Northern Gas Networks

A22.d – Offtakes & PRS: Preheating

Engineering Justification Paper

Contents

1. Summary table

Name of Project	*Offtake and Pressure Reduction Sites – Preheating RIIO-GD3*		
Scheme Reference	*A22.d.NGN*		
Primary Investment Driver	*Asset Health/ Compliance /Operational*		
Project Initiation Year	*2026/2027*		
Project Close Out Year	*2030/31*		
Total Installed Cost Estimate (£)	*£45.82m*		
Cost Estimate Accuracy (%)	*+/-5%*		
Project Spend to date (£)	*£0m*		
Current Project Stage Gate	*Specific delivery identification*		
Reporting Table Ref	*5.01 LTS, Storage & Entry*		
Outputs included in GD3 Business Plan	*As per BDPT above, impact of programme in NARM BPDT*		
Spend Apportionment	**RIIO-GD2**	**RIIO-GD3**	**RIIO-GD4***
	£14.40m	*£45.82m*	*c.£26-32m*

*Expecting all investments listed for RIIO-GD3 to complete in RIIO-GD3. RIIO-GD4 spend estimate has been based on indicative asset health spend in RIIO-GD3.

2. Executive summary

This Engineering Justification Paper (EJP) sets out the interventions that we plan to undertake on preheating assets at our Offtake and Pressure Reduction Stations (PRSs) during RIIO-GD3.

Interventions in this area are asset health and compliance driven, as it is imperative that our preheating assets remain in good condition to ensure gas continues to flow through our network in a safe and reliable manner. Interventions are primarily safety led as around half of our water bath heaters require intervention to ensure safe nitrous oxide levels to comply with the Medium Combustion Plant Directive (MCPD). Our preferred strategy includes 107 interventions at a cost of £45.82m over RIIO-GD3.

We considered the implications of a 'Do More' option, under which we would pro-actively replace rather than refurbish planned boiler houses and water bath heaters, against a 'Do Less' option where we allowed our planned boiler assets to reach 20 years of age rather than 15 before we replace them, accepting a likely increase in faults resulting from aging assets. A summary of these options is provided below in Table 1Table 1 Options summary.

	Number of Interventions	Total RIIO-GD3 Cost (£m)
Preferred Option	107	45.82
Do More Option	107	75.32
Do Less Option	99	40.51

Table 1 Options summary

Costs for Preheating for the RIIO-GD3 EJP are significantly increased (£45.82m) on projected RIIO-GD2 spend (£14.40m) on a comparable 23/24 price basis. However, we are also required to undertake more interventions, as demonstrated in Table 2.

	RIIO-GD2		RIIO-GD3 EJP Preferred Option	
	Workload units	Capex (£m) 23/24 prices	Workload units	Capex (£m) 23/24 prices
Preheating	63	14.40	107	45.82

Table 2 RIIO-GD2 vs RIIO-GD3 investment

The investment strategy throughout RIIO-GD1 and RIIO-GD2 has largely been to refurbish the water bath heaters as the default option to extend life. As the age of our water bath heaters is increasing and associated condition is decreasing, we are now facing a situation where it is becoming more economical to look at a full replacement rather than a refurbishment (£10.5m). This also includes replacing some trial preheating assets installed as part of an innovation project to identify more efficient alternatives, where we have identified efficiencies can be made (£4.8m). We also have to ensure compliance with the MCPD directive to meet legislative low NOx requirements. This programme began in RIIO-GD2 but now has to be continued in RIIO-GD3 (£14.4m).

We view our preferred option as balanced programme required to deliver investments to combat obsolescence and compliance issues: maintaining a safe, reliable, compliant network of assets for our customers whilst minimising costs for customers (See Section 9 for options appraisal). The investments listed above in our preferred scenario and detailed further in the body of the EJP will enable for us to continue to meet our licence obligations over the course of RIIO-GD3 whilst achieving a 13% reduction in monetised risk and 25% reduction in supply interruptions from 2026 through to the end of RIIO-GD3.

3. Introduction

This EJP details our proposals for investment on our Offtake and PRS preheating assets during RIIO-GD3 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 and PRS 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-GD2 we have implemented a more robust maintenance and refurbishment strategy to extend asset life and ensure our gas transportation service continues to function safely and reliably whilst representing value for our customers. This strategy will continue throughout RIIO-GD3, however, there are also compliance and supplier requirements which will require the replacement of mechanical assets such as water bath heaters, odorant, and metering systems.

This engineering paper aims to outline the justification for our proposed RIIO-GD3 PRS and Offtake preheating 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.

The MCPD is an important piece of health and safety legislation which ensure that we limit emissions of sulphur dioxide (SO2), nitrogen oxides (NOX) and dust which are harmful to both the environment and the health of our population. Following the studies we have undertaken, we know that 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. We discuss this in more detail in **Section 5**.

We have used a combination of our Value Framework and our asset data and expertise to determine the appropriate interventions during RIIO-GD3, as set out in Table 3:

	RIIO-3 EJP Preferred Option		
Intervention	**Workload units**	**Capex (£m) 23/24 prices**	**Driver**
NIC Preheating Replacement	4	4.81	Asset Health
Low NOx Compliance	12	14.42	Compliance
E&I Upgrade associated with preheating replacement	20	5.60	Asset Health / Compliance
Water Bath Heater to Boiler House - Replacement	3	3.61	Asset Health
Electrical preheating	4	2.00	Asset Health
New Preheating Installation	3	3.61	Asset Health / Compliance
Water Bath Heater Refurbishment	15	2.57	Asset Health
Boiler House to Boiler House - (mechanical) Replacement	4	4.45	Asset Health
Boiler House (mechanical) Refurbishment	17	4.13	Asset Health
PH Adams Retrofit	25	0.63	Asset Health
Total	**107**	**45.82**	

Table 3 RIIO-GD3 Workload, cost and drivers

Options appraisal and selection can be found in Sections 8.1 to 8.5 and Section 9.

The profile of the workload across the price control period is shown in more detail in Section 10.4 and the Spend profile is detailed in Section 10.2. Unit costs used within the cost benefit analysis have been fully detailed within Section 8.6.

Overall, our preferred strategy for asset health related preheating spend results in a 13% reduction in monetised risk from 2026 through to the end of RIIO-GD3. We also expect a 25% reduction in supply interruptions. The payback period for this option is 14 years and Net Present Value at 2050 is £19.0m. Overall, we are confident that the achieved risk reduction and supply interruption risk mitigated represents good value for our customers.

4. Equipment summary

Preheating is a key element of many NGN Offtake and PRS sites. There is no specific rule where it must be installed, but the overarching policy document, IGEM/TD/13 Edition 3, specifies that preheating should be installed on sites where the pressure is reduced by more than 15 barg. This is the majority of NGN Offtake sites and a large number of NGN PRS sites.

A Preheating system is the facility used to heat the gas before it is reduced in pressure. This is required to protect the pressure control system and downstream pipework/equipment from freezing due to the impact of low outlet temperature caused by the Joule- Thomson- effect, which results in a 0.5 degrees Celsius reduction in temperature per 1 barg of pressure reduction. As per IGEM/TD/13 Edition 3 the outlet temperature needs to maintain a minimum temperature of 0 degrees Celsius.

Preheating can be split up into a distinct number of asset types;

- Water bath heaters - A water bath heater provides the required thermal heat through a thermal solution of water with antifreeze and corrosion inhibitor properties. Gas burners are fired into a large fire tube which heats up this thermal medium to transfer heat to the gas coils that generally multipass and can vary greatly in size depending on the system design. Exhaust gases are released through a flue stack that must be sized and maintained along with the air intake to ensure efficiency of the system.
- Boiler house and heath exchangers - Modular boiler systems offer an increased efficiency compared to water bath heaters. They provide heat to the gas flow through external heat exchanger systems that are also subject to cyclical revalidation inspections. These include external and internal inspection of the heat exchanger tube bundle and pressure testing to identify and repair any defects. Although these systems are more efficient, they can prove to be less reliable than water bath heating systems due to the increased complexity of the technology.
- Electric preheating (Immersion heaters/ Inline electric heater etc) - An electrical pre-heating system provides gas heating through immersion heaters. These are reliable systems due to their low complexity of the heating delivery and control system. They are generally used on installations with low gas heating requirements as there are limitations on the heat transfer these units can provide due to the substantial power requirements which cannot be provided by standard mains power systems.
- NIC new technology preheating – This includes the Proheat system, which utilises steam to warm the gas process pipework. This steam is held within a vacuum, meaning it can produce steam at lower temperatures (only 42 degrees Celsius). It also includes Hot Cat units which utilise catalytic heater panels to heat up the gas process pipework that runs through the enclosure. The NIC preheating trial was an innovation funded trial to understand a number of things, namely;
    - What alternative preheating systems are available?
    - To tackle inefficiency of old equipment such as water bath heaters.

As part of this trial to improve efficiency of our preheating assets NGN installed 3 Proheat and 3 Hotcat systems across 6 sites, with a further 2 Proheats installed outside of the NIC trial. Following this trial, we have identified that package boiler systems would be the more optimal solution and we have therefore taken the decision to replace Hotcat and Proheat systems with package boiler systems to ensure efficiency of our assets.

All the above replacement interventions include a control system that is considered to form a part of the scope of works. For refurbishment, whether the control system is included depends upon the specific scope of works.

There are currently 105 preheaters in operation across the NGN network. 66 of these are boiler houses and 34 are water bath heaters.

During RIIO-GD2 we have implemented a more robust maintenance and refurbishment strategy on preheating assets to extend asset life and ensure our gas transportation service continued to function safely and reliably whilst representing value for our customers. In RIIO- deteriorating asset health (increasing age and deteriorating condition) are contributing to significant rises in risk without intervention. There are also required interventions which are primarily safety and compliance led to ensure safe nitrous oxide levels to comply with the MCPD. This Directive is an important piece of health and safety legislation which ensure that we limit emissions of sulphur dioxide (SO2), nitrogen oxides (NOX) and dust which are harmful to both the environment and the health of our population. Following the studies we have undertaken (see **Section 5** for more detail); we know that 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. The combination of these two drivers, asset health and compliance are leading us to an increase in our investment in RIIO-GD3 over RIIO-GD2 with the focus in RIIO-GD3 now turning to a programme with a mixture of refurbishment and replacement to address the afore mentioned issues to retain a safe, reliant and compliant network for our customers and the public.

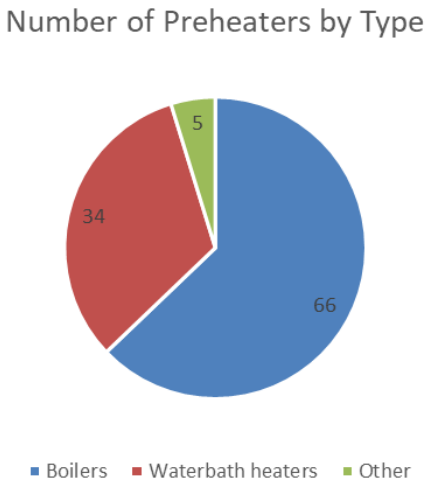

Figure 1 Number of Preheaters

The different types of interventions we have considered for metering and odorant are discussed in Section 8.

The change in Asset Health (Health Index) over RIIO-GD3 with and without investment is detailed in Section 5.

5. Problem / opportunity statement

Why are we doing this work?

The investment strategy throughout RIIO-GD1 and RIIO-GD2 has largely been to refurbish the water bath heaters as the default option to extend life. As the age of our water bath heaters is increasing and associated condition is decreasing, we are now facing a situation where it is becoming more economical to look at a full replacement rather than a refurbishment. This accounts for around £10.0m of the proposed spend. There are then associated E&I works required where, for example, we are replacing a water bath heater with a boiler house which we expect to cost around £5.6m. The additional functionality and efficiency generated will ensure that this investment is paid back. Proposed investment in relation to MCPD compliance accounts for £14.4m, replacement of NIC preheating £4.8m and installation of new preheating £3.6m.

The key activities we plan to carry out across our pre-heating assets include:

1. **Compliance with MCPD** – Our preheating equipment must comply with the Medium Combustion Plant Directive which states that any existing combustion plant with between 1 and 5 MW of thermal input must comply with a NOx limit of 250mg/Nm3 by 1st January 2030. Following the studies we have undertaken, we know that approximately half of our water bath heaters have the potential to fall outside of this limit and will need replacing to ensure they are compliant by this date.
2. **General condition and asset age** – a number of our preheating assets are at or are exceeding 50 years old which would be their assumed useful life. Although age would not be a primary reason to intervene by itself, it can be viewed as a leading indicator to condition and faults and as the age of assets increase, it becomes more economical to replace rather than refurbish.
3. **Removal of trial preheating equipment** – we are removing trial preheating equipment on NGN sites due to the following issues (see Section 4 for further details);
    a. Build quality (regular capex intervention has been required).
    b. Design issues (design has caused further issues that have affected integrity of system).
    c. Efficiency targets significantly failed (Hotcat).
    d. Potential for the removal of maintenance support.
    e. Security of supply concerns.
4. **Refurbishment of boiler systems** - due to the life span of commercial and domestic boilers being around 15 years, we will need to undertake refurbishments to maintain efficiency of these assets.
5. **New preheating assets** – In some cases we have identified an operational or compliance need to have pre-heating assets installed where they currently do not exist.

The Medium Combustion Plant Directive

The Medium Combustion Plant Directive (MCPD) is emissions legislation applied to combustion plant (and power generation systems) with a thermal input between 1 and 50 MW. It complements existing legislation for Large Combustion Plant (LCPD), and forms part of the Industrial Emissions Directive. It means that all combustion plant now have targetry associated with minimising emissions and reducing the impact on the environment and local air quality. The introduction of the MCPD was supported by the UK government, and it was transposed into UK law in January 2018.

During 2023 we investigated the flue emissions from our water bath heater (WBH) assets. For natural gas fuelled plant with thermal inputs between 1 MW and 5 MW the only combustion products to be monitored and limited

are Nitrous Oxides (NOx). The Emission Limit Values (ELV) for NOx to be complied with by 2030 is 250 mg/Nm3. Carbon Monoxide measurements must also be recorded, but no ELV is to be enforced by the directive.

All of our WBH installations with an inlet heat capacity above 1MW were investigated to determine if the emissions from the plant are below the ELV. Tests were completed during January & February 2023 using the portable Testo 350 Emission Analyser. The tests were conducted 'as found' without undertaking any combustion 'tuning' to improve combustion efficiency.

The tests undertaken with Advanced Engineering Solutions Limited on NGN's WBH during this project highlighted that a number of WBHs are currently creating emissions above the NOx ELV as set out in the EU directive 2015/2193. However, it has to be noted that this is only true for the burner setup as tested. It may be possible with adjustment of the air to fuel ratio to regulate the emissions, such that the concentration can be reduced to comply with the EU MCPD directive.

It was recommended following these tests that we consider a programme of works to further investigate and adjust the air and fuel gas inlets to the WBH burners. This is particularly important at sites where identical WBHs give a reading such that one is below the ELV and one is above the ELV. This may require cleaning and adjustment of air intakes, cleaning and adjustment of burners as well as adjustment of fuel gas inlet pressures undertaken in conjunction with the exhaust emissions analyser.

For sites where burner emissions cannot be reduced sufficiently through adjustment, consideration to exploring the replacement of the existing burners with low NOx burners to ensure compliance should be undertaken.

In RIIO-GD3 we are proposing 26 boiler house replacements or installations. As shown below, almost half of these are required to ensure compliance with the MCPD where adjustments are not able to reduce emissions to suitable levels. Note that there are also 17 refurbishments not included in the graph below. 4 of these relate to removal of equipment where the GD1 NIC project was not successful. There are 3 sites with no preheating currently installed, where we have identified a need for it. The remainder of the interventions are due to asset condition or age.

We have further assessed whether our interventions are driven by compliance, asset health, or a mixture of the two, Table 4.

Table 4 RIIO-GD3 Intervention Drivers for Preheating Assets

	RIIO-3 EJP Preferred Option		
Intervention	**Workload units**	**Capex (£m) 23/24 prices**	**Driver**
NIC Preheating Replacement	4	4.81	Asset Health
Low NOx Compliance	12	14.42	Compliance
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Total	**107**	**45.82**	

As shown in Figure 2, 32% of proposed spend is compliance driven, as required by the need to comply with the MCPD by 1st January 2030. 20% of the proposed spend is compliance driven but also delivering asset health benefits (such as where we have identified a need for new preheating installations). The remaining 48% (£22.2m) is asset health driven.

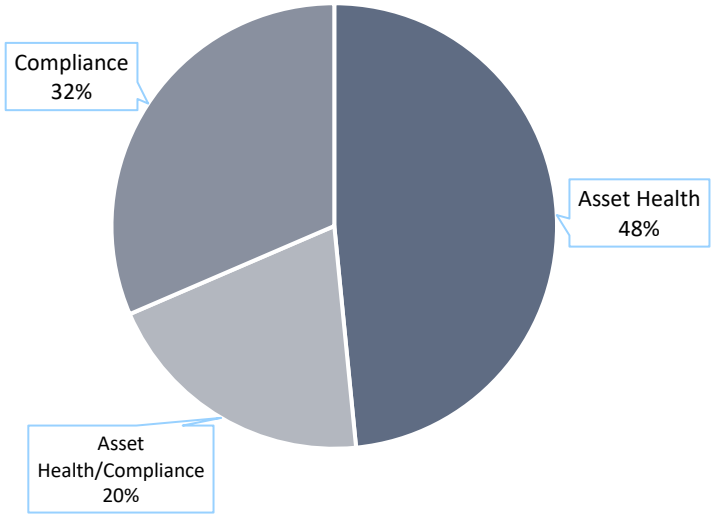

Figure 2 Preheating intervention drivers

What happens if we do nothing?

NGN's Value Framework

We have developed the NGNNGN Value Framework which we use to assess the value of intervention options consistently across asset classes for CBA and business planning purposes. We use the NARM 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. This is further explained in our Network Asset Management Strategy. 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 NARM 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-GD3 capital programme the monetary value of each Consequence Measure is calculated to determine the benefit or avoided cost of an intervention. Examples include:

- **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 NARM models.
- **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 NARM 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 NARM methodology and industry approved values.
- **Compliance Risk** – Avoided GDN costs through a reduction in costs of fines and paying for explosion damage. These costs are in accordance with the NARM methodology. They have been separated from

direct Financial Risk as we consider them highly uncertain and likely significantly underestimated by the values in NARM, 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 NARM methodology.

OT PRS Risk Profile (start RIIO-GD3)	Compliance Risk £m	Customer Risk £m	Environmental Risk £m	Financial Risk £m	Health & Safety Risk £m	Total Risk £m	%
Preheating (excl Low Nox)	1.59	3.48	0.78	0.27	0.59	**6.71**	14%
Preheating (Low Nox)	0.19	0.95	0.14	0.04	0.07	**1.40**	3%
Filters	3.31	0.01	7.68	1.29	1.22	**13.51**	28%
Pressure Control	3.92	0.07	12.28	2.14	1.44	**19.85**	42%
Odorant & Metering	1.29	2.89	0.00	1.70	0.43	**6.31**	13%
Total	**10.30**	**7.39**	**20.89**	**5.44**	**3.75**	**47.78**	

Table 5 Offtake and PRS risk profile at the start of RIIO-GD3

As can be seen in Table 5, preheating accounts for 17% of total risk across our Offtake and PRS sites at the beginning of RIIO-GD3. The predominant risk is customer risk, but compliance risk is also a significant contributor to total risk.

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. This 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.

Without intervention, over the course of RIIO-GD3 risk increases predominantly due to deterioration of the assets but also due to other effects such as the rising cost of carbon. Table 6 highlights that without intervention we would see total risk on our preheating assets increase by 17-21% over RIIO-GD3.

OT PRS Risk Change over RIIO-GD3 w/o intervention	%
Preheating (excl Low Nox)	17%
Preheating (Low Nox)	21%
Filters	13%
Pressure Control	20%
Odorant & Metering	28%
Total	**19%**

Table 6 Risk change for Offtake and PRS over RIIO-GD3 without intervention

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 Offtake and PRS assets the key service measure is the Total Expected number of Supply Interruptions (SI).

Table 7 shows the impact on this service measure over RIIO-GD3 without investment. It highlights that we would be facing 7% increase in supply interruptions relating to our preheating assets.

OT PRS Service Level Change over RIIO-GD3 w/o intervention	%
Preheating (excl Low Nox)	
Preheating (Low Nox)	7.3%
Filters	8.5%
Pressure Control	0.6%
Odorant & Metering	24.2%
Total	**9.9%**

Table 7 Offtake and PRS service level change over RIIO-GD3 without intervention

Consideration of Preheating Asset Health

We have utilised the NARM Value Framework in order to assess the health of our assets. We are however using the latest NGN asset data rather than the NARM data which is held in time as at the start of RIIO-GD2 for regulatory reporting purposes.

Offtake and PRS assets are assigned a Health Banding 1-10 based entirely on the total failure rate (i.e. the sum of all failure rate components). There are ranges of failure rates which assign an asset to bands 1-10. For preheating, if the asset has less than 0.35 total failure rate (expected number of failures per year), is it in band 1, but greater than 3.19 then it is in band 10.

Consideration of preheating health trends is useful in the calculation of asset risk. Table 8 highlights the health of our assets using the NARM value measures. This shows that 12% of our preheating assets have a score of 6 or more at the start of RIIO-GD3. Without intervention, this rises to 16% by the end of RIIO-GD3. If our Preferred Option of investment is followed in RIIO-GD3, this falls back down to 9% at the end of RIIO-GD3 with investment.

Preheating Health Index	1	2	3	4	5	6	7	8	9	10	Total
Baseline start of RIIO-GD3	3	8	8	33	40	6	4	2	0	1	105
	3%	8%	8%	31%	38%	6%	4%	2%	0%	1%	100%
End of RIIO-GD3 w/o intervention	3	0	14	26	45	3	7	4	2	1	105
	3%	0%	13%	25%	43%	3%	7%	4%	2%	1%	100%
End of RIIO-GD3 with interventions	23	2	37	9	25	0	4	3	2	0	105
	22%	2%	35%	9%	24%	0%	4%	3%	2%	0%	100%

Table 8 Offtake and PRS Preheating asset health scoring

What is the outcome that we want to achieve?

From our stakeholder research (for example, see Insight 1, 9 and 10 from Appendix A3, as shown in Table 9), we know that network reliability and cost remain our customers key priorities. Customers also value the importance of improving resilience against extreme weather, such as storms. 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. For this particular group of assets, customer risk is the main risk driver, as discussed in Section 5

What we heard	Appendix A3
Keeping bills as low as possible continues to be domestic and Small and Medium Enterprise customers' top priority, however stakeholders are supportive of investment to respond to significant challenges of climate resilience and decarbonisation. Balancing the trade-off between investing now to future-proof and minimising expenditure to prioritise essentials poses a challenge.	Insight 1
Customers expect our top sustainability commitment to be keeping our infrastructure resilient. This means continuing to reliably supply customers in the short and long term, regardless of climatic conditions and impacts experienced by interconnected sectors (such as telecommunications, road networks etc). As customers are satisfied with the performance and availability of our services, they prefer us to maintain service levels at levels similar to today, and asked for us to reduce future risk with targeted investments to enhance removal, reduction, resistance and recovery strategies.	Insight 9
The impact of climate change requires us to proactively reduce the vulnerability of networks to storms, particularly in rural areas, and a collaborative, cross-network approach. 'Preventing supply interruptions from extreme weather by providing back up power' was the most highly valued service improvement among billpayers in our Customer Value Perception study (on average, respondents were willing to pay £0.53pp at 75%).	Insight 10

Table 9 Customer insights

Risk Objective: to maintain total risk to the same level as the starting position of RIIO-GD3 (plus or minus 10%)

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 19% for Offtakes and PRS overall (38% for preheating, Table 6) within the RIIO-GD3 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-GD3 to plus or minus 10% from the RIIO-GD3 starting position, however we understand the need to balance this ambition with service and cost constraints.

We are on track to meet our NARM target in RIIO-GD2. As the regulatory landscape is likely to broadly remain the same in RIIO-GD3, we have seen no need to take a step change approach to risk and have therefore adopted a risk objective that is consistent with that adopted in RIIO-GD2.

Efficiency Objective = to minimise spend in RIIO-GD3 over and above RIIO-GD2 levels

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-GD3 it is expected that we will need to intervene on more assets than we have during RIIO-GD2 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. Whilst our RIIO-GD3 spend exceeds our RIIO-GD2 spend at a total level, a significant proportion of this is compliance led driving the need for asset replacement (for example to ensure ongoing compliance with Health and Safety legislation such as the Medium Combustion Plant Directive and the Pressure Systems Safety Regulations). Our aim at outset is to maintain spend relating to asset health in RIIO-GD3 broadly in line with RIIO-GD2 levels, where this is possible. We discuss this in more detail in **Section 10.2**.

Our objective in RIIO-GD2 was to maintain cost. However, the objectives we are setting out are becoming increasingly conflicted with one another as we move into RIIO-GD3. For example, increasing rises in risk and supply interruption from deterioration in the asset health of our assets, alongside obsolescence and compliance are key drivers for additional investment in RIIO-GD3 over and above the levels we saw in RIIO-GD2. We view maintaining risk and service levels and delivering a reliable, safe and compliant network for customers as a higher priority than maintaining cost at RIIO-GD2 given the evidenced need for additional investment, which is shown and discussed in our options appraisal. We are continually committed to providing a balanced programme of work and delivering value for customers. We have therefore updated our efficiency objective in RIIO-GD3 to be to minimise cost over and above RIIO-GD2 levels.

Our unit costs are discussed in Section 8.6.

Service Objective = to maintain supply interruptions to the same level as the starting position of RIIO-GD3 (plus or minus 10%)

We want to continue to provide exceptional service

The key service measure for our PRS assets is the Total Expected number of Supply Interruptions. Table 1.06 of the 2023/24 Regulatory Reporting Pack (RRP) submission highlights that our current customer satisfaction scores for unplanned interruptions are exceeding the targets set by Ofgem (9.37 target against our actual performance of between 9.543 and 9.650 between 2022 and 2024). We therefore consider that current service levels are acceptable to our customers and provide a suitable benchmark.

As the regulatory landscape is likely to broadly remain the same in RIIO-GD3, adopting risk and service level objectives that are consistent with that adopted in RIIO-GD2 seems appropriate. Other Reliability metrics outlined in Table 1.06 demonstrate that we are currently operating a highly reliable network. Our aim therefore to maintain our industry leading service levels in RIIO-GD3.

From the analysis in the section above we understand that supply interruptions are increasing by 10% for Offtakes and PRS overall (7% for preheating, Table 7) within the RIIO-GD3 period to a point where we would be expecting a supply interruption approximately every 3 years across Offtakes and PRS at the end of RIIO-GD3 without

intervention. Our RIIO-GD3 investments need to target this service measure and reduce it back down to a more acceptable level.

Certainty Objective = to ensure our investments pay back within 16 years

We will protect our customers from future uncertainty

To ensure the investments we make in RIIO-GD3 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. The RIIO-GD3 Business Plan Guidance states that a 16 year payback period is appropriate for the GD sector (page 45)[1], meaning that any new, refurbished or replaced equipment that pays back within this time frame will be deemed suitable for investment.

Compliance Objective = to ensure we are compliant with legislation relevant to each asset class

We want to ensure compliance with all relevant Health and Safety, or technical Regulations.

During RIIO-GD3 we are required to undertake a number of interventions for compliance reasons. For preheating assets we need to ensure compliance with the Medium Combustion Plant Directive (MCPD) and Pressure Systems Safety Regulations (PSSR).

How will we understand if the spend has been successful?

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

In addition to the NARM target, we would expect to keep the number of supply interruptions from Offtake and PRS asset failure at a manageable level, ideally at the same level seen during RIIO-GD2. 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.

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.

[1] https://www.ofgem.gov.uk/publications/RIIO-GD3-business-plan-guidance

5.1 Narrative real-life example of problem

This section provides a real life example of where we have undergone a boiler system refurbishment.

CASE STUDY 1 – BOILER SYSTEM REFURBISHMENT

[redacted]

Boiler systems became a feasible alternative to water bath heaters in the late 1990's to preheat gas at our sites. These systems consist of various components with different design lives. When we start to experience issues with a preheating system, for example where we are not able to economically repair the boilers, we will look to refurbish the system by only replacing the faulty/obsolete parts. A recent example is at [redacted] where frequency of faults and depletion of spares meant we replaced the boilers, pumps and control system within the kiosk however all other components of the preheating system such as the kiosk, let down unit and heat exchangers remained. In addition to the refurbishment, a software and comms upgrade was completed that allows further detail to be seen by NGN system control and also allows a remote reset of the system, this will enable a reduction in callout and site visits. This refurbishment strategy has proven successful in GD1 and GD2. The plan is for it to continue into GD3.

5.2 Project boundaries

The boundaries of spend provided in this EJP relate only to the intervention of preheating equipment at our offtake and PRS sites. It includes all necessary project costs such as design, procurement of materials, construction (including labour and materials), commissioning and overheads. It does not include any other offtake or PRS assets such as the cost of filters, pressure control assets, or meters for example, which are covered under separate Investment Decision Packs A22.a to A22.g.

Any directly associated costs for required E&I has been included within the Preheating CBA, only where it is directly linked to a Preheating intervention. We have done this to ensure that our CBAs are taking into account all costs applicable to our Preheating interventions. Where the costs relating to E&I has been accounted for in the Preheating CBA, it has not been included in the CBA relating to E&I specifically to avoid double counting those costs. As the NARM benefit would be associated with the mechanical intervention, we have not attributed any further NARM benefit to any E&I within the Preheating CBA since to do so would overstate the NARM benefit and not provide a true reflection of the benefits of the intervention being carried out. The benefits of the new preheating installations and Adams Retrofits were not able to be modelled in our decision support software using NARM as they are not covered in the methodology. These benefits and also the associated costs are therefore not included within the CBA. However, these elements are key components in protecting the underlying assets and ensuring they continue to operate safely and efficiently. Therefore we expect the benefits of these elements to be of a similar magnitude to those covered by the NARM methodology and represent value for money for customers over the time period to 2050. The impact of new preheating installations will be to increase baseline risk – this will come into fruition in the NARM modelling when we have the appropriate data for the new sites to perform the calculation. We detail costs included and excluded from the CBA in Table 10.

Table 10 RIIO-GD3 CBA vs non-CBA costs

	CBA RIIO-GD3 Costs (£m)	Non-CBA RIIO-GD3 Costs (£m)	TOTAL (£m)
NIC Preheating Replacement	4.81		
Water Bath Heater to Boiler House - Replacement	3.61		
Electrical preheating	2.00		
Water Bath Heater Refurbishment	2.57		
Boiler House to Boiler House - (mechanical) Replacement	4.45		
Boiler House (mechanical) Refurbishment	4.13		
Low NOx Compliance		14.42	
E&I Upgrade associated with preheating replacement		5.60	
New Preheating Installation		3.61	
PH Adams Retrofit		0.63	
TOTAL	**21.57**	**24.25**	**45.82**

Two separate CBAs have been carried out: one for preheating excluding NOx compliance investments and one covering the NOx compliance investments. Details of these can be found in Section 9.2.

6. 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-GD3 Capital Investment, our Cost Benefit Analysis uses the recently updated NARM methodology to calculate the failure rate of our Offtake and PRS assets. The NARM methodology algorithm used to calculate the initial failure rate (to which deterioration is applied) for each Failure Mode is:

Failure rate including factors = Failure rate excluding factors x Fault Detection Rate x Coastal Factor x Housing Factor x FS Factor x Flood Factor x Kiosk Factor

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

Types of Failure

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 for Preheating 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.

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 ***Failure rate excluding factors (initial failure rate)***from the NARM 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 whether the housing of the asset is above or below ground.

Kiosk Risk – a multiplication factor is applicable depending on the condition of the building/kiosk.

Fencing / Security Risk (FS Factor) – 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.

Table 11 shows the Failure Rates by failure mode for preheating at the start and end of RIIO-GD3 without intervention and the rate of failure over the period.

Preheating			
Failure Mode	Total Expected no. of Failures		RIIO-3 Failure Rate
	Start RIIO-GD3	End RIIO-GD3	
Capacity	0.0	0.0	0.0
General Failure	31.8	41.4	9.6
High Outlet Temp	5.9	7.7	1.8
Low Outlet Temp	109.5	119.2	9.7
Release of Gas	10.0	13.1	3.0
Total	**157.2**	**181.4**	**24.1**

Table 11 Offtake and PRS failure rates over RIIO-GD3 for preheating

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. Table 11 shows that without intervention in RIIO-GD3 the failure rate of our Offtake and PRS preheating will increase by 24 (15%), predominantly driven by increases in General Failure and Low Outlet temperature failure which are the dominant failure modes.

Changes to the NARM Methodology

LTRB Updates

The NARM methodology has been updated since RIIO-GD2 to incorporate changes for long term risk modelling and some changes in failure rates and deterioration rates to better reflect reality. This was carried out as a cross GDN project, underwent a consultation process and is awaiting approval by Ofgem. Please refer to full details of updated methodology changes in the updated version of the NARM Risk Methodology document. A brief summary of the updates include updates enabling GDNs to report on Long Term Risk (LTR) increases and impact of investments on this metric. Data has been pooled across networks enabling an update to deterioration curves to include an end of life (EOL) assumption to eliminate artificially high rates of deterioration towards EOL in the

previous models in particular for Governor and Offtake and PRS mechanical assets - these now taper off towards end of life (EOL) and provide much more realistic LTR analysis. Pressure Control and governors regulator and slamshut failure analysis was also updated, now providing a system view of reliability and failure in the updated version of the model. Mains deterioration was also reviewed as part of the project. The effect of these changes which have been implemented in the production of the GD3 business plan analysis is to better reflect the reality of operation of the above-mentioned assets. ICS performed a validation process on the results of the changes to the model and LTR as part of the project, but further validation across GDNs is required.

Updates to the methodology have been discussed with Ofgem during their development and have gone out to consultation. Formal approval is to follow on from the consultation. It was agreed with Ofgem that model updates as part of this project including Long Term risk would be used for RIIO-GD3 business planning purposes.

6.1 Probability of failure data assurance

The data used in our probability of failure / failure rate calculations comes directly from the NARM 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.

We have an annual process for gathering asset data from the business to support NARM RRP delivery, with majority of data coming ultimately from SAP. There is a documented process where the business leads supplying the data carryout reasonableness checks on the data supplied to the Asset Strategy team, who then carryout validation and consistency checks.

Our 2024 Data improvement plan assess key areas of data for robustness and completeness:
Our **Core Asset Data** for PRS includes location, fault data, health indices, 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 2023/24. Our Core Asset Data is assessed to be robust and complete.

Our **Asset Health and Failure Data** includes design specification, age, condition, duty, capacity, location and environmental health factors. All other factors within this category are static and are only updated when we install new assets. Our Asset Health and Failure Data has been assessed as having some data gaps and assumptions have been applied. This applies in particular toto default condition data being applied to some kiosks and no condition data for fences or control systems. Through Smarter Work Management Systems, field work capture capabilities will be developed to improve this. If assumed condition assumptions are lower than reality, this will lead to a conservative calculation of baseline risk and risk reduction on intervention; and vice versa.

Our **Financial Data** includes all the financial data held in the core system that is used within the risk models. There is still some uncertainty around overlap in functional location with PRS/Holder sites. We have recently updated all the interventions costs within the system using historical project cost knowledge and SME input on current cost trends (See **section 8.6**).Data relating to cost nodes in the modelling have been inflated to 2023/24 prices using the Ofgem agreed inflation factors. Our Financial Data has been assessed as having some data gaps and assumptions have been applied. If assumed financial costs are lower than reality, this will lead to a conservative calculation of baseline risk and risk reduction on intervention, and vice versa.

It is recognised in the NARM methodology that the GDNs will have data gaps and will not hold the same level of asset data. To facilitate the population of the Monetised Risk modelling, a flexible but consistent methodology (with

options) will be utilised to derive the Probability of Failure, Deterioration, Probability of Consequence and associated impacts of Intervention. This is set out in Table 6 of the NARM Methodology and ranges from Option A (GDN specific data from company systems) to Option B (Pooled/Shared data – where applicable) to Option C (Global/Assumed). Assumed data could be data that has been analysed to be representative of the population, arrived at by expert elicitation, or arrived at by researching relevant published studies/reports.

7. Consequence of failure

This section sets out the potential consequence were preheaters at our PRS and offtake sites to fail to operate as expected. We will consider the impact on customers, safety and the environment.

For each failure there may be a Consequence of Failure (CoF) which can be valued in monetary terms. In the NARM 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.

The NARM 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. . Within the CBA we quantify each of these risks over time (note that health and safety risk is split between fatality risk and non-fatality risk). These are detailed below for Offtake and PRS assets:

Customer Risk

- **Offtake / PRS Site Failures** – a failure of the site resulting in loss of supply to downstream domestic, commercial or industrial consumers.

Health and Safety Risk

- **Down stream gas escapes / Explosion** – an explosion at the Preheating asset itself or in the downstream network following failure. This could lead to subsequent death, injury and / or property damage. Failure of the asset can lead to an increase in downstream gas escapes, which in turn leads to an increased risk of explosion and injury / damage.

Carbon Risk

- **Down stream gas escapes / Loss of gas** - the volume of loss of gas from either the asset itself or in the downstream network constitutes the consequence of a failure. Environmental impact is assessed from the carbon equivalent of the gas lost.

Financial Risk

- **Down stream gas escapes / Loss of gas -** the volume of loss of gas from either the asset itself or in the downstream network constitutes the consequence of a failure. Financial risk is determined from the cost of the lost gas.
- **Ground Heave –** a preheater failure resulting in damage to structures, roads and other assets due to low outlet temperatures. Financial risk is determined from the cost to repair the ground heave.
- The direct financial costs to the business for without intervention work to the assets such as such as repair.

All of these aspects of risk have been taken into account to analyse the impact on total risk with respect to the start of RIIO-GD3 level for all of our options in Section 8, and within our cost benefit analysis.

Where the principal of total monetised risk, applied across the asset base, is:

Total monetised risk = PoF x PoC x CoC

Different supply/demand scenarios have not been considered during our modelling as the current NARM Methodology does not include analysis for this. This is a future update to NARM in gas distribution that has been identified within the Methodology document and will be reviewed by the networks through NARM working groups. Overall, we are forecasting a slow recovery from impacts of the cost of living crisis and total domestic demand is forecast to return to 2021 levels between 2029 and 2031 for the NE and NO distribution zones of our network. This is based on established econometric modelling and demand forecasting methodologies.

Although the NARM Methodology does not account explicitly for supply demand scenario analysis, the fault and failure data we currently base our modelling calculations includes data collected over a period of historic years, which goes back to before 2021. Consequence data from company systems also reflects the latest available view for our asset base at 2023/24 and is also based on data from historic events collected over a period of time. Therefore, we do not anticipate demand to have a material impact on our investment decisions or their benefits during the 20 years from the start of RIIO-GD3.

Our Commitment to Resilience

Chapter 5 of our Business Plan demonstrates our longstanding commitment to ensuring that we are able to operate and maintain a resilient network. We have formalised our Resilience Framework and developed a number of individual resilience strategies which allow us to maintain our high standards. Our Resilience Framework ensures that we continually review the hazards facing our business and assess whether mitigations that we have in place remain sufficient or need to change. This is relevant to our asset management strategies as we need to take into account exogenous factors when considering both short and long term investment plans. Our Network Asset Management Strategy which is set out in **Appendix A18** brings this all together.

We have introduced a range of other resilience strategies, such as **Appendix A8 – Climate Resilience Strategy**. A climate risk assessment sets out the risks facing NGN currently, in 2050 and in 2100, as set out in section 1.5.2 of the strategy. The climate scenario risk analysis did not identify high risks for either the 2oC or worst-case 4oC warming scenarios assessed. As such, this recognises our resilience to material climate change risks in the long to very long term (2050+). This is due to our comprehensive asset integrity and management procedures that are in operation to ensure asset condition and performance. In addition, there is inherent resilience afforded by gas infrastructure assets being a sealed, pressurised system principally located underground. Resilience levels to climate change risks will be greater in lesser warming scenarios should they arise, due to lower climatic extremes. The likely current and future climate risk has been factored into our preferred strategies across Offtake and PRSs from the outset by utilising our SME knowledge and risk assessments mentioned above.

We are taking a similar approach to RIIO-GD2 in putting together our investment plan, taking a balanced approach to asset management to ensure a safe, reliant and compliant network – ensuring we can continue to meet our licence obligations whilst at the same time minimising costs for customers.

8. 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. This intervention type is the basis of our baseline option detailed in Section 8.1.

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 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 or compliance requirements. An example of this would be the replacement of a Water Bath Heater or existing boiler house where we have identified that the emissions are not compliant with the MCPD.

Addition – installation of a new asset on our network. For example, we have identified 3 new preheating installations that are required during RIIO-GD3 in order to ensure compliance with IGEM/TD/13 ed3 in respect to preheating requirements. These have been identified either through maintenance feedback, identification of a need for preheating installation due to ice build up for example, or through a review of outlet pipework and site demand. Where the latter is the driver, these changes are likely to have come about through changes to demand across the network, or due to the roll out of the Repex programme.

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 preheating assets within RIIO-GD3.

Future Energy Pathways

The assumed proportion of methane is important within the risk calculations and CBA as within the NARM methodology the carbon equivalent of the methane content of the gas lost from our assets is quantified, resulting in a monetised Carbon Risk. Gas can be lost from our mechanical assets through leakage or failure. Civils and E&I asset condition and failure are important because they influence the failure rate of mechanical assets; and the duration of the loss of gas consequence respectively.

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.

We have not explicitly modelled changes in the methane content of gas in our CBAs, as overall gas demand and the change in CO2 content of the gas is not expected to be different enough to materially impact the NPV, Payback & Option Ranking of our preferred investment programme. 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-GD2 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 values such as the cost of carbon and specific values such as the loss of supply, costs from our updated unit cost analysis (see **section 8.6**) and the NARM methodology to calculate risk and value. Technical experts analyse options and set constraints (such as a constraint with the objective of maintaining risk) 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 option to determine the most suitable capital programme in RIIO-GD3. 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 Decision Support Software is used to quantify risk and level of service measures and to aid asset management decision making. Optimisation within the software allows us to maximise the value of investments we are making, but we also combine this with bottom-up analysis and constraint application which comes from collaboration with our subject matter experts.

Our process for Offtake and PRS assets is to undertake asset class optimisations where we set different constraints for our options and use our Decision Support Software to optimise within each secondary asset class. By undertaking optimisations at this level, we are allowing the system to maximise the value from investments within each asset class. 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.

In the early stages of options analysis, optimisations were carried out in our decision support software to obtain the best value investments over RIIO-GD3, by applying constraints such as maintain risk and maintain investment cost with the objective of maximising value from intervention. The resulting intervention plan recommendations were then reviewed by SMEs, who fed back on specific site and asset intervention applicability providing additional bottom-up insights around factors such as obsolescence and compliance. This information was used to further develop the modelling and intervention selections by applying additional constraints within the modelling process.

A preferred option has been arrived at using a combination of bottom-up analysis and optimisation using our Decision Support Tool (DST) to maximise the value of investments we are making. From this preferred option, further sensitivity analysis is undertaken to see if we can in any way improve the option. This sensitivity analysis is undertaken at the asset class level looking at the different effects of refurbishment and replacement

interventions, as well as seeing if there is more merit in delaying the investment. During this sensitivity analysis 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 different options we have modelled are set out below in Sections 8.1 to 8.5. These have been appraised against our objectives in Section 5 to determine a preferred option. In summary, we have produced a preferred option focussing on compliance and asset health drivers which we have deemed appropriate to maintaining a safe, reliable and compliant network. Subject matter experts were consulted to create reasonable Do More and Do Less options, with a particular focus on practical deliverability of the programme of works. The SME's high level of site expertise and knowledge in combination with analysis in our Decision Support Software was critical to developing a balanced programme of work, whilst minimising the risk of overinvestment. It is important to note however that the options discussed have implications on a combination of safety, reliability and compliance which are discussed in the options analysis review. A deferral investment option was also considered.

It should be noted that our risk and CBA analysis in our summary tables has been based on preheating investment excluding NOx compliance investments. We have carried out a CBA for these separately (detailed in Section 9.2)

We provide a summary output schedule under each option in Table 14 and detailed information on how we have reached our unit cost assumptions are provided in section 0.

Ofgem CBA Template Assumptions

For all CBAs in our RIIO-GD3 submission, we used an assumed weighted average cost of capital (WACC) of 3.92% based on Ofgem guidance (a real average basis). We have assumed a depreciation Acceleration Factor of 100% across all CBAs and scenarios, i.e. no additional acceleration of depreciation. For Capex CBAs we have assumed a capitalisation rate of 33.7% based on our Totex forecasts in BPDTs and 100% for Repex CBAs. First year of expenditure outflow is set to 2027 in all scenarios for consistent relative NPV calculations. This is in line with Ofgem guidance for RIIO-GD3 and the approach taken in RIIO-GD2. We consider that the plausible ranges of these parameters would not materially affect CBA outcomes and have provided only one version of templates with these consistently applied (as they can be adjusted by Ofgem in any case).

We have not provided direct Opex associated with each CBA scenario as it would require us to artificially and subjectively divide up our maintenance and repair expenditure into each sub-asset class (CBA) and make a judgement on how this would be affected by each scenario. We do not record or report data at this level and we have no robust basis on which to provide it. In reality, maintenance and repair teams attend to multiple asset classes in single visits as part of an efficient function. Instead, we have provided the objectively calculated VF Financial risk, which is based on agreed industry NARM based calculations for estimating impacts on Opex under each CBA scenario. For those asset groupings not covered by NARM we have only included benefits and impacts of key benefits e.g. leakage. We consider this to be a more robust and objective approach to our CBAs. We have completed the NARM monetised risk memo lines from values in the NARM BPDT for baseline and preferred where they are available and relevant.

8.1 Baseline – Do minimum/do 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 which is

included within the financial risk element of the NARM modelling. There are no direct benefits accrued under this option, however it does include societal impacts associated with leakage, fatality and injury.

The baseline option shows that there will be an increase of risk of 17% and an increase of supply interruption levels of 7% above start of RIIO-GD3 levels if we were to adopt this Do Nothing/ Do Minimum option (Table 16). The primary driver of risk increase is carbon risk as the cost of carbon is increasing, but significant increases are also seen from compliance, financial and health and safety risk over RIIO-GD3 (Table 18).

Given our objectives in Section 5 of maintaining risk and supply interruption levels, this option has been deemed to be unacceptable and lead to non-compliance with PSSR and MCPD, but forms the option against which the following options have been measured against.

8.2 First option summary – Balanced Strategy (preferred option)

Our preferred option for preheating interventions has been arrived at following consideration of how we can ensure compliance with the MCPD and the IGEM/TD/13 ed3. We also have some asset health driven interventions which are required in order to ensure our pre-heating assets remain in good working order. We discuss this in more detail below:

1. **Compliance with MCPD** – Our preheating equipment must comply with the Medium Combustion Plant Directive which states that any existing combustion plant with between 1 and 5 MW of thermal input must comply with a NOx limit of 250mg/Nm3 by 1st January 2030. Following the studies we have undertaken, we know that 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. There are 12 water bath heater replacements planned in order to ensure compliance with this Directive.
2. **General condition and asset age** – a number of our preheating assets are at or are exceeding 50 years old which would be their assumed useful life. Although age would not be a primary reason to intervene by itself, it can be viewed as a leading indicator to condition and faults and as the age of assets increase, it becomes more economical to replace rather than refurbish.
3. **Removal of trial preheating equipment** – we are removing trial preheating equipment on NGN sites due to the following issues (see Section 4 for further details):
    a. Build quality (regular capex intervention has been required).
    b. Design issues (design has caused further issues that have affected integrity of system).
    c. Efficiency targets significantly failed (Hotcat).
    d. Potential for the removal of maintenance support.
    e. Security of supply concerns.
4. **Refurbishment of boiler systems** - due to the life span of commercial and domestic boilers being around 15 years, we will need to undertake refurbishments to maintain efficiency of these assets. This primarily an asset health driven investment.
5. **New preheating assets** – In some cases we have identified an operational or compliance need to have pre-heating assets installed where they currently do not exist. For example, we have identified 3 new preheating installations that are required during RIIO-GD3 in order to ensure compliance with IGEM/TD/13 ed3 in respect to preheating requirements. These have been identified either through maintenance feedback, identification of a need for preheating installation due to ice build up for example, or through a review of outlet pipework and site demand. Where the latter is the driver, these changes are

likely to have come about through changes to demand across the network, or due to the roll out of the Repex programme.

A full breakdown of the interventions that we need to carry out in order to meet all of the requirements outlined above include the following 107 interventions at a cost of £45.82m:

- 4 NIC Preheating Replacements
- 12 Low NOx Compliance replacements
- 3 Water Bath Heater to Boiler House Replacements
- 20 E&I Upgrades associated with preheating replacement
- 4 Electrical preheating
- 3 New Preheating Installation
- 15 Water Bath Heater Refurbishment
- 4 Boiler House to Boiler House – (mechanical) Replacement
- 17 Boiler House (mechanical) Refurbishment
- 25 PH Adams Retrofit

The preferred option shows that there will be a decrease of total risk of 13% and a decrease of supply interruption levels of 25% compared to start of RIIO-GD3 levels if we were to adopt this option (Table 16). We see the risk in almost all categories of risk falling by around 40% absolute from the baseline percentages, the change in customer risk is about half of this. All categories of risk are mitigated to start of RIIO-GD3 levels or below (Table 18Table 18).

In respect of our objectives set out in Section 5:

Risk objective (maintain risk +/- 10%) – we are meeting this objective and slightly improving on the risk objective by reducing risk by 13%.

Service level objective (maintain SI levels +/- 10%) – we are over delivering on this objective (-25%).

Efficiency objective (minimise RIIO-GD3 spend over and above RIIO-GD2 levels) – We have met this objective by using our SME's high level of site expertise and knowledge in combination with analysis in our Decision Support Software to develop a balanced programme of work meeting the requirement of increased workload caused by compliance and deteriorating asset health drivers, whilst minimising the cost for customers in our investment solutions.

Uncertainty objective: This option pays back in 14 years delivering positive NPV from 2040 onwards. This meets Ofgem's requirement of paying back in less than 16 years.

Compliance objective: This option was devised specifically to ensure compliance with the MCPD and ensures our compliance objective is achieved.

8.3 Second option summary – Do more

We have 17 boiler house (mechanical) refurbishments and 15 water bath heater refurbishments planned for RIIO-GD3 under our preferred option. We considered the impact if we were to adopt a more pro-active solution and replace rather than refurbish these. The reason for this was that this option would enable us to future proof our preheating assets by reducing their average age and thereby reduce the likelihood of future faults which we know

positively correlate with the age of the assets. All other interventions remained the same as under the preferred option.

A summary of this Do More options covers the 107 interventions below at a cost of £75.32m:

- 4 NIC Preheating Replacements
- 12 Low NOx Compliance replacements
- 18 Water Bath Heater to Boiler House Replacements
- 20 E&I Upgrades associated with preheating replacement
- 4 Electrical preheating
- 3 New Preheating Installation
- 21 Boiler House to Boiler House – (mechanical) Replacement
- 25 PH Adams Retrofit

This Do More option shows that there will be a decrease of total risk of 24% and a decrease of supply interruption levels of 38% compared to start of RIIO-GD3 levels if we were to adopt this option (Table 16). We see the risk in almost all categories of risk falling by around 50% absolute from the baseline percentages, the change in customer risk is about a 30%. All categories of risk are mitigated to significantly below start of RIIO-GD3 levels (Table 18).

In respect of our objectives set out in Section 5:

Risk objective (maintain risk +/- 10%) – we are over-delivering compared to our risk objective with this option by delivering a significant risk change (-24%) to start RIIO-GD3 levels, so this objective is not met.

Service level objective (maintain SI levels +/- 10%) – we are significantly overdelivering on this objective (-38%).

Efficiency objective (minimise RIIO-GD3 spend over and above RIIO-GD2 levels) – We are spending an extra £29.5m over and above the preferred option in Section 8.1. This is not necessary as it is only contributing to the over delivery of risk and service level reductions beyond our objectives.

Uncertainty objective: This option pays back in 22 years (Table 16) delivering positive NPV from 2048 onwards. This option therefore does not meet Ofgem's requirement of paying back in less than 16 years.

Compliance objective: This option would still result in all non-compliant boiler replacements being carried out and would therefore meet our compliance objective.

Overall, whilst we acknowledge the further positive impact on risk and service levels that this option would have, overall it was determined that the increased spend could not be justified given customers have told us that they want us to maintain our service levels and that cost is important to them (for example, see Insight 9 in Table 9).

8.4 Third option summary – Do less

Our preferred strategy involves 17 boiler house (mechanical) refurbishments, which are required due to those assets reaching 15 years of age (the end of their expected life). We considered that we may be able to sweat those assets further and wait to intervene until those assets reach 20 years of age. This would have the impact of reducing our boiler house (mechanical) refurbishments to 12 in RIIO-GD3. We also propose to undertake 4 boiler house replacements in our preferred strategy. We scaled these asset health led interventions back in order to accept a greater risk at these assets by replacing only 1 in RIIO-GD3. All other interventions remained the same given the implications for compliance with the various legislation if we did not intervene.

A summary of this Do Less options covers the 99 interventions below at a cost of £40.5m:

- 4 NIC Preheating Replacements
- 12 Low NOx Compliance replacements
- 3 Water Bath Heater to Boiler House Replacements
- 20 E&I Upgrades associated with preheating replacement
- 4 Electrical preheating
- 3 New Preheating Installation
- 15 Water Bath Heater Refurbishment
- 1 Boiler House to Boiler House – (mechanical) Replacement
- 12 Boiler House (mechanical) Refurbishment25 PH Adams Retrofit

This Do Less option shows that there will be a decrease of total risk of 1% and a decrease of supply interruption levels of 15% compared to start of RIIO-GD3 levels if we were to adopt this option (Table 16). We see the risk in almost all categories of risk falling by around 40% absolute from the baseline percentages, the change in customer risk is about half of this. All categories of risk are mitigated to start of RIIO-GD3 levels or below (Table 18).

In respect of our objectives set out in Section 5:

Risk objective (maintain risk +/- 10%) – we are meeting this objective and slightly improving on the risk objective by reducing risk by 1%.

Service level objective (maintain SI levels +/- 10%) – we are overdelivering this objective with a decrease of 15%.

Efficiency objective (minimise RIIO-GD3 spend over and above RIIO-GD2 levels) – We are spending £5.3m less that the preferred option in Section 8.1. This cost reduction has come from a consideration of sweating our assets beyond their expected design life. This poses an increased risk of faults (for taking assets beyond design life) - this is not fully appreciated within the NARM models or the risk and SI analysis summaries in Table 16. This would have implications for our maintenance teams, as well as potential customer impact if increased supply interruptions were to ensue from this.

Uncertainty objective: This option pays back in 17 years delivering positive NPV from 2043 onwards. This option therefore does not meet Ofgem's requirement of paying back in less than 16 years.

Compliance objective: This option would still result in all non-compliant MCPD boiler replacements being carried out but sweating our assets would potentially place our PSSR compliance at risk.

8.5 Fourth option summary – Deferral of investment

We then considered the impact of deferring investment of our preferred option Section 8.2) for preheating assets out to the beginning of RIIO-GD4.

We did not consider deferral of investment to be a viable option for reasons of risk of non-compliance with the MCPD and IGEM/TD/13 ed3. The MCPD has a deadline of 1st January 2030 and the studies that we have undertaken have already outlined that we do have assets emitting levels of nitrous oxide that are higher than the permitted levels. For this reason it has not been modelled.

8.6 Options technical summary table

NGN's expenditure forecasts are built on a tried and tested, robust and efficient process. This is founded in asset management principles that has seen NGN consistently benchmarked as the most efficient gas distribution

company by Ofgem since 2005. It should be noted that "robust and efficient costs" should not be interpreted as lowest cost. We have and are currently experiencing external and internal cost drivers that are increasing the cost to deliver some workloads and maintain service and compliance objectives. At NGN robust and efficient costs are defined as those which address the network, customer service and environmental risk in an effective and enduring way, to avoid future additional costs or service interruptions. Notably, Health and Safety and Security of Supply are priority drivers in determining the appropriate balance of risk and cost which enables investment decision making. As such, our costs are efficient over the life of the intervention and not just at a point in time, which would reduce cost but risk service failures or increased costs in future periods.

NGN's efficient and robust process to determine expenditure is as follows:

1. Historic analysis of previous investment programmes to understand how expenditure has been effective in managing network risk (NARM) and the service levels that have been delivered. This provides the actual delivered cost of reducing risk and delivering services levels.
2. Forward looking analysis of risk profile, cost drivers and pressures to understand what the forecast programme of work is and the cost associated with maintaining or enhancing performance. This allows a clear articulation of how actual delivered efficiency translates into future cost, accounting for any cost variance.
3. A comparison of historic cost base versus forward projection to ensure costs are targeted at addressing compliance requirements (HSE), supply demand and account for additional costs drivers or challenging areas of work. To ensure costs are robust we embed the following process.
    - Compare asset specific costs against Third party industry database to understand where deviations from average costs might be and the reason for these changes. Third party data base provided by Aqua Consultants who maintain database for other regulated sectors.
    - Compare costs against Yr3 Industry RRP to assess how NGN costs compare to current delivered costs across GDNs (with Aqua Consultants highlighting that NGN's unit costs were competitive when compared to other GDNs).
    - Compare future investment programme to current actuals using Ofgem GD2 benchmarking to understand where NGN may be benchmarked on a like for like for like basis.
    - Undertake robust Internal challenge with Independently appointed experts to weigh pro's and cons of business case and relevance of costs to meet service levels and manage network risk.
4. The costs are then deemed to be robust and efficient from an NGN perspective and will be subject to a final technical scrutiny by an external consultant to ensure costs, benefits and risk removal are justified.

As demonstrated above, the unit costs used in both our Cost Benefit Analysis and capital expenditure forecasts have been derived using historical project cost knowledge, SME input on current cost trends and current cost quotations, to provide confidence in their accuracy, consistency and credibility. Since the introduction of SAP HANA S4 in Oct 2019 we have captured project costs at a more granular level to support regulatory reporting and to aid future investment decisions. During RIIO-GD1 the Unit Cost Database (UCD) was developed, this used extensive volumes of project cost data to derive cost curve models and provide a cost trend allowing for an accurate cost estimate, the allowances for GD2 were driven by the UCD. External Project management, untimely delivery by contractors and 3rd party delays could all impact on costs, but uncertainty risk relating to unit cost was built in during the development of the UCD in RIIO-GD1 and has carried through as these costs have been developed into the unit costs for developing the RIIO-GD3 business plan, as described below. The RIIO-GD3 unit rates incorporate analysis of efficient historical projects (note that we removed outliers from our sample in cases where we had identified things such as significant delays, unusually high mobilisation/demobilisation rates to ensure those inefficient costs were excluded). No explicit efficiency over and above this is included within this EJP appendix as our efficiency target is covered within the main business plan - a 0.5% Ongoing Efficiency (OE) target.

This means that in reality, NGN will be subject to a further 0.5% cost reduction target throughout RIIO-GD3 in order to meet the OE objectives that will be set by Ofgem (refer to Chapter 6 of NGN's business plan).

As a reliable starting point, our RIIO-GD2 unit cost allowances were converted to 23/24 prices, RIIO-GD2 project costs and forecasts were then compared against the 23/24 allowances. Where there were significant variances time was spent with delivery and commercial Subject Matter Experts to thoroughly review those costs. Technology improvements (new functionality), resource scarcity and project management are examples of where we have seen deviations in the GD2 allowance, these have been reflected in the base RIIO-GD3 unit costs.

We have Framework partners in place for Capex delivery projects which improve certainty and ensure efficiency of costs.

Table 12 provides a summary of the assumed unit costs applied in modelling and CBA analysis for preheating. For the avoidance of doubt, costs are shown in 2023/24 prices.

Intervention		GD3 Unit Cost 23/24
NIC Preheating Replacement	Replacement	£1,201,788
Low NOx Compliance	Replacement	£1,201,788
E&I Upgrade associated with preheating replacement	Replacement	£280,000
Water Bath Heater to Boiler House - Replacement	Replacement	£1,201,788
Electrical preheating	Replacement	£500,000
E&I Upgrade associated with preheating replacement	Replacement	£280,000
Water Bath Heater Medium Refurb	Refurbishment — full	£171,376
Boiler House to Boiler House - Replacement	Replacement	£1,113,435
Boiler House Refurb	Refurbishment — full	£243,047
PH Adams Retrofit	Refurbishment - partial	£25,000

Table 12 RIIO-GD3 unit costs for Preheating

In Table 13 package boiler systems and heat exchangers are assumed to have an asset life of 40 years plus. Boilers and electrical elements have an assumed asset life of 15-20 years.

Option	First Year of Spend	Final Year of Spend	Volume of Interventions	Equipment or Investment Design Life	Total Installed Cost (RIIO-GD3 Capex) 23/24 prices
Baseline Do Nothing	2026/27	2030/31	0	N/A	**£0**
First Option Summary – Preferred Option	2026/27	2030/31	107	15-40 years	£45,820,521
Second Option Summary – Do more and replace rather than refurbish	2026/27	2030/31	107	15-40 years	£75,323,282
Third Option Summary – Do less and reduce boiler	2026/27	2030/31	99	15-40 years	£40,514,981
Fourth Option Summary – Deferral of investment	2031/32	2036/37	107	15-40 years	£45,820,521

Table 13 Options Cost Technical Summary Table

We detail below how our output schedule would differ under each of the options:

Workload Intervention Options	2026/27	2027/28	2028/29	2029/30	2030/31	Total
Preferred Option	27	17	24	24	15	107
Do More Option	27	17	24	24	15	107

Do Less Option	17	10	15	15	7	99

Table 14 Workload intervention volumes by option

9. Business case outline and discussion

Option	Description	Objectives					Comments
		Maintain Risk (+/- 10%)	Maintain Supply Interruptions (+/- 10%)	Efficiency	Uncertainty	Compliance	
-	Baseline	Not Met (+17%)	Met (+7%)	N/A	N/A	Not Met	Not meeting risk objective or compliance objective.
1	Preferred	Slight Overdelivery (-13%)	Overdelivery (-25%)	Met using SME expertise - additional £31m to RIIO-GD2 spend	Met (14yrs)	Met	There is slight over delivery on the risk objective with greater overdelivery on SI levels (because cutomer risk shows lower levels of increase over RIIO-3 but benefits from the same magnitude of mitigation as the other risks.
2	Do More	Significant Overdelivery (-24%)	Overdelivery (-38%)	Not Met - additional £29.5m spend to Preferred	Not Met (22yrs)	Met	Additional spend results in signifcant over delivery of risk and service level objectives. The uncertainty objectives is also not met.
3	Do Less	Met (-1%)	Overdelivery (-15%)	Cost Reduction (£5.9m less than Preferred) - refer to comments	Not Met (17yrs)	Not Met	This cost reduction has come from a consideration of sweating our assets beyond their expected design life. This poses an increased risk of faults and associated consequences not fully captured by the NARM risk modelling and places compliance at risk.
4	Deferral	Not modelled	Not modelled	Not modelled	Not modelled	Not Met	Places Compliance at risk.

Table 15 Options Appraisal versus Objectives Summary

Table 15 details a summary of the options appraisal against objectives carried out in Sections 8.1 to 8.5.

In Summary:

The baseline and deferred options have been rejected as this increases risk and service levels over start of RIIO-GD3 levels significantly. This is unacceptable and misaligned with our objectives of maintaining risk and SI levels.

Option 2 the Do More option has been rejected as this costs an additional £29.5m but this additional spend leads to over delivery of risk and service level reductions compared to start of RIIO-GD3 levels. This is misaligned with our objectives. The payback for this option also does not meet the 16 year threshold set out in Ofgem's guidance.

Option 3 the Do Less option does not meet the uncertainty (payback) or maintain compliance objectives, so has been rejected on this basis. The key difference between the Preferred and the Do Less option is that Option 3 (Do Less) achieves cost reduction cost reduction by the sweating of our preheating assets beyond their expected design life. This poses an increased risk of faults (for taking assets beyond design life) - this is not fully appreciated within the NARM models or the risk and SI analysis summaries in Table 16. This would have implications for our maintenance teams, as well as potential customer impact if increased supply interruptions were to ensue from this. For this reason, we have deemed Option 3 unacceptable from a compliance (PSSR) risk perspective.

For Option 1 there is slight over delivery on the risk objective with greater over delivery on SI levels (because customer risk shows lower levels of increase over RIIO-GD3 but benefits from the same magnitude of mitigation as the other categories of risks). We have assessed this option to meet the efficiency, uncertainty and compliance objectives and have therefore selected it as our preferred option. It will deliver a balanced programme of work ensuring we can meet our licence and customer commitments around reliability, safety, compliance and value for money. RIIO-GD3 spend versus RIIO-GD2 spend is discussed further in Section 10.1.

Our Preferred option is detailed in full in Section 10.1.

9.1 Key business case drivers description

This section discusses the development of the preferred strategy and sensitivity analysis then undertaken.

We have assessed the present value of each investment option utilising Ofgem's CBA template. To calculate all present value figures, we have compared the capital and operational costs associated with each option and overlaid them against the leakage reductions (associated with reduced number of failures) and reductions in risk relating to customer, compliance, financial and health and safety we expect each to attain.

All alternative options should be compared to the baseline counterfactual of the baseline position, which is shown in Table 17. The baseline position outlines what we expect our annual shrinkage position to be assuming zero interventions on preheating assets across Offtakes and PRS. The present value of each alternative relates to our expected reduction in shrinkage given the funding received under each option. To value each of these efficiency gains we have used the non-traded price of carbon dioxide, as quoted by Ofgem.

As noted above, each alternative option also analyses the impact of the change in customer, compliance, financial and health and safety risk. The preferred Strategy development is discussed in Section 8.2 with the options (sensitivity analysis) detailed in Sections 8.1 to 8.5.

The key drivers for investment in Preheating are asset health and compliance.

Compliance with MCPD – Our preheating equipment must comply with the Medium Combustion Plant Directive which states that any existing combustion plant with between 1 and 5 MW of thermal input must comply with a NOx limit of 250mg/Nm3 by 1st January 2030.

Compliance / Operational: New preheating assets – In some cases we have identified an operational or compliance need to have pre-heating assets installed where they currently do not exist.

Asset health: General condition and asset age – a number of our preheating assets are at or are exceeding 50 years old which would be their assumed useful life. Although age would not be a primary reason to intervene by itself, it can be viewed as a leading indicator to condition and faults and as the age of assets increase, it becomes more economical to replace rather than refurbish.

Asset health: Refurbishment of boiler systems - due to the life span of commercial and domestic boilers being around 15 years, we will need to undertake refurbishments to maintain efficiency of these assets.

Operational: Removal of trial preheating equipment – we are removing trial preheating equipment on NGN sites due to the following issues (see Sections 4 and 8.2 for further details).

Conditionalities included within our options analysis are detailed in Section 7.

9.2 Business case summary

The analysis results for each of the options detailed in Sections 8.1-8.5 are summarised in Table 16, Table 17 and Table 18. Options appraisal is detailed in Sections 8.1 to 8.5 for each option and option selection is detailed at the start of Section 9.

Capex costs for all interventions are included in the table below and the intervention number summary includes all interventions. It should be noted that the NOx investments were not included within our risk and service level impact assessment or CBA analysis detailed below as the driver for these investments was compliance. We did

however carry out a separate CBA for NOx compliance related investments and the payback for these is 25 years. Whilst outside the threshold of 16 years set out in Ofgem guidance these investments are being targeted for solely compliance reasons. If they are looked at in combination with the asset health investments (payback 14 years) then the payback for the combined programme is 16 years overall.

Option	Desciption	RIIO-3 Primary Interventions			Secondary Intervention	Total NPV compared to Baseline at 2070 (£m)	Objectives			
		Replace	Refurb	New Asset	Adams Retrofit		Total Risk Change from 2026	RIIO-3 Total Capex Cost (£m)	Supply Interruption change from 2026	Payback (years)
-	Baseline	0	0	0	0	-£ 1,126.7	17.4%	0	7.3%	-
1	Preferred	47	32	3	25	£ 274.3	-12.9%	45.8	-24.8%	14
2	Do More	79	0	3	25	£ 360.6	-23.3%	75.3	-38.2%	22
3	Do Less	44	27	3	25	£ 177.8	-1.0%	40.5	-15%	17

Table 16 Options Summary Risk and SI impact and CBA

Option	Description	No. of Primary Interventions in RIIO-3	Forecast		Total NPV Compared to Baseline (£m)						Payback (years)	Total Risk Change from 2026	Supply Interruption change from 2026	Preferred Option
			Capex RIIO-3 (£m)	Totex RIIO-3 (£m)	2035	2040	2045	2050	2060	2070				
-	Baseline	0	0	0	-£ 61.7	-£ 96.3	-£ 132.1	-£ 169.9	-£ 615.9	-£ 1,126.7	-	17.4%	7.3%	N
1	Preferred	82	45.8	45.8	-£ 5.8	£ 1.1	£ 9.4	£ 19.0	£ 136.7	£ 274.3	14	-12.9%	-24.8%	Y
2	Do More	82	75.3	75.3	-£ 25.9	-£ 18.0	-£ 7.4	£ 5.5	£ 169.9	£ 360.6	22	-23.3%	-38.2%	N
3	Do Less	74	40.5	40.5	-£ 6.4	-£ 2.3	£ 3.1	£ 9.5	£ 85.4	£ 177.8	17	-1.0%	-15%	N

Table 17 Options Summary including NPV

Option	Desciption	Risk Change from 2026					Total Risk
		Total VF Carbon Risk	Total VF Compliance Risk	Total Customer Risk	Total VF Financial Risk	Total VF Health & Safety Risk	
-	Baseline	42.5%	27.7%	4.8%	23.8%	27.7%	**17.4%**
1	Preferred	0.7%	-10.4%	-17.5%	-12.4%	-10.4%	**-12.9%**
2	Do More	-13.0%	-21.6%	-26.5%	-26.1%	-21.6%	**-23.3%**
3	Do Less	11.4%	-1.5%	-3.2%	-3.5%	-1.5%	**-1.0%**

Table 18 Options detailed risk summary

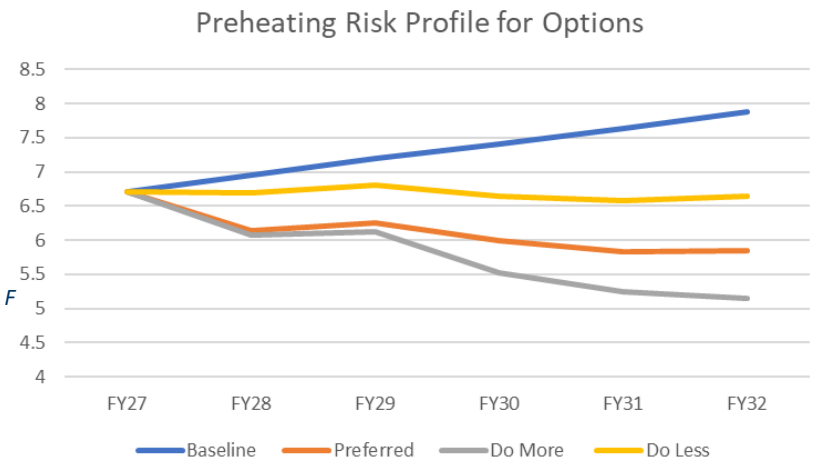

Figure 3 Preheating Risk Profile for Options

10. Preferred option scope and project plan

10.1 Preferred option

Options appraisal for each option is detailed in Sections 8.1 to 8.5 with a summary of option selection with reference to our objectives detailed at the start of Section 9. Business case summary tables detailing risk and service level impacts as well as CBA analysis can be found in Section 9.

The preferred option for Offtake and PRS preheating assets in RIIO-GD3 is Option 1, which includes the following 107 interventions at a cost of £45.8m:

- 4 NIC Preheating Replacements
- 12 Low NOx Compliance replacements
- 3 Water Bath Heater to Boiler House Replacements
- 20 E&I Upgrades associated with preheating replacement
- 4 Electrical preheating
- 3 New Preheating Installation
- 15 Water Bath Heater Refurbishments
- 4 Boiler House to Boiler House – (mechanical) Replacement
- 17 Boiler House (mechanical) Refurbishment
- 25 PH Adams Retrofit

This option broadly achieves the aims of maintaining risk and service levels to an acceptable level, compared with our position at the start of RIIO-GD3 whilst minimising spend and ensuring compliance with our legal requirements under the MCPD to account for interventions required to ensure safe levels of NOx and manage growing asset health risks.

Costs for Preheating for the RIIO-GD3 period are significantly increased (£45.8m) on projected RIIO-GD2 spend (£14.4m) on a comparable 23/24 price basis. The investment strategy throughout RIIO-GD1 and RIIO-GD2 has largely been to refurbish the water bath heaters as the default option to extend life. As the age of our water bath heaters is increasing and associated condition is decreasing, we are now facing a situation where it is becoming more economical to look at a full replacement rather than a refurbishment. (+£10.5m). This also include responding to issues with installed NIC Preheating on our network (£4.8m). We also have to ensure compliance with the MCPD directive to meet legislative low NOx requirements. This programme began in RIIO-GD2 but now has to be continued in RIIO-GD3 (+£14.4m). We view our preferred option as balanced programme required to deliver investments to combat asset health and compliance issues: maintaining a safe, reliable, compliant network of assets for our customers whilst minimising costs for customers.

Long Term Risk impact on Preferred Option

Table 19 provides details of the Preferred option Capex spend alongside Single Year Risk benefit and Long Term Risk benefit output as shown in our NARM BPDT. Long Term Risk calculations allow for accrual of benefit over the life of the intervention. These intervention lives are detailed in full in our NARM BPDT submission. Section 5.2 Project boundaries detail the investments within our Preferred option where we have been able to model risk and risk reduction under NARM. We have provided undiscounted Long Term Risk benefit both here and in the NARM BPDT. Further clarification with SRWG is needed around the requirement for discounting LTR.

	Capex Spend (£m)	Capex Spend (£m)	NARM BPDT	
	All Investments	NARM Modelled Investments	Single Year Risk Benefit (R£m)	RIIO-3 Long Term Benefit Output (R£m)
Preheating (excluding Low NOx)	31.40	21.57	2.06	49.48
Preheating (Low NOx)	14.42	14.42	1.38	34.14

Table 19 Long term risk for preheating

10.2 Asset health spend profile

The unit costs used for the purposes of carrying out the analysis within this paper are provided in Section 8.6. Table 12 details our spend profile over RIIO-GD3 for our Preferred option.

£m 23/24 prices	2026/27	2027/28	2028/29	2029/30	2030/31	Total
NIC Preheating Replacement	1.2	0.0	1.2	1.2	1.2	**4.8**
Low NOx Compliance	3.6	3.6	3.6	3.6	0.0	**14.4**
E&I Upgrade associated with preheating replacement	1.7	0.6	1.4	1.4	0.6	**5.6**
Water Bath Heater to Boiler House - Replacement	1.2	0.0	0.0	1.2	1.2	**3.6**
Electrical preheating	0.5	0.5	0.5	0.5	0.0	**2.0**
New Preheating Installation	2.4	0.0	1.2	0.0	0.0	**3.6**
Water Bath Heater Refurbishment	0.5	0.5	0.5	0.5	0.5	**2.6**
Boiler House to Boiler House - Replacement	2.2	0.0	1.1	1.1	0.0	**4.5**
Boiler House Refurb	0.7	0.7	1.0	1.0	0.7	**4.1**
PH Adams Retrofit	0.1	0.1	0.1	0.1	0.1	**0.6**
Total	**14.2**	**6.0**	**10.6**	**10.6**	**4.3**	**45.8**

Table 20 RIIO-GD3 Spend Profile for Preheating

The graph below highlights our projected spend over the period. As shown, our spend is frontloaded, which also correlates to workload profile. This is due to a number of factors: minimising the risk of programme under-delivery, maintaining compliance, effectively managing asset health and risk, internal resource and contractor availability and material availability.

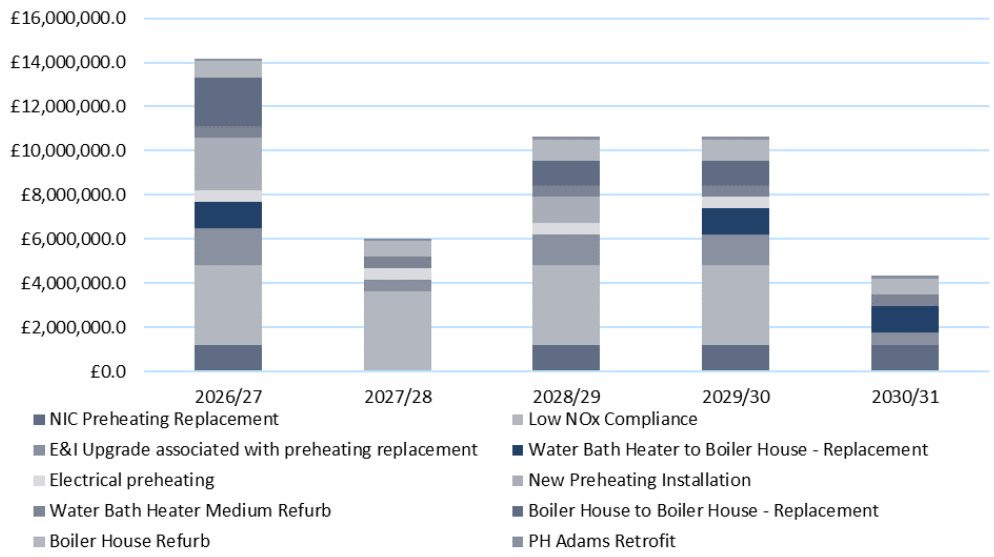

Figure 5 Breakdown of Preheating spend

The total forecast capital expenditure for Offtakes and PRS's has been included within the accompanying CBA.

Given a key driver for our preheating spend is compliance with the MCPD requiring 12 boiler house (mechanical) replacements to ensure safe nitrous oxide levels, we wanted to understand the split between asset health and compliance driven spend for our preheating assets. We have separated out our spend into the following categories:

Asset health driven spend	Compliance driven spend	Compliance driven spend with associated asset health benefits
NIC preheating replacement	Low NOx compliance boiler house replacement	E&I upgrade associated with preheating replacements
Electrical preheating		New preheating installation
Water bath heater refurbishment		
Boiler house to boiler house replacement		
Boiler house refurbishment		
PH Adams Retrofit		

Table 21 Asset health vs compliance drivers

The pie chart below shows how our total £45.82m spend is split out between asset health and compliance drivers:

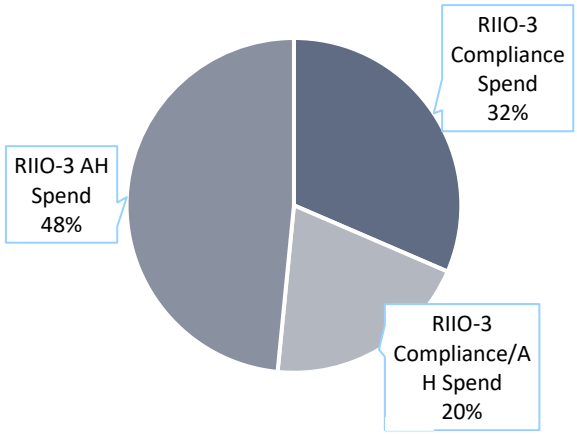

Figure 6 Compliance and asset health driven spend

Costs for RIIO-GD3 compared to RIIO-GD2 spend are discussed in Section 10.1.

10.3 Investment risk discussion

We have controls and processes in place throughout the development of our RIIO-GD3 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 NARM methodology to calculate individual assets Probability of Failure which uses asset attributes to determine specific failure rates.

- As most of our equipment installed on our Offtake and PRS sites are from a few select manufacturers, for example our boiler houses are almost exclusively from Armstrong's, 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.
- There is an increase in workload for RIIO-GD3 over RIIO-GD2, therefore there are increasing risks around delivery of project workload to timescales, however we have experienced Project Managers who have a proven track record of delivering this type of work. Some Particular risks to delivery have been discussed in Key Business Risks below. We have consistently engaged on our preferred strategy with our SMEs and operational colleagues to ensure that our strategy is both viable and deliverable.
- As part of the above, we have ensured adequate internal and external resource for design and delivery.
- We have procurement strategies in place which take into account the likely volumes and lead times we could experience. Our Workforce and Supply Chain Resilience Strategy (Appendix A7) has been developed with this in mind.
- Our project managers have been engaged throughout so that we have developed appropriate workload planning procedures.
- Land requirements have been factored into our project plans to ensure that they are dealt with well in advance of project construction to avoid undue delays.

Unit Cost Risk Mitigations

We have used our updated unit cost analysis (see section 8.66) to determine our 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 analysis.

We have well developed processes and assurance activities in place, with scrutiny and challenge provided throughout. This ensure that we can deliver value for money by driving cost efficiency. Details on unit cost processes are provided within Section 8.6.

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.

Section 4.1 of **Appendix A7 – Workforce and Supply Chain Resilience Strategy** sets out some of the supply chain challenges that we have faced throughout RIIO-GD2. It acknowledges how NGN is a comparatively smaller GDN, which reduces our buyer power (section 4.1.2) and also discusses the significant inflationary pressures that have been placed on GDNs (section 4.1.4). For example, it discusses how the prices charged for coiled pipes have increased by 82% in the period from January 2020 to August 2023. In spite of these challenges, we are confident that our input unit costs remain efficient. This Appendix also touches on a number of external shocks which have impacted on things such as lead times. Examples include the Covid-19 pandemic, the Suez Canal blockage, Russia's invasion of Ukraine and rising geopolitical tensions. We outline in the strategy how we expect volatility to continue across our supply chain, and that we will utilise storage facilities in order to mitigate against supply input shortages. We plan to resource our supply chain and procurement team appropriately to help us overcome these challenges.

Appendix A21 – Cost Assessment and Benchmarking Approach demonstrates how, despite challenges facing us, NGN leads the industry in terms of cost efficiency, having been ranked the most efficient operator by Ofgem in both RIIO-GD1 and RIIO-GD2. This Appendix further outlines the value of NGN in Ofgem's cost assessment modelling at RIIO-GD2 by showing how NGN's frontier setting performance enabled Ofgem to set cost allowances that were £211 million lower than they would otherwise have been. In other words, our efforts to lead the sector on cost efficiency have resulted in significantly lower bills for consumers across the whole country.

We have achieved this position by being innovative in our thinking and directly and aggressively challenging industry norms and practices by bringing forward market-led, commercially focussed business solutions across almost every area of our business. For example:

- NGN introduced modern labour terms and conditions (T&Cs) for the majority of its operational workforce, leading to a significant reduction in legacy staff costs.
- NGN introduced a Direct Service Provider (DSP) model, leveraging small local engineering firms to deliver its replacement program instead of relying on the traditional 'tier 1' companies that have typically dominated the industry.
- Given that NGN has made strong productivity improvements over time, we have re-invested our outperformance payments in areas that (among other things) improve our productivity further. For example, we have used outperformance to invest heavily in IT systems through the SAP4 Hana investment and 'Future Ways of Working' programme. These projects are expected to significantly improve the customer experience and enable NGN to become a data-focused business.

We also outline in this Appendix our suggestion to target a 0.5% Ongoing Efficiency (OE) target, alongside the reasons why this is an appropriate level (see section 6 of the Appendix). This means that in reality, NGN will be subject to a further 0.5% cost reduction target throughout RIIO-GD3 in order to meet the OE objectives that will be set by Ofgem.

We outlined above how we have faced price increases significantly above inflation during RIIO-GD2. The Real Price Effects (RPE) methodology attempts to adjust for the difference between input price inflation and consumer price inflation. We outline in the Appendix our broad support for RPEs, however we note that during RIIO-GD2, all networks have seen relatively large swings in real term allowances year to year due to RPE and inflation volatility from the geopolitical energy shocks in 2022 and 2023. RIIO-GD3 therefore presents an opportunity to refine the basket of reference indices to better capture GDNs actual input price movements and better mitigate this risk. The impact of RPEs have not been factored into our unit cost pricing.

10.4 Project plan

As highlighted below, we plan to undertake the most interventions in 2026/27, including 2 new pre-heating installations. As this programme of works is primarily compliance led, by maximising our interventions undertaken in Year 1, we are ensuring our risk of non-compliance with the various health and safety legislation is minimised.

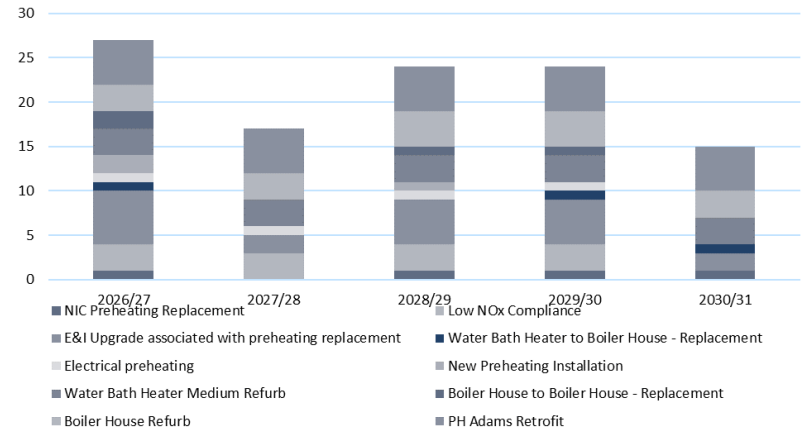

Figure 7 Workload Profile for Preheating RIIO-GD3

Workload Intervention	2026/27	2027/28	2028/29	2029/30	2030/31	Total
NIC Preheating Replacement	1	0	1	1	1	4
Low NOx Compliance	3	3	3	3	0	**12**
E&I Upgrade associated with Preheating Replacement	6	2	5	5	2	**20**
Water Bath Heater to Boiler House - Replacement	1	0	0	1	1	**3**
Electrical preheating	1	1	1	1	0	**4**
New Preheating Installation	2	0	1	0	0	**3**
Water Bath Heater Refurbishment	3	3	3	3	3	**15**
Boiler House to Boiler House - Replacement	2	0	1	1	0	**4**
Boiler House Refurbishment	3	3	4	4	3	**17**
PH Adams Retrofit	5	5	5	5	5	**25**
Total	**27**	**17**	**24**	**24**	**15**	**107**

Table 22 Preheating Workload Profile RIIO-GD3 Tabulated

Project planning is currently underway for RIIO-GD3. The screenshot below provides an insight to the level of detail to which we are going into developing Offtake and PRS investment projects, which are being planned at the site level. The excerpts show the timings and milestones for the key project stages of an example project. There is greater level of detail below this that can be drilled into.

A Risk Register for Preheating investment over RIIO-GD3 is included within the CBA and the key risks and mitigations are covered in Sections 10.3 and 10.5.

10.5 Key business risks and opportunities

We discussed in section 7 that we are not expecting any changes to supply or demand scenarios in RIIO-GD3.

There are a number of important investments required in our preheating assets during RIIO-GD3. We detail below the key risks and opportunities for NGN:

Risks

A key driver for this work is compliance with the MCPD which is driving 12 boiler house replacements. Our preheating equipment must comply with the Medium Combustion Plant Directive which states that any existing combustion plant with between 1 and 5 MW of thermal input must comply with a NOx limit of 250mg/Nm3 by 1st January 2030. Failure to replace our preheating equipment which is falling outside of these limits would mean non-compliance with the MCPD.

More generally, a number of our preheating assets are at or are exceeding 50 years old which would be their assumed useful life. Although age would not be a primary reason to intervene by itself, it can be viewed as a leading indicator to condition and faults and as the age of assets increase, it becomes more economical to replace rather than refurbish. This is the driver for a number of our asset health driven interventions as we are forward looking into the likely need to replace more assets in RIIO-GD3 compared to RIIO-GD2.

In RIIO-GD2 we undertook an innovation project in relation to NIC preheating trial to understand what alternative preheating systems were available and also to help us to overcome inefficiency of old kit such as water bath heaters. Where these trials proved unsuccessful or where we are facing issues with the equipment that is in place, we will need to replace those systems with a more suitable alternative. The risk would therefore be the potential for future issues with reliability, lack of future support or even non-compliance.

Cost variability - External Project management, untimely delivery by contractors and 3rd party delays could all impact on costs. However, framework partners who deliver the capex workload are rigorously challenged to deliver value for money and alternative partners are continually being used were cost or delivery is a challenge. Uncertainty risk associated with unit costs has also be built into the analysis for unit costs used in the RIIO-GD3 planning process (see Section 8.6 for further details).

Opportunities

Our proposals include 25 PH Adams retrofit installations across preheating assets. This piece of kit allows for improved site metrics and communications. For example, it would enable remote monitoring and the ability to carry out activities such as remote reset. There are therefore potential efficiency savings going forwards where we can remotely fault repair rather than sending our maintenance team physically to the site.

Where there is opportunity to extend out the life of our preheating assets, we have opted for this option in order to ensure maximum cost efficiency. For example, where it is deemed a viable option to refurbish boiler houses or water bath heaters, we have opted for this in our preferred solution rather than replacing the asset entirely.

We have planned these interventions in such a way that our equipment is standardised and our installation processes are consistent. This is important in the sense that our operational team become more experienced at dealing with these assets, which should reap benefits from both a cost and time efficiency point of view. Ensuring standardisation is also beneficial in terms of sourcing spares and retaining knowledge on an ongoing basis.

Efficiencies – the level of efficiency depends on the site we are working on, the type of asset being replaced, and whether the site gas supply can be isolated. Ideally if we were carrying out 3 separate replacements (crossing asset types) on a single site we would look to do all the work at the same time to minimise mobilisation and demobilisation cost for instance.

We discuss in Chapter 5 of our Business Plan how we are mitigating against the immediate risks facing our business in the RIIO-GD3 period. In terms of network asset management we have identified asset condition deterioration, obsolescence and compliance – all of which are relevant to the odorant and metering interventions set out in our preferred strategy. There are also wider considerations which indirectly impact on our investment decisions. Our Workforce and Supply Chain Resilience Strategy (Appendix A7) sets out our plans to tackle potential future skills shortages. Whilst we are not envisaging specific skills shortages in the RIIO-GD3 period thanks to our long standing commitment to ensuring we have a 24/7, highly skilled workforce, we do need to ensure that our longer term investment proposals are deliverable given the future challenges we may face as an industry. This strategy also discusses how we ensure that we have a resilient supply chain that can withstand shocks and unforeseen circumstances. This is also an important consideration given the limited supplier and resource pool facing increased demand as we move towards Net Zero.

10.6 Outputs included in RIIO-GD2 plans

We do not expect to carry over any RIIO-GD2 interventions into RIIO-GD3.