Risk

Loss of gas – volume of loss of gas from either the asset itself or in the downstream network. Linked to the following Failure Modes: Release of Gas, Low Odorant, and High Outlet Pressure.

NGN's Value Framework

We have developed a Value Framework which we use to assess the value of intervention options consistently across asset classes. We use the NARMs methodology as the basis of our Value Framework and are consistent with the Consequence Measures. However, we have recategorized them into five risk groups, not four, so that there is clear distinction between NGN and societal costs and benefits and so that the present values being calculated are correct. The five risk groups within our Value Framework are: Customer Risk, Health & Safety Risk, Environmental Risk, Compliance Risk and Financial Risk.

To derive a monetary value for the Cost of Consequence each Consequence Measure is allocated a monetary value which is multiplied by the quantity of the consequence. The monetary values used within our Value Framework are based on the agreed NARMs assumptions and uses values common across GDN's such as the base price year, industry approved values such as the cost of carbon or the social cost of an injury. In addition, we use values specific to our business such as the cost of maintenance or the cost of loss of supply. The quantities used are specific to our network such as the number of domestic properties at risk of a supply interruption and have been derived from system data, network analysis or assumptions based on demands, flow and redundancy.

When justifying our RIIO-2 capital programme the monetary value of each Consequence Measure is calculated to determine the benefit or avoided cost of an intervention. Examples include:

Health & Safety Risk – Societal benefits in avoided costs through reductions in the probability of fatality or non-fatality injury. These costs are in accordance with the NARMS methodology.

Customer Risk – Avoided GDN costs through a reduction in costs of supply incidents (loss of supply). These costs have been calculated from historic incidents and the probability and scale of the incidents are based on NARMs models.

Compliance Risk – Avoided GDN costs through a reduction in costs of fines and paying for explosion damage. These costs are in accordance with the NARMS methodology. They have been separated from direct Financial Risk as we consider them highly uncertain and likely significantly under estimated by the values in NARMs, which does not consider reputation, legal and handling costs.

Financial Risk – Avoided GDN costs through reductions in the costs to fix assets on failure and the direct financial cost of the gas leaked from and consumed by our assets. These costs are in accordance with the NARMS methodology.

Environmental Risk – Societal benefits in avoided costs through reductions in the volume of carbon emitted when gas is leaked or consumed. These costs are in accordance with the NARMS methodology and industry approved values.

Probability of Consequence

Within our assessment of asset risk, we use the Probability of Consequence data from the NARMS methodology which has been calculated from a mix of observed data, shared GDN data, industry standard data and expertly elicited data.

7. Options Considered

Types of Intervention

There are various ways in which we can intervene on our assets within this asset group. Each intervention has its own merits and drawbacks and the key to good asset management is to understand how the assets behave and use data and information to ensure the right decisions are made to balance risk and value to deliver a safe and reliable service for our customers. The interventions available for this asset group are:

Maintenance and repair – pre-planned inspections and reactive repair works to ensure that performance is optimised, and the asset reaches its expected life. An example of this would be replacement of corroded water pipework on a heat exchanger following a planned Pressure Systems Safety Regulations (PSSR) major inspection.

Refurbishment – a proactive planned intervention which includes inspection and replacement or servicing of major components and soft parts with the intention of extending the expected life of the asset. An example of this is would be replacement of the gas coil and fire tubes within a Water Bath Heater to ensure it is fit for purpose for the foreseeable future.

Replacement – installation of a new asset to replace an existing asset, often because of poor condition, the new asset will of the same capacity but likely be a newer model or design. An example of this would be the replacement of a Water Bath Heater with a Boiler House to deliver the same heating requirements but with more modern technology.

Addition – installation of a new asset on our network to provide extra capacity or increased service levels, usually in response to increased growth, customer requests or a Cost Benefit Analysis assessment. An example of this would be replacement of a pressure control system with larger diameter regulators to allow for increased gas flow through the site.

Removal – where we no longer require an asset, or we can manage our network in a more efficient manner we decommission and dispose of the asset from our network. We are not considering the removal of any Offtake assets within RIIO-2.

The optimisation tool used within our decision support software will choose the intervention above that delivers the most benefit. This removes any objective bias from the process.

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.

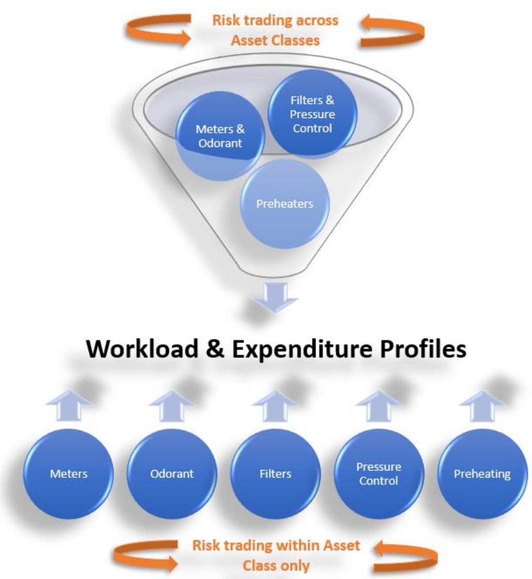
We have not explicitly modelled changes in the methane content of gas in our CBAs, as overall gas demand and the change in C02 content of the gas is not expected to be different enough to materially impact the NPV, Payback & Option Ranking of our preferred investment programme. This is because carbon risk benefit accounts for less than 1% of overall risk benefit and this will be reduced by up to 40% by 2040 across all scenarios if the ambitious but realistic ENA Navigant report pathway is chosen. Our chosen programme represents value for money over a 20-year period regardless and is mainly driven by customer benefits such as avoiding loss of supply. The investments also ensure that we are compliant with relevant legislation. 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.

How we make Asset Decisions

We aspire to make conscious decisions that are balanced across our asset portfolio to ensure we can leverage the most value out of our assets. In making conscious decisions we can evaluate the risk we hold as a business and the impact it has on our strategic objectives. Asset management relies on accurate data, during RIIO-1 we have been working to improve our data and the way we capture and store this information, so it can be used to benefit our decision-making process. We use a wide range of asset data, global value such as the cost of carbon and specific values such as the loss of supply, costs from our Unit Cost Database and the NARMs methodology to calculate risk and value. Technical experts analyse options and set constraints within our Decision Support Software which maximises the value of our investments for the given constraints. We use the value measures from our Decision Support Software in Ofgem's Cost Benefit Analysis template to compare the Net Present Value (NPV) of each option against the baseline scenario to determine the most suitable capital programme in RIIO-2. The diagram above is a simplified representation of this process.

Options Analysis

We consider various options when making asset management decisions to ensure the interventions we undertake are in the best interests of our customers and are optimal in terms of asset performance, capital expenditure and risk management.



Our process for Offtake assets is to undertake 'enterprise optimisations' where we set different constraints for our options and use our Decision Support Software to optimise across all the asset classes. By undertaking optimisations at this level, we are allowing the system to trade risk across each asset class and the interventions on the assets which drive the most benefits are chosen. If we were to only optimise within an asset class and not at this enterprise level, we would be limiting this risk trading and we would not necessarily be intervening on the assets which drive the most value. Once we have run these optimisations, we analyse the results in terms of risk, service and cost and use Ofgem's CBA template to understand the customer benefits derived from each option.

From this analysis a preferred option is chosen, and further sensitivity analysis is undertaken to see if we can in any way improve the option. This sensitivity analysis is undertaken in two parts, the first is sensitivity at the enterprise level looking at the different effects of refurbishment and replacement interventions, as well as seeing if there is more merit in delaying the investment. The second sensitivity is undertaken at the asset class level where we focus on one asset class at a time to see if either outperforming or underperforming risk of the preferred option delivers a better outcome for our customers. During this second sensitivity we will also run each asset class individually through Ofgem's CBA template to ensure that they have a positive Net Present Value and within a reasonable timeframe. This provides additional confidence that our decision support software hasn't been inadvertently constrained during the first stage and not been able to deliver the best value for our customers. The diagram is a simplified representation of this process.

7.1. Options Summary

Stage 1 – Enterprise Optimisations

7.1.1. Baseline – Do Minimum/Nothing

This option is used as the baseline for which all other options are measured against. It does not include any capital investment but instead considers the cost of ongoing maintenance activities and repairs on failure. There are no direct benefits accrued under this option however it does include societal impacts associated with leakage, fatality and injury.

7.1.2. First Option Summary – Reduce/Maintain Total Risk

This option aims to reduce risk from the risk position at the start of RIIO-2. It uses our Decision Support software to optimise the portfolio of Offtake assets to deliver the maximum value whilst constraining the system to deliver a risk outcome of between -5% and 0%. This option will have the benefit of reducing risk and will positively impact our objective associated with maintaining the current level of service for customers.

7.1.3. Second Option Summary - Maintain/Small Total Risk Increase

This option aims to increase risk from the risk position at the start of RIIO-2. It uses our Decision Support software to optimise the portfolio of Offtake assets to deliver the maximum value whilst constraining the system to deliver a risk outcome of between 0% and +5%. This option will have the benefit of maintaining/allowing risk to increase slightly from the first option which should mean less interventions and therefore a smaller investment. It will also likely achieve our objective associated with maintaining the current level of service for customers.

7.1.4. Third Option Summary – Small Total Risk Increase

This option aims to increase risk from the risk position at the start of RIIO-2. It uses our Decision Support software to optimise the portfolio of Offtake assets to deliver the maximum value whilst constraining the system to deliver a risk outcome of between +5% and +10%. The perceived benefit expected with this option is that by allowing risk to increase slightly, but still within a manageable level, that investment will be reduced when compared to option 1 and 2.

7.1.5. Fourth Option summary – Medium Total Risk Increase

This option aims to increase risk from the risk position at the start of RIIO-2. It uses our Decision Support software to optimise the portfolio of Offtake assets to deliver the maximum value whilst constraining the system to deliver a risk outcome of between +10% and +16%. The perceived benefit expected with this option is that by allowing risk to increase, a further reduction in RIIO-2 capital investment, also positively impacting the payback period.

7.1.6. Fifth Option Summary – Large Total Risk Increase

This option aims to increase risk from the risk position at the start of RIIO-2. It uses our Decision Support software to optimise the portfolio of Offtake assets to deliver the maximum value whilst constraining the system to deliver a risk outcome of between +15% and +20%. The perceived benefit expected with this option is that by allowing risk to increase, a further reduction in RIIO-2 capital investment, also positively impacting the payback period.

Stage 2 – Enterprise Sensitivity Analysis

7.1.7. First Option Summary – Pre-emptively Replace Only

This option considers the preferred option from Options 1 – 5 and looks at the effects of replace versus refurb interventions. It uses the total workload derived from the preferred option and uses our Decision Support software to optimise value whilst constraining the system to only allow replacement of Offtake assets. The perceived benefit expected with this option is to outperform our preferred option in terms of total risk. This means key service measures such as the number of supply interruptions should also be positively impacted.

7.1.8. Second Option Summary-Pre-emptively Refurbish Only

This option considers the preferred option from Options 1 – 5 and looks at the effects of replace versus refurb interventions. It uses the total workload derived from the preferred option and uses our Decision Support software to optimise value whilst constraining the system to only allow refurbishment of Offtake assets. The perceived benefit expected with this option is to outperform our preferred option in terms of RIIO-2 capital investment and payback. It has been assumed as part of this option that all assets are suitable for a refurbishment.

7.1.9. Third Option Summary – Deferred Investment

This option considers the effects of deferring investment until RIIO-3. This option delivers the baseline 'do nothing / minimum' solution during RIIO-2 and then undertakes the preferred option from Options 1 – 5 during RIIO-3. The benefit of this option is to understand, at an Offtake level, if there is more value in delaying investment, therefore saving our customers money.

Stage 3 – Individual Asset Class Sensitivity Analysis

7.1.10. Baseline – Do minimum/Nothing

We have used the baseline scenario described above in section 7.1.1 to allow the following options to be analysed against the correct baseline values specific to the asset class in question.

7.1.11. First Option Summary – Outperform Total Risk

This option considers the effects of outperforming the risk position based on the preferred option from stage 1. It uses our decision support software to optimise the portfolio of assets to deliver an improved risk position. The perceived benefit of this option is to see if we can improve risk for little or no extra investment.

7.1.12. Second Option Summary – Preferred Option

This option is the extracted secondary asset workload, cost and risk data taken from our preferred option from stage 1. This option allows us to understand the strategies at an asset level and will enable us to understand the value of the proposals in terms of NPV, CBA, risk impact and cost at a secondary asset level.

7.1.13. Third Option Summary – Underperform Total Risk

This option considers the effects of underperforming the risk position based on the preferred option from stage 1. It uses our decision support software to optimise the portfolio of assets to deliver a worsened risk position. The perceived benefit of this option is to see if we can save significant investment for a slight increase in risk.

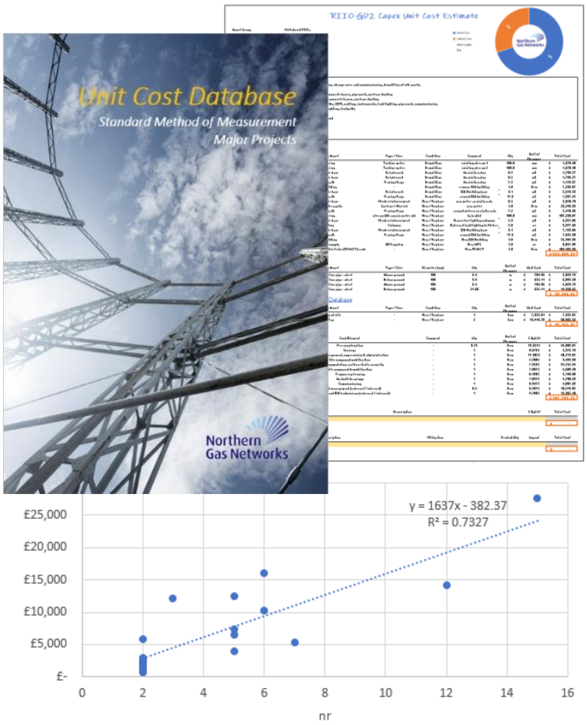
7.1.14. Fourth Option Summary – Deferred Investment

This is the extracted secondary asset workload, cost and risk data taken from stage 1 – option 8. The perceived benefit of this option is to see at a secondary asset class level if there is more value in delaying investment therefore saving our customers money.

7.2. Options Technical Summary Table

Option	Description	First Spend Year	Final Spend Year	Workload Volume	Design Life (Refurb/Replace)	RIIO-2 Capex (£m)
Baseline	Do Minimum/Nothing	2021/22	2025/26	0	10 / 40 years	£0.0
Option 1	Reduce/Maintain Total Risk	2021/22	2025/26	56	10 / 40 years	£41.6
Option 2	Maintain/Small Total Risk Increase	2021/22	2025/26	43	10 / 40 years	£26.1
Option 3	Small Total Risk Increase	2021/22	2025/26	62	10 / 40 years	£23.0
Option 4	Medium Total Risk Increase	2021/22	2025/26	38	10 / 40 years	£13.8
Option 5	Large Total Risk Increase	2021/22	2025/26	34	10 / 40 years	£14.3

7.3. Options Cost Summary Table



The unit costs used in both our Cost Benefit Analysis and capital expenditure forecasts have been derived using our Unit Cost Database (UCD) to provide confidence in their accuracy, consistency and credibility. We have developed our UCD during RIIO-1 which is a set of processes and systems used to allocate the costs of our capital projects to assets. It uses a standard method of measurement which is a measurement rule book detailing the costs associated with an asset unit cost and detailing how the asset should be measured (e.g. m^2). These rules ensure that costs are allocated accurately and consistently to assets and the measures allow for cost curves to be derived. All our capital project costs in RIIO-1 have been input into this database which has allowed for a significant number of data points for each asset providing greater cost confidence. The UCD uses these data points to derive cost curve models which provide a cost trend for a given yardstick and allows for an accurate cost estimate for a given asset based on actual historic costs. A cost estimating template is used to build up the individual elements of an asset intervention such as the indirect costs associated with construction projects for example mobilisation, site set up and welfare, and direct costs for example civil, mechanical and E&I costs associated with the intervention.

The table below shows our unit costs in 2018/19 prices which have been used in our CBA options analysis and the final proposed RIIO-2 capital expenditure forecasts. In addition, we have detailed the inclusions and exclusions from the unit costs and explained where we have used a weighted average unit cost in the instances where a single unit cost is not representative of the whole population of assets, for example varying asset sizes or varying scopes of work.

Asset Class	Intervention	Unit Cost (£k)	Unit	Inclusions / Exclusions
Filters	Replace	**£202**	System	Weighted average of the unit costs of <8" filters, >8" filters, single asset only, whole system only and skid unit. **Unit costs include:** design, procurement, construction, commissioning and NGN overheads. All necessary civil upgrades including bases, ducting and footpaths. All necessary instrumentation upgrades. **Unit costs exclude:** all items outside of the inlet and outlet flanges of the filter stream.
Meters	Replace	**£878**	System	**Unit costs include:** design, procurement, construction, commissioning and NGN overheads. All necessary civil upgrades including bases, ducting and footpaths. Twin stream ultrasonic metering skid, associated pipework, spools, supports and fittings including ball valves, plug valves, flow conditioning plate. Includes new E&I building and Flow Weighted Average Calorific Value rack, micro box, danalyser, flow computer, gas chromatograph, associated software and hardware, UPS, task lighting and field instrumentation. **Unit costs exclude:** all items outside of the inlet and outlet flanges of the metering skid.
Water Bath Heaters	Replace	**£1,230**	System	**Unit costs include:** design, procurement, construction, commissioning and NGN overheads. All necessary civil upgrades including bases, ducting and footpaths. Boiler House, heat exchangers and let down unit and interconnecting gas and water pipework. A full site E&I upgrade including installation of a standby generator. **Unit costs exclude:** all items outside of the inlet and outlet flanges of the heat exchanger apart from the boiler house and let down unit.
Water Bath Heaters	Refurb	**£196**	Asset	Weighted average of the unit costs of a small, medium and large Water Bath Heater. **Unit costs include:** design, procurement, construction, commissioning and NGN overheads. All necessary mechanical upgrades including the shell, gas coil, fire tubes, burner assembly, chimney, control cabinet and instrumentation **Unit costs exclude:** all items outside of the inlet and outlet flanges of the preheater system.
Boiler Houses	Replace	**£1,030**	System	**Unit costs include:** design, procurement, construction, commissioning and NGN overheads. All necessary civil upgrades including bases, ducting and footpaths. Boiler House, heat exchangers and let down unit and interconnecting gas and water pipework. Installation of a standby generator. **Unit costs exclude:** all items outside of the inlet and outlet flanges of the heat exchanger except from the boiler house and let down unit.
Boiler Houses	Refurb	**£201**	Asset	Weighted average of the unit costs of a small and large boiler house refurb and a preheating system refurb (i.e. replace boiler house only). **Unit costs include:** design, procurement, construction, commissioning and NGN overheads. Replacing one or more of the boilers with the boiler house and all necessary control system upgrades. **Unit costs exclude:** replacing the entire boiler house and kiosk and all necessary E&I upgrades, all items outside of the boiler house such as the heat exchangers and let down unit.
Non Volumetric Pressure Control Systems	Replace	**£874**	System	**Unit costs include:** design, procurement, construction, commissioning and NGN overheads. All necessary civil upgrades including bases, ducting and footpaths. All items inside of the inlet and outlet flanges of the regulator streams such as the control valves, slam shut valves and pipework. Control system modifications and a full site E&I upgrade. **Unit costs exclude:** all items outside of the inlet and outlet flanges of the regulator streams.
Volumetric Pressure Control Systems	Refurb	**£301**	System	**Unit costs include:** design, procurement, construction, commissioning and NGN overheads. Replacing one or more of the regulator control valves or slam shut valves, associated civil works, pipework alterations and control system and instrumentation modifications. **Unit costs exclude:** all items outside of the inlet and outlet flanges of the regulator streams.
Non Volumetric Pressure Control Systems	Refurb	**£67**	Asset	**Unit costs include:** design, procurement, construction, commissioning and NGN overheads. Replacing one or more of the regulator control valves or slam shut valves, associated civil works, pipework alterations and control system and instrumentation modifications. **Unit costs exclude:** all items outside of the inlet and outlet flanges of the regulator streams.
Odorant	Replace	**£325**	System	**Unit costs include:** design, procurement, construction, commissioning and NGN overheads. Full system replacement including pumps, verometers, filters, pressure vessels, pipework, odorant controller and control centre, associated civils and E&I. **Unit costs exclude:** excludes replacement of the tanks and alterations to the bund.
Odorant	Refurb	**£41**	System	**Unit costs include:** design, procurement, construction, commissioning and NGN overheads. System strip down and replacement of wearable parts and replacement of one or more components were necessary. **Unit costs exclude:** excludes replacement of the tanks and alterations to the bund.
Electrical & Instrumentation	Replace	**£198**	Site	**Unit costs include:** design, procurement, construction, commissioning and NGN overheads. Full site E&I upgrade including cabling, primary distribution, final circuits, PSU, lighting, heating, earthing system, transmitters, switches and alarms. **Unit costs exclude:** all mechanical and civil upgrades, standby generator.
Electrical & Instrumentation	Refurb	**£66**	Site	**Unit costs include:** design, procurement, construction, commissioning and NGN overheads. Partial site E&I upgrade including cabling, primary distribution, final circuits, PSU, lighting, heating, earthing system, transmitters, switches and alarms. **Unit costs exclude:** all mechanical and civil upgrades, standby generator.
Telemetry	Refurb	**£31**	Site	**Unit costs include:** design, procurement, construction, commissioning and NGN overheads. Upgrade of the satellite comms system on site including V SAT, hardware and software. **Unit costs exclude:** all mechanical and civil upgrades and ongoing opex costs.
GPRS	Replace	**£5**	Site	**Unit costs include:** design, procurement, construction, commissioning and NGN overheads. Upgrade of the GPRS system on site with an alternative technology. **Unit costs exclude:** all mechanical and civil upgrades and ongoing opex costs.
Buildings	Replace	**£189**	Asset	**Unit costs include:** design, procurement, construction, commissioning and NGN overheads. Replacement of a walk in GRP or brick building with explosion relief roof, including internal fixtures and fittings and associated civils works, fixings, concrete base, footpaths, internal and external lighting. **Unit costs exclude:** mechanical assets or E&I equipment within the building.
Buildings	Refurb	**£48**	Asset	**Unit costs include:** design, procurement, construction, commissioning and NGN overheads. Replace doors, roof, wall sections, vents, guttering, fixings, repointing, guttering. **Unit costs exclude:** mechanical assets or E&I equipment within the building.
Fences	Refurb	**£85**	Site	**Unit costs include:** design, procurement, construction, commissioning and NGN overheads. Replacement of individual fence panels, posts, gates, surface treatment **Unit costs exclude:** access, footpaths, roads
Other Security	Refurb	**£91**	Site	**Unit costs include:** design, procurement, construction, commissioning and NGN overheads. Perimeter intrusion detection system, security lighting, alarm receiving centre, line demarcation barrier, smart water application, CCTV, locks **Unit costs exclude:** task lighting, fences, gates
Other Civil	Refurb	**£4**	Item	**Unit costs include:** design, procurement, construction, commissioning and NGN overheads. Pipework, supports, risers, sandboxes, ducting, roads, footpaths, access, bunds, pits, covers, handrails, stairs, signage, landscaping **Unit costs exclude:** building and fence upgrades
Cathodic Protection	Refurb	**£60**	Site	**Unit costs include:** design, procurement, construction, commissioning and NGN overheads. Transformer rectifier, ground beds, cabling and connections, posts **Unit costs exclude:** blasting and recoating of pipework
Ball Valves	Refurb	**£3**	Asset	**Unit costs include:** procurement, installation and NGN overheads. Safety upgrades to the small bore manual valves between the valve casing and the sealant head / blank plug. **Unit costs exclude:** Any other works on the valve not relating to the safety upgrade.
Pipework	Replace	**£278**	Site	**Unit costs include:** design, procurement, construction, commissioning and NGN overheads. Replacement of larger diameter inlet or outlet pipework associated with capacity upgrades due to velocity constraints. **Unit costs exclude:** Capacity upgrades to other assets such as regulators or meters.

8. Business Case Outline and Discussion

8.1 Key Business Case Drivers Description

This section discusses the advantages and disadvantages of the five enterprise optimisations, a preferred option is chosen, and sensitivity analysis then undertaken.

Stage 1 – Enterprise Optimisations

Workload outcomes

Option	Description	No. of Replacements							No. of Refurbishments							Total Workload
		Filter	Pressure Control	Preheat	Metering	Odorant	Secondary	Total	Filter	Pressure Control	Preheat	Metering	Odorant	Secondary	Total	
-	Baseline	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	Reduce/Maintain Total Risk	4	12	2	7	17	10	52	0	0	1	0	0	3	4	56
2	Maintain/Small Risk Increase	2	4	1	2	17	3	29	0	6	2	0	0	6	14	43
3	Small Total Risk Increase	6	0	1	9	4	2	22	0	5	7	0	19	9	40	62
4	Medium Total Risk Increase	0	0	1	0	4	11	16	0	5	4	0	5	8	22	38
5	Large Total Risk Increase	0	0	1	2	4	8	15	0	5	2	0	6	6	19	34

Option 3 delivers the most filter interventions in RIIO-2 with 6 whilst Options 4 and 5 don’t propose any. There are no filter refurbishments in any option which is consistent with our view that these are either not economical or in some cases even possible. We predominately intervene on filters following recommendations from PSSR inspections. In RIIO-2 we have 93 filters split between Offtakes and PRS’s which are due an inspection, most of which won’t have been inspected for 12 years and 13 filters showed signs of cracking at the time. It is expected that these 13 will require replacement during RIIO-2. Considering filter workload at our PRS sites, Options 1 and 3 align with our expectations of RIIO-2 workload.

Half of our pressure control systems will have been in operation for more than 40 years by the end of RIIO-2, which equates to 12 systems on our Offtakes. In addition, we are experiencing increasing faults within this asset class which will only increase further without intervention. Within our maintenance budget we have allowed for 8 minor refurbishments at our Offtakes which involves replacement of soft parts. To be able to intervene on all our asset over 40 years old we would therefore need to intervene on a further 4. Option 1 and 2 significantly exceed this amount with 12 and 10 interventions respectively. Option 1 involves only replacements whereas Option 2 is weighted towards refurbishments. Options 3, 4 and 5 all propose 5 refurbishments aligning with our expectations to intervene on the worst performing assets. There is a risk with these options however if condition means a replacement is the only viable option.

We have 22 Preheating systems on our Offtakes split evenly between Water Bath Heaters and Boiler Houses. These assets are also ageing with over half beyond their expected design lives in RIIO-2. Options 1, 2, 4 and 5 propose five or less interventions which represents less than 23% of the population and considering many of our Water Bath Heaters will be over 50 years old without having had any prior capital investment, this few interventions would leave a considerable risk of asset failure. Option 3 proposes eight interventions weighted towards refurbishment which more closely aligns with the numbers of interventions expected. We are trialling Water Bath Heater refurbishments in RIIO-1 and are confident that this is a viable option going forward and one that will mean we maximise the value of our existing assets in lieu of expensive asset replacements. The refurbishments undertaken in RIIO-1 are also planned to ensure the preheating assets that fall within the scope of the Medium Combustion Plant Directive (MCPD) are made compliant. This is to ensure that a refurbishment is an effective and future proof solution that will allow our larger preheating assets to be utilised beyond 2029 when the MCPD comes into effect.

Around half of our Metering systems are operating on obsolete auxiliary equipment which is a single point of failure, and with only two spares left within our network it is considered a significant risk. Failure of this equipment would affect the level of odorisation which could lead to serious health and safety risks to downstream customers. Failure resulting in a meter read error would also result in a knock-on impact to the customer, who would have to pay for the impact of the failure directly through inflated bills until shipper's costs are recouped. We do not want to be responsible for any such meter error that will impact customer bills as this is out of alignment with stakeholder feedback wanting to keep costs down. None of the options consider refurbishment of meters which is not a cost-effective solution due to site reconfigurations generally required. Options 2, 4 and 5 only propose 4 interventions which is short of the 9 obsolete metering systems. Option 1 considers 7 replacements and Option 3 considers 9 replacements which more closely align with the numbers of interventions required to manage this risk.

All our odorant systems are over 20 years old and considered beyond their design life, we have been able to keep these assets operational through RIIO-1 with upgrades to the controllers however we are seeing increasing numbers of faults and to ensure we continue to comply with the legislative safety requirements in the Gas Safety Management Regulations (GS(M)R) we will need further interventions on these assets in RIIO-2. Options 4 and 5 fall short of our expectations with only 9 and 10 interventions respectively. Options 1, 2 and 3 all propose considerably more interventions with Options 1 and 2 proposing 17 and Option 3 proposing to intervene on all assets. Options 1 and 2 only consider full replacement of the odorant system where as Option 3 proposes 4 full replacements and 19 refurbishments. As all odorant systems will require some form of intervention in RIIO-2 it is Option 3 that delivers against this requirement. Due to the make up of these systems a refurbishment in most cases will be adequate as we will be able to replace the worn or faulty components and continue to use those that still function well. In refurbishing 19 sites this will keep the cost down and 4 replacements will allow us to replace the worst assets thereby managing risks on all sites.

Secondary assets include replacement or refurbishment of control systems, buildings and fences. During RIIO-1 we have made good progress tackling the safety concerns over the deteriorating condition of the electrical systems that existed at the start of the period. Due to the short life of electrical equipment we will need to undertake further work in RIIO-2 however not at the same level as RIIO-1. Options 1, 4 and 5 propose 9, 14 and 12 interventions respectively. This represents intervening on at least 40% of sites which would lead to interventions on electrical equipment in reasonable condition. Options 2 and 3 propose six and five interventions respectively both weighted more towards refurbishment. This workload aligns with our view that the electrical systems are in good condition and the focus on refurbishment will allow us to just replace the components which are worn or faulty thereby delivering a cost-effective solution. During RIIO-1 we have invested more than our allowance in building upgrades due to the worsening condition of these assets, however there are still buildings that will require intervention in RIIO-2. Options 1, 2 and 5 propose either 1 intervention or no interventions, this would result in further deterioration throughout RIIO-2, increasing both Health & Safety risk and accelerating the deterioration of the assets within the buildings. Options 3 and 4 represents a more sensible workload with 4 and 3 interventions respectively. Finally, all options propose 2 security refurbishments apart from Option 1 which suggests 3. We have developed a physical security model and during RIIO-1 we have upgraded the sites within the highest risk bracket. The numbers of interventions proposed in all options would allow us to intervene on the worst few sites in the next risk bracket.

Objective Outcomes

Option	Description	Total NPV Compared to Baseline at 2070 (£m)	Objectives			
			Total Risk change from 2021	RIIO-2 Annual Cost (£m)	Supply Interruption change from 2021	Payback (years)
-	Baseline	-£7,455	45%	£0.0	52%	-
1	Reduce/Maintain Total Risk	£2,298	0%	£8.3	5%	1
2	Maintain/Small Risk Increase	£2,121	5%	£5.2	19%	1
3	Small Total Risk Increase	£1,767	7%	£4.6	15%	2
4	Medium Total Risk Increase	£1,836	16%	£2.8	20%	1
5	Large Total Risk Increase	£1,732	19%	£2.9	34%	1

Within our Decision Support Software, we set our constraints on Customer Risk as this risk category makes up 88% of the total risk of our Offtake assets and is closely linked to the expected number of supply interruptions. The figures above show the Total Risk change that resulted with intervention over RIIO-2.

The first objective was to maintain risk. Option 1 achieves this by maintaining total risk to 0%. The remaining options do not achieve this, but this is due to the process followed. It was noted that the first option managed to maintain risk but at a very high capex cost over RIIO-2. The remaining interventions were constrained to fail the risk target in preference of a reduction in spend that brought this closer into alignment with our second objective.

Our second objective was to ensure efficient costs, option 1 is the highest cost option as it delivers the best risk position, each subsequent option is at a reduced cost as the risk position can worsen. All Options apart from Option 1 meet our objective to invest no more than our average annual RIIO-1 spend.

Our third objective was focussed on maintaining current standards of service, this has been measured by looking at the expected number of supply interruptions. None of our options were able to achieve a reduction or maintenance position, even with a high RIIO-2 annual investment as per option 1. Option 1 & 3 align with what we know is a reasonable increase in supply interruptions that will not affect actual incidents greatly.

All options payback within one year apart from Option 3 which is two years, therefore all pass this objective and represent a worthwhile investment that provides benefit to our customers and reduces the risk of asset stranding. The short time in which the options payback is because of the criticality of Offtake assets owing to the numbers of customers which they feed and the significant consequence of failure costs in a loss of supply scenario.

Conclusion

Option 3 has been chosen as it delivers the largest total workload and most appropriate workload for all asset classes and is weighted more towards refurbishment, delivers a manageable increase in total risk and supply interruptions at a 25% reduction on expenditure compared to RIIO-1.

Option 1 has been discounted due to extremely high capital investment with a workload mix centred on asset replacement rather than asset refurbishment. Option 2 has been discounted because it underdelivers on Filtering, Preheating and Metering interventions and weighted more towards replacement than refurbishment. Options 4 and 5 have been discounted because they underdeliver on Filtering, Preheating, Metering and Odorant interventions and risk and service levels are deemed unmanageable.

Stage 2 – Enterprise Sensitivity Analysis

We have undertaken sensitivity analysis on our preferred option to see the effects of replace, refurbish and deferring interventions.

Objective Outcomes

Option	Description	Total NPV Compared to Baseline at 2070 (£m)	Objectives			
			Total Risk change from 2021	RIIO-2 Annual Cost (£m)	Supply Interruption change from 2021	Payback (years)
3	Small Total Risk Increase	£1,767	7%	£4.6	15%	2
6	Pre-emptively Replace Only (preferred option)	£2,010	1%	£8.4	4%	1
7	Pre-emptively Refurbish Only (preferred option)	£690	24%	£3.1	26%	4
8	Deferred Investment (preferred option)	£1,091	45%	£0.0	52%	13

Option 6 delivers the best risk and service positions due the increased benefits delivered through replacement interventions however the unit cost associated with asset replacement is much higher than refurbishment leading to a 33% increase in annual expenditure when compared to RIIO-1. Payback remains at one year. A replacement only strategy does not align with our approach to maximise the value of our existing assets and the cost of this option is prohibitive in accepting this as our preferred RIIO-2 plan.

Option 7 proposes a £1.5m cost saving per year when compared to Option 3 however it does this at detriment to both risk and service levels which have both worsened by 11%. This is demonstrated by the significantly lower NPV compared to the other options. Payback has increase to four years due to the reduced benefits delivered through refurbishment activities. Although a refurbishment strategy aligns with our approach to maximise the value of our existing assets, this analysis shows that for certain assets we can deliver improved risk and service positions for a relatively minor increase in cost. In addition, engineering issues and the costs associated with the refurbishment of small diameter filters (<8") show that refurbishment is not always a feasible option an option which allows for no asset replacements is unrealistic.

Option 8 defers capital investment until RIIO-3 and so delivers the baseline level of risk and supply interruptions during RIIO-2 which is a significant increase in both. The payback and NPV demonstrate that this option still adds value to the customer so is a viable option, however both the payback and NPV are lower than the other options considered and as such this option does not provide as much value as the preferred option, or other options considered. This option conflicts with our stakeholder feedback on safety and reliability and does not represent good asset management for our customers and therefore is not an improvement on Option 3.

Conclusion

Option 3 remains our preferred option as the sensitivities undertaken at the enterprise level have not been able to better the overall position considering all objectives.

Stage 3 – Individual Asset Class Sensitivity Analysis

Workload and Objective Outcomes

In all options the Baseline has been extracted from the parent level optimisation baseline option to allow secondary asset to be correctly interpreted.

Offtake Filters

Option	Description	RIIO-2 Primary Interventions		Total NPV Compared to Baseline (£m)	Objectives			
		Replace	Refurb		Total Risk change from 2021	RIIO-2 Total Capex Cost (£m)	Supply Interruption change from 2021	Payback (years)
-	Baseline	0	0	-£95.0	46%	£0.0	52%	NA
1	Preferred Option	6	0	£30.1	9%	£1.6	-34%	13

This shows that as a stand-alone investment, intervention on Filtering assets performs well on risk and payback and exceptionally well on the level of supply interruptions for a relatively modest investment. Sensitivity analysis for filters has not been completed as it is below the materiality threshold of £2m over the RIIO-2 period.

Offtake Preheating

Option	Description	RIIO-2 Primary Interventions		Total NPV Compared to Baseline (£m)	Objectives			
		Replace	Refurb		Total Risk change from 2021	RIIO-2 Total Capex Cost (£m)	Supply Interruption change from 2021	Payback (years)
-	Baseline	0	0	-£5,332.1	39%	£0.0	51%	NA
1	Outperform Preferred Total Risk	3	1	£1,543.6	-10%	£6.6	4%	1
2	Preferred Option	1	7	£1,165.9	1%	£5.4	14%	2
3	Underperform Preferred Total Risk	1	2	£1,109.7	16%	£4.2	34%	1
4	Deferred Investment (Preferred Option)	0	0	£718.5	39%	£0.0	51%	13

Option 1 requires an additional £1m over the RIIO-2 period to result in an 11% risk and 10% service level improvement when compared to our preferred option. This option only intervenes on 4 systems as it chooses to replace 3 to achieve the risk position. Reducing the numbers of interventions will mean there will be assets over 50 years old and in relatively poor condition that will not be intervened on in RIIO-2. Increasing cost and reducing workload is not a better solution than our preferred option.

Option 2 shows that as a stand-alone investment, intervention on Preheating assets performs well on all aspects including risk, service, cost and uncertainty. The weighting towards refurbishment aligns with our strategy to maximise the value of existing assets and the increase in numbers of interventions is critical given the age and condition of many of these assets. A further benefit to intervening on more assets will also allow us to rectify any issues with larger preheating assets that would otherwise be non-complaint under the Medium Combustion Plant Directive that will come into force in 2029. All preheating assets that fall within these parameters will need refurbishment to ensure compliance.

Option 3 proposes the least number of interventions at only 3 and given many of these assets will be over their design life in RIIO-2 subsequently increases risk and supply interruptions considerably compared to the other options. Although it proposes a reduction in expenditure, the preferred option is already 25% less than we have historically been investing and so further cost reductions at the detriment of risk and service is not considered appropriate. For these reasons this option does not better our preferred option.

Option 4 shows that delaying investment results in a much worse position for our customers in terms of risk and service, this conflicts with our stakeholder feedback on safety and reliability.

Offtake Pressure Control

Option	Description	RIIO-2 Primary Interventions		Total NPV Compared to Baseline (£m)	Objectives			
		Replace	Refurb		Total Risk change from 2021	RIIO-2 Total Capex Cost (£m)	Supply Interruption change from 2021	Payback (years)
-	Baseline	0	0	-£116.9	48%	£0.0	53%	NA
1	Outperform Preferred Total Risk	11	0	£50.6	-11%	£12.9	-18%	31
2	Preferred Option	0	5	£10.9	14%	£2.3	-2%	15
3	Underperform Preferred Total Risk	1	2	£14.1	34%	£2.4	25%	30
4	Deferred Investment (Preferred Option)	0	0	-£0.7	48%	£0.0	53%	NA

Option 1 improves risk and service levels when compared to our preferred option, but it comes at a significantly higher capital cost due to an increase in the number of interventions and a focus on asset replacement. Due to the high cost this option does not pay back in the 20-year period increasing the risks associated with asset stranding. For these reasons this option does not better our preferred option.

Option 2 shows that as a stand-alone investment, intervention on Pressure Control assets performs the best on three out of our four objectives. It is the only option with a payback of less than 20 years, offers the lowest expenditure and improves the level of supply interruptions expected. The focus on refurbishment aligns with our strategy to maximise the value of our existing assets.

Option 3 has a worse risk and service position for greater cost. Although it has a greater NPV than our preferred option, this is not the case until 2060 where there is less certainty in the deliverable benefits. This option also does not meet our objective to payback within 20 years. For these reasons this option does not better our preferred option.

Option 4 shows that delaying investment results in a much worse position for our customers in terms of risk and service, this conflicts with our stakeholder feedback on safety and reliability.

Offtake Metering

Option	Description	RIIO-2 Primary Interventions		Total NPV Compared to Baseline (£m)	Objectives			
		Replace	Refurb		Total Risk change from 2021	RIIO-2 Total Capex Cost (£m)	Supply Interruption change from 2021	Payback (years)
-	Baseline	0	0	-£928.6	88%	£0.0	85%	NA
	Outperform Preferred Total Risk							
1	Preferred Option	9	0	£14.0	66%	£10.8	68%	10
2	Underperform Preferred Total Risk	4	0	£1.1	82%	£6.0	79%	31
3	Deferred Investment (Preferred Option)	0	0	-£134.2	88%	£0.0	85%	NA

There is not a reasonable option to outperform the preferred scenario as an intervention on all meters not previously replaced in RIIO-1 have been selected within the preferred option.

Option 2 provides the best Net Present Value and delivers a payback within ten years which proves that this is a good investment for our customers. However as can be seen in the risk and service measures, replacement of these assets has a relatively small impact due to several meters previously replaced in RIIO-1 with high base levels of risk. As discussed previously this option delivers against the risks of obsolescence and a single point of failure.

Option 3 delivers a lower cost but at the detriment of risk and service. The total NPV is considerably worse than our preferred option, it does not payback until year 31 and hence does not meet our objective on uncertainty, this payback is not acceptable as elements of the metering system are expected to have an asset life of 20 years due to the I.T infrastructure used. Considering our preferred option is already a 25% reduction on historic investment further reduction in cost delivering increased risk and worse service is not an improved position for our customers.

Option 4 shows that delaying investment results in a much worse position for our customers in terms of risk and service, this conflicts with our stakeholder feedback on safety and reliability.

Offtake Odorant

Option	Description	RIIO-2 Primary Interventions		Total NPV Compared to Baseline (£m)	Objectives			
		Replace	Refurb		Total Risk change from 2021	RIIO-2 Total Capex Cost (£m)	Supply Interruption change from 2021	Payback (years)
-	Baseline	0	0	-£979.5	63%	£0.0	62%	NA
1	Outperform Preferred Total Risk	17	0	£709.8	-41%	£6.7	-50%	1
2	Preferred Option	4	19	£556.8	-18%	£2.8	20%	1
3	Underperform Preferred Total Risk	1	0	£420.2	-1%	£2.5	11%	1
4	Deferred Investment (Preferred Option)	0	0	£499.2	63%	£0.0	62%	8

Option 1 delivers a large reduction in risk and supply interruptions however is only achieved through proportionally larger increases in expenditure. A focus on replacement rather than refurbishment means that we will not maximise the value of our existing assets where refurbishment would only replace the worn or faulty components. For these reasons this option does not better our preferred option.

Option 2 shows that as a stand-alone investment, intervention on Odorant Injection Systems performs well on all risk, cost and payback. The weighting towards refurbishment aligns with our strategy to maximise the value of existing assets and intervening on all assets is critical given the age and increasing faults we are experiencing.

Option 3 only considers one replacement of an odorant injection system and however has been able to reduce risk through an increase in tertiary assets. Due to this fact there is minimal saving over the RIIO-2 period and a worsening of the risk position when compared to our preferred option. As this option does not focus on intervening on the odorant system and rather tertiary assets, this option does not better our preferred option.

Option 4 shows that delaying investment results in a much worse position for our customers in terms of risk and service, this conflicts with our stakeholder feedback on safety and reliability.

Conclusion

Option 3 remains our preferred option as the sensitivities undertaken at the asset class level have not been able to better the overall position considering all objectives.

8.2 Business Case Summary

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

Option	Description	No. of Primary and Secondary Interventions	Capex RIIO-2 (£m)	Totex RIIO-2 (£m)	Total NPV Compared to Baseline (£m)						Payback (years)	Total Risk change from 2021	Supply Interruption change from 2021	Preferred Option
					2030	2035	2040	2050	2060	2070				
-	Baseline	0	£0.0	£8.4	-£668	-£1,046	-£1,423	-£2,167	-£5,039	-£7,455	NA	45%	52%	N
1	Reduce/Maintain Total Risk	56	£41.7	£44.4	£179	£295	£411	£638	£1,589	£2,298	1	0%	5%	N
2	Maintain/Small Risk Increase	43	£26.1	£29.2	£166	£270	£373	£576	£1,464	£2,121	1	5%	19%	N
3	Small Total Risk Increase	62	£23.0	£28.3	£129	£223	£309	£470	£1,242	£1,767	2	7%	15%	Y
4	Medium Total Risk Increase	38	£13.8	£19.1	£119	£203	£292	£466	£1,276	£1,836	1	16%	20%	N
5	Large Total Risk Increase	34	£14.3	£19.5	£105	£181	£259	£410	£1,193	£1,732	1	19%	34%	N
6	Pre-emptively Replace Only (preferred option)	62	£42.1	£45.6	£169	£276	£381	£582	£1,358	£2,010	1	1%	4%	N
7	Pre-emptively Refurbish Only (preferred option)	62	£15.6	£23.5	£60	£115	£166	£269	£570	£690	4	24%	26%	N
8	Deferred Investment (preferred option)	0	£0.0	£8.4	-£43	£15	£75	£178	£765	£1,091	13	45%	52%	N

The table below details the headline business case metrics to allow a high-level comparison of the individual asset class optimisations:

Filters

Option	Description	No. of Primary Interventions in RIIO-2	Forecast		Total NPV Compared to Baseline (£m)						Payback (years)	Total Risk change from 2021	Supply Interruption change from 2021	Preferred Option
			Capex RIIO-2 (£m)	Totex RIIO-2 (£m)	2030	2035	2040	2050	2060	2070				
-	Baseline	0	£0.0	£0.1	-£3	-£5	-£8	-£13	-£52	-£95	NA	46%	52%	N
1	Preferred Option	6	£1.6	£1.7	£0	£0	£1	£2	£16	£30	13	9%	-34%	Y

Preheating

Option	Description	No. of Primary Interventions in RIIO-2	Forecast		Total NPV Compared to Baseline (£m)						Payback (years)	Total Risk change from 2021	Supply Interruption change from 2021	Preferred Option
			Capex RIIO-2 (£m)	Totex RIIO-2 (£m)	2030	2035	2040	2050	2060	2070				
-	Baseline	0	£0.0	£1.1	-£560	-£867	-£1,170	-£1,765	-£3,745	-£5,332	NA	39%	51%	N
1	Outperform Preferred Total Risk	4	£6.6	£7.6	£181	£287	£389	£579	£1,170	£1,544	1	-10%	4%	N
2	Preferred Option	8	£5.4	£6.4	£116	£195	£265	£394	£890	£1,166	2	1%	14%	Y
3	Underperform Preferred Total Risk	3	£4.2	£5.2	£88	£147	£209	£327	£827	£1,110	1	16%	34%	N
4	Deferred Investment (Preferred Option)	0	£0.0	£1.1	-£32	£22	£76	£167	£564	£719	13	39%	51%	N

Pressure Control

Option	Description	No. of Primary Interventions in RIIO-2	Forecast		Total NPV Compared to Baseline (£m)						Payback (years)	Total Risk change from 2021	Supply Interruption change from 2021	Preferred Option
			Capex RIIO-2 (£m)	Totex RIIO-2 (£m)	2030	2035	2040	2050	2060	2070				
-	Baseline	0	£0.0	£1.1	-£6	-£10	-£14	-£22	-£69	-£117	NA	48%	53%	N
1	Outperform Preferred Total Risk	11	£12.9	£14.0	-£8	-£7	-£7	-£5	£23	£51	31	-11%	-18%	N
2	Preferred Option	5	£2.3	£3.4	-£1	£0	£0	£1	£6	£11	15	14%	-2%	Y
3	Underperform Preferred Total Risk	3	£2.4	£3.5	-£1	-£1	-£1	£0	£7	£14	30	34%	25%	N
4	Deferred Investment (Preferred Option)	0	£0.0	£1.1	-£1	-£2	-£2	-£2	-£1	-£1	NA	48%	53%	N

Metering

Option	Description	No. of Primary Interventions in RIIO-2	Forecast		Total NPV Compared to Baseline (£m)						Payback (years)	Total Risk change from 2021	Supply Interruption change from 2021	Preferred Option
			Capex RIIO-2 (£m)	Totex RIIO-2 (£m)	2030	2035	2040	2050	2060	2070				
-	Baseline	0	£0.0	£1.8	-£62	-£104	-£148	-£235	-£599	-£929	NA	88%	85%	N
1	Outperform Preferred Total Risk	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	N
2	Preferred Option	9	£10.8	£12.1	£0	£3	£6	£10	£12	£14	10	66%	68%	Y
3	Underperform Preferred Total Risk	4	£6.0	£7.6	-£2	-£2	-£1	£0	£1	£1	31	82%	79%	N
4	Deferred Investment (Preferred Option)	0	£0.0	£1.8	-£10	-£15	-£20	-£31	-£86	-£134	NA	88%	85%	N

Odorant

Option	Description	No. of Primary Interventions in RIIO-2	Forecast Capex RIIO-2 (£m)	Forecast Totex RIIO-2 (£m)	Total NPV Compared to Baseline (£m) 2030	2035	2040	2050	2060	2070	Payback (years)	Total Risk change from 2021	Supply Interruption change from 2021	Preferred Option
-	Baseline	0	£0.0	£3.8	-£36	-£59	-£83	-£131	-£571	-£980	NA	63%	62%	N
1	Outperform Preferred Total Risk	17	£6.7	£5.3	£21	£38	£55	£89	£412	£710	1	-41%	-50%	N
2	Preferred Option	23	£2.8	£3.9	£17	£30	£44	£72	£328	£557	1	-18%	20%	Y
3	Underperform Preferred Total Risk	1	£2.5	£3.5	£13	£24	£35	£56	£246	£420	1	-1%	11%	N
4	Deferred Investment (Preferred Option)	0	£0.0	£3.8	£3	£14	£27	£52	£289	£499	8	63%	62%	N

9. Preferred Option Scope and Project Plan

9.1. Preferred Option

The preferred option is Option 3 – Small Total Risk Increase.

9.2. Asset Health Spend Profile

The table below details the preferred option's intervention workloads and capital expenditure forecasts for RIIO-2:

Asset Class	Intervention	Workload	Unit	Capital Expenditure (£m) 2018/19 prices					
				21/22	22/23	23/24	24/25	25/26	Total
Filters	Replace	4	system	£0.1	£0.2	£0.0	£0.8	£0.0	**£1.2**
Meters	Replace	9	system	£1.8	£1.7	£0.9	£1.7	£1.7	**£7.9**
Water Bath Heaters	Replace	1	asset	£0.0	£1.2	£0.0	£0.0	£0.0	**£1.2**
Water Bath Heaters	Refurb	13	asset	£0.0	£0.1	£0.1	£0.9	£1.2	**£2.4**
Boiler Houses	Refurb	1	asset	£0.0	£0.0	£0.0	£0.1	£0.0	**£0.1**
Pressure Control Systems	Refurb	6	system	£0.5	£0.4	£0.3	£0.3	£0.3	**£1.8**
Odorant Injection Systems	Replace	4	system	£0.3	£0.3	£0.3	£0.3	£0.0	**£1.3**
Odorant Injection Systems	Refurb	19	system	£0.2	£0.1	£0.2	£0.2	£0.2	**£0.8**
Electrical & Instrumentation	Replace	1	site	£0.2	£0.0	£0.0	£0.0	£0.0	**£0.2**
Electrical & Instrumentation	Refurb	4	site	£0.3	£0.0	£0.0	£0.0	£0.0	**£0.3**
Buildings	Replace	1	asset	£0.2	£0.0	£0.0	£0.0	£0.0	**£0.2**
Buildings	Refurb	3	asset	£0.2	£0.0	£0.0	£0.0	£0.0	**£0.2**
Other Civil	Refurb	1	sum	£0.4	£0.4	£0.4	£0.4	£0.4	**£1.8**
Cathodic Protection	Refurb	2	site	£0.1	£0.1	£0.1	£0.1	£0.1	**£0.6**
Subtotal	**BPDT 3.01**	-	-	**£4.2**	**£4.6**	**£2.4**	**£4.8**	**£3.9**	**£19.9**
Fences	Refurb	2	site	£0.1	£0.0	£0.1	£0.0	£0.0	**£0.2**
Other Security	Refurb	18	site	£0.3	£0.3	£0.3	£0.3	£0.3	**£1.6**
Telemetry	Refurb	23	site	£0.2	£0.2	£0.2	£0.2	£0.2	**£0.9**
Valves	Refurb	173	no.	£0.1	£0.1	£0.1	£0.1	£0.1	**£0.5**
Subtotal	**BPDT 3.05**	-	-	**£0.7**	**£0.6**	**£0.7**	**£0.6**	**£0.6**	**£3.1**
Total	-	-	-	**£4.9**	**£5.2**	**£3.1**	**£5.4**	**£4.4**	**£23.0**

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

- RIIO-2 Business Plan – Tables 6.4 & 6.8
- RIIO-2 Business Plan Data Tables – Table 3.01 & 3.05
- A23.B - NGN RIIO-2 Investment Decision Pack – Offtakes - CBA
- A23.B - NGN RIIO-2 Investment Decision Pack – Offtakes – CBA (Meters)
- A23.B - NGN RIIO-2 Investment Decision Pack – Offtakes – CBA (Preheating)
- A23.B - NGN RIIO-2 Investment Decision Pack – Offtakes – CBA (Pressure Control)
- A23.B - NGN RIIO-2 Investment Decision Pack – Offtakes – CBA (Odorant)

9.3. Investment Risk Discussion

We have controls and processes in place throughout the development of our RIIO-2 Capital Expenditure programme to ensure we mitigate both our customer's and our own exposure to risk. Workload and unit cost risks are inherent when forecasting failure rates and intervention solutions for large populations of assets. The bullet points below outline the steps we have undertaken to ensure we limit these risks to provide an accurate capital programme.

Workload Risk Mitigations

- We have used the NARMs methodology to calculate individual asset's Probability of Failure which uses asset attributes to determine specific failure rates.
- We have undertaken recent surveys during 2017/18 on half of our Offtake sites. This latest information has been used within our modelling.
- As most of our equipment installed on our Offtake sites are from a few select manufacturers, for example our boiler houses are almost exclusively from Armstrongs, we have not witnessed different failure rates across the populations.
- We have considered various options including workload volumes and chosen the solution which provides our customers with the most appropriate balance between cost, risk and service.
- We have sense checked our preferred option against other asset data such as age, condition surveys, fault trends.
- We have shared our preferred strategy with our businesses industry experts to sense check volumes and costs
- Our RIIO-2 strategy is comparable with our RIIO-1 strategy and so we have a proven record we can manage our assets in this way.

Unit Cost Risk Mitigations

- We have used our Unit Cost Database to determine our unit costs. This database holds c.17,000 datapoints which have been collated in a consistent way to ensure our historic costs accurately inform our RIIO-2 unit costs.
- We are not planning to undertake new work activities. We have undertaken all interventions previously and have historic costs allocated within our Unit Cost Database.
- We have benchmarked our unit costs against other GDN's to ensure our unit costs are efficient.
- We have experienced Project Managers who have a proven track record of delivering this type of work in the past and we have a commercial team of quantity surveyors who are focussed on delivering value for money.