Cadent
Your Gas Network

Appendix 09.26

Mains reinforcement below 7 bar

RIIO-2 Spend: £XXXXm

Investment Decision Pack Overview

This investment pack outlines the scope, costs and benefits for our proposals. We have prepared an Engineering Justification Paper (EJP) and Cost Benefit Analysis (CBA) for these interventions.

Overview

Our Gas Transporter Licence conditions require us to provide a reliable service to customers. This means that we need to have enough network resilience to cope with extreme events (including a 1 in 20-year event). Where there is growth in demand, or where we are undertaking other changes on the network that impact capacity, we may need to reinforce the network to ensure that we can continue to meet this requirement. In summary, there are two main reasons we need to invest in reinforcement:

- Where there is growth in demand (either general growth in demand or a new point load at a specific location) that impacts the capacity of the network; or
- Where we are replacing mains via an insertion technique which reduces network capacity.

In the case of **reinforcement to meet growth in demand**, we assessed the overall volume and cost of work that may be required in RIIO-2. We are proposing to use information on the workload and average costs in RIIO-1 as the basis for our forecast in RIIO-2. We considered four options for this:

- The maximum workload in any year of RIIO-1
- The average workload across RIIO-1
- The minimum workload in any year of RIIO-1
- A more conservative view based on a percentage (80%) of the minimum workload in RIIO-1

As it is difficult to predict the specific location and length of mains that will need to be reinforced, our preferred option is the more conservative view (Option 4). Our proposals are based on the minimum level of activity that might be required, in conjunction with an uncertainty mechanism to adjust the level of funding if the actual level exceeds this minimum. We remain open to discussion with Ofgem on how best to manage this uncertainty but believe that using an uncertainty mitigation approach protects customers from funding unnecessary costs.

In the case of **reinforcement to enable insertion**, we conducted an options appraisal (as part of our review of the Iron Mains Risk Reduction Programme (IMRRP)) to determine the optimal level of insertion and hence the level of reinforcement required. We considered the following options:

- The level of insertion achievable without reinforcing the network or increasing pressure
- The level of insertion achievable by increasing pressure but without reinforcing the network
- The level of insertion achievable by increasing pressure and reinforcing where it is cost-beneficial
- The level of insertion achievable by increasing pressure and reinforcing the network to maximise insertion.

As there are trade-offs between the costs of reinforcement and broader renewal costs, our preferred option is to promote a level of reinforcement to enable insertion which provides the minimum net cost (Option 3).

A summary of the preferred option is set out in the table below.

Summary of preferred option (base plan)	RIIO-2 km (length)	RIIO-2 cost
Growth in demand – general	2.03km	Redacted due to commercial sensitivity
Growth in demand – specific	23.13km	
Insertion	48.4km	
Total	73.6km	

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2. Introduction

This document sets out our proposals for reinforcement of the below 7 bar gas-distribution network. The need for reinforcement is driven by projected population growth (and other growth-related factors) within our four gas-distribution networks. Specifically, the investment requirements covered in this document are linked to the following factors:

- **General Reinforcement:** Reinforcement linked to a general growth in demand in specific parts of the network (including upsizing pipelines). We define general growth as multiple small increases in demand which gradually diminish capacity over time (Cadent line ref 129).
- **Specific Reinforcement:** Reinforcement linked to a particular/specific new demand (including upsizing pipelines). We define specific growth as a new point load at a specific location (Cadent line ref 131).
- **Insertion Reinforcement:** Reinforcement linked to increasing the mains insertion rate for RIIO-2 (Cadent line ref 195) in order to reduce net costs.

It is difficult to predict the specific location and length of mains that will need to be reinforced in RIIO-2 because the work is reactive and driven by changes in domestic and industrial customer demand and the specific location and volume of new connections. Forecasts would require both knowledge of change in demand and its impact on the local network. For example, a large new housing estate built on the site of a former industrial complex that had a large gas demand is unlikely to require reinforcement. However, if the same large housing development is built at the edge of a town, at the extremity of the network where pressure is lowest, reinforcement is likely to be required.

Notwithstanding, we know that some level of reinforcement will be required in RIIO-2, to ensure that we maintain pressure and flow across our network. We have considered how to best protect customers given this uncertainty. The best approach is to base our proposals for general and specific reinforcement on the minimum level of activity that may be required, in conjunction with an uncertainty mechanism to adjust the level of funding if the actual level of activity required exceeds this minimum. This new approach is the best means to protect customers from funding unnecessary costs but are open to working with Ofgem on how to manage this uncertainty.

In relation to reinforcement linked to increasing the mains insertion rate for RIIO-2, we have undertaken an options appraisal (as part of our review of the IMRRP) to determine the best approach to the renewal programme overall. As there are trade-offs between the costs of reinforcement and the broader renewal costs, our proposals are based on the lowest overall cost of delivering the renewal programme (rather than the cost of reinforcement in isolation).

3. Equipment Summary

As at the 2018/19 RRP there are 126,250km of mains across Cadent's network. The entirety of Cadent's stock of mains is therefore summarised by material for each network in the table below.

	EoE	Lon	NW	WM
PE	37,048	13,716	24,929	16,140
Steel	3,011	978	1,414	1,500
Iron	9,284	5,605	6,858	5,697
Other	1	-	68	-
Total	**49,344**	**20,299**	**33,270**	**23,337**

Table 1: Km Distribution Mains in Cadent

It is difficult to predict the specific location and length of mains that will need to be reinforced in RIIO-2 because the work is reactive and driven by changes in domestic and industrial customer demand (for example, changes due to the energy transition) and the specific location and volume of new connections on the network (noting that there are wide ranges in forecasts for new properties). However, there are general statements that can be made for each network:

- EoE (EA and EM) networks are at or near capacity and sit near their maximum pressure on peak days (this means majority of new developments require reinforcement)
- Lon has the most spare capacity and pressure increase availability.
- NW and WM are robust networks with some spare capacity and pressure availability.

4. Problem Statement

Cadent Gas' Gas Transporter Licence conditions (Standard special conditions A9 and A17) requires us to ensure proportionate and timely investment in infrastructure to support our commitment to provide a reliable service to customers and enable economic growth.

Investment in reinforcing the distribution network to accommodate local growth in gas-demand will help ensure that our customers do not suffer any supply interruptions, particularly during periods of peak demand.

Investment drivers

There is evidence to show that reinforcement activity in RIIO-2 will need to increase because of the following drivers, however there is a high level of uncertainty on when and exactly where the reinforcement will be required:

- Increased peak winter demand
- Continued growth in housing
- Continued growth in local power-generation
- Cadent's target mains renewal insertion rate

Peak Winter Demand: For load-related capacity the regulatory framework for our business clearly defines a '1 in 20 peak day' demand obligation we must provide for all customers, new and old.

Even though we forecast aggregate peak day capacity being fulfilled by an ongoing reliance on existing assets, we have to invest to remove highly localised constraints where these cannot be resolved by the use of commercial alternatives. Such constraints are inevitable, and driven by changes in customers' profiles, localised redevelopment and urban spread occurring across our towns and cities.

The winter of 2017/18 was particularly cold, leading to a high gas demand which ultimately led to the loss of supply to 1,600 customers. A combination of events led to this supply interruption but, gas demand and network performance have played a significant role. This event changed our view of the "worst case" design case for modelling network reinforcement needs.

Housing growth is expected to continue: Housing growth projections show that there will be an increase in the number of new homes being built in the coming years. Many of the Cadent networks can expect housing growth to be above the national average and at a greater rate than experienced in RIIO-1. If these houses connect onto areas of the gas network with low capacity, additional reinforcement will be required.

	Mid-2016	Mid-2041	Percentage change 2016 to 2041
London	3,447,000	4,292,000	24%
East Anglia	2,528,000	3,065,000	21%
East Midlands	1,968,000	2,312,000	18%
West Midlands	2,367,000	2,743,000	16%
North West	3,084,000	3,424,000	11%
England	22,885,000	26,855,000	17%

Table 2: ONS Projected households for English regions, 2016 to 2041[1]

[1] https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationprojections/bulletins/2016basedhouseholdprojectionsinengland/2016basedhouseholdprojectionsinengland

Power generation: There is evidence of local Power-Generation growth. These small, garage sized, gas turbines are being developed to take advantage of short spikes of high electricity market prices. Switching on quickly when electricity generation prices are high and then cutting out again when they fall. Although the total demand over a year may be small the peak demand is very high and has significant impact on the network. We can try and influence where these units are connected but it is often the ability to connect to the electricity network which dictates where the units are constructed. Although in some circumstances some costs of reinforcement can be recovered from the developer we find that the current charging mechanisms allow these units to connect without significant contributions.

We have also identified that East Midlands is our regional hot-spot with the greatest volume of power-generation requests.

Increased Insertion: Insertion is generally the most efficient method of replacing mains. This technique, when compared to other options, dramatically reduces the amount of excavation work needed, which in turn reduces cost and disruption to the public. The method does, however, reduce the capacity of the network – the newly inserted pipe is smaller and therefore can transport less gas. Analysis shows that there is a point at which the net cost of a mains replacement can be reduced by investing in reinforcement to allow more insertion to be delivered, see Appendix 09.02 for details of our mains renewal programme. This work is not reactive to changes in customer demand but is rather planned by Cadent.

Required outcome and measuring success

Our overriding objectives are to satisfy customers' requests for new connections to our networks, to fulfil peak demand, and build sufficient network resilience to cope with extreme events (including a 1 in 20 year event) for all customers in a safe and economic manner.

For specific customer led changes and developments, investment will be considered economic where our network modelling and other tests demonstrate the investment to be the most economic course of action, or the customer has met the costs of the investment upfront.

We will be successful if, and only if, these objectives are met.

4.1. Narrative Real-life Example of Problem

A delay in investing in mains-reinforcement will result in customers suffering from low gas pressure or potentially suffering from a supply interruption, because certain areas of the network fall below operating parameters, causing areas of the network to fail and gas to cease flowing. Below is a real life example of a network reinforcement project being triggered by the development of new housing which resulted in a temporary solution being installed to allow us to meet customers needs before a long term solution was found.

In Burton, Derbyshire, two new housing developments were to be connected to the south of the low pressure network. To enable the properties on the new development to be supplied with gas, network reinforcement was required to elevate pressures at a pinch point over a railway crossing and a pressure elevation was required to ensure sequrity of supply.

Figure 1: Pressure Modelling the Reinforcement

The initial solution developed was to lay a reinforcement main under the railway, but due to access issues with Network Rail this was not allowed. To allow the development to continue their build, and to ensure we met our obligations over winter, a temporary solution was developed laying a steel main on top of the railway crossing. This temporary solution required agreement from the local authority.

The long term solution that has been identified is to lay a medium pressure main before and after the railway crossing, pressure testing of the existing assets buried in the bridge and the installation of a new governor.

There is a local plan to have 2,000 homes built in this area and once this longer term reinforcement is in place it'll mean all future housing requests can be connected without delay.

4.2. Spend Boundaries

The spend detailed in this investment case covers the cost of any investment to reinforce the network to cope with increases in demand. The major area of investment will be installing new, or upsizing existing mains assets. In some cases investment will also be required on non-pipeline assets such as pressure control systems (governors).

5. Probability of Failure

Introduction

Our obligation is absolute; we must fulfil customer led connections and develop our networks, or commercially interrupt consumption to meet a defined level of customers' demand. The defined level is that which, having regard to historical weather data derived from at least the previous 50 years and other relevant factors, is likely to be exceeded (whether on one or more days) only in 1 year out of 20 years.

It is this '1 in 20 year' peak day demand level that determines our networks' capacity requirements and sets our output for RIIO-GD2. However, it is difficult to accurately predict the future capacity of the network given consumers changing attitudes to energy and the change in the climate. The Future Energy Scenarios (FES)[2] produces a range of credible energy scenarios for the next 30 years and beyond.

The FES study shows that there is a large range of uncertainty in the forecast of peak gas demand as it will depend heavily on the energy policies introduced by future governments and consumer behaviour. For instance, if a property converts from a gas boiler to an electric heat pump, this will reduce both the annual and the peak demands. Similarly, energy efficiency measures impact peak demand, as well as annual demand, as a better insulated property would retain heat better during winter and require less gas in cold snaps.

However, if properties move to hybrid heating systems, the annual demand for gas is likely to be reduced as the electric heat pump contributes a large share of the energy; but on a peak day, the gas boiler would fire up and peak demand could stay relatively high even as annual demand decreases.

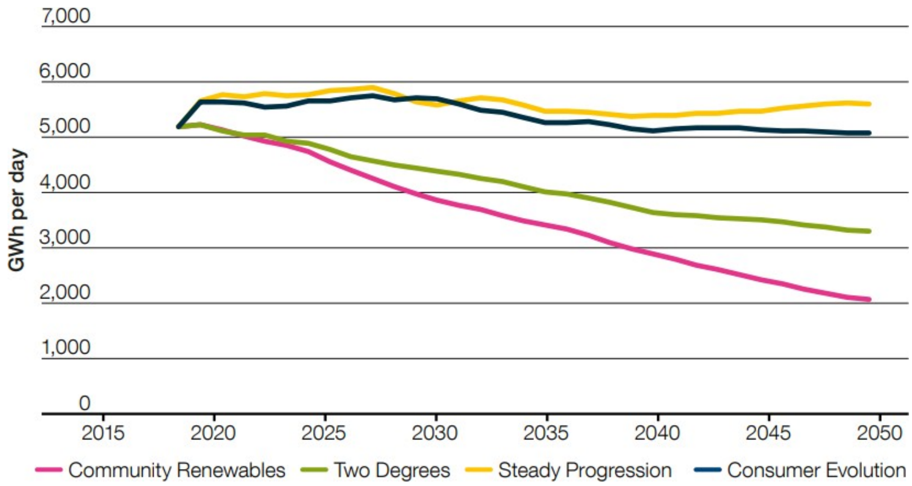


Figure 2: Peak Winter Demand Scenarios from the Future Energy Scenarios 2019 Report

Failure modes

Failure is defined as not being able to meet our 1 in 20 pressure obligation (21mb in the main, 19mb at the Emergency Control Valve).

This work is driven by the interaction between societal and economic change and the specific demands placed on different sections of our network at a local scale. As such probability of failure can best be represented by examining the workload requirements which have been driven by past changes. This analysis is described below in options development.

5.1. Probability of Failure Data Assurance

The data used to develop pur forecasts for RIIO-2 has been taken from RIIO-1 RRP.

[2] http://fes.nationalgrid.com/media/1409/fes-2019.pdf

6. Consequence of Failure

Failure to supply capacity in the network to meet peak demand will result in a dereliction of our obligation. We must fulfil customer led connections and develop our networks, or commercially interrupt consumption to meet a defined level of customers' demand.

Failure will mean that customers lose their gas supply at the time they need it most, during the coldest winter days. Or that we block or slow economic developments which will bring benefits to our communities.

7. Options Considered

Our approach is to build a plan which best reflects customer and stakeholder expectations, and which enables us to meet our obligations. This requires us to reinforce the distribution network – in the most cost-effective way – so that our customers do not suffer supply interruptions during periods of peak demand.

Our approach to investment involves two main elements:

- **Investment required in response to (general & specific) customer demand**. For this element, we have undertaken a review of historical (RIIO-1) workload and costs in order to determine the appropriate the level of investment to include in the base plan. As this work is mandatory, we have undertaken a brief options appraisal only, though our analysis is set out below for completeness in Section 7.1.1 - 7.1.4.
- **Investment required to enable insertion** for the distribution mains renewal programme. For this element, we have undertaken cost analysis (as part of our analysis of the IMRRP) to determine the appropriate level of investment in reinforcement. A summary of our analysis is set out in Sections 7.2.1 - 7.2.2.

We have therefore structured this section to discuss each element separately; providing separate option, technical and cost summaries for each.

In addition, we have developed an **uncertainty mechanism** to address any variability in the level of specific and general reinforcement required. This should be considered in conjunction with the level of investment included in the base plan (see section 9.3).

For both elements of mains reinforcements we have assessed the level of customer contributions we have received during RIIO-1, as a basis for RIIO-2 forecasting. There are minimal contributions (2.5%) reported in the RRP for reinforcements. As such, for RIIO-2 we have taken the view not to include contributions in the base case.

7.1. General and Specific Reinforcement

As highlighted above, the workload (i.e. length) for general and specific reinforcement is reactive – it depends on the volume and location of new connections and changes in consumption behaviour. As a result, any forecast for RIIO-2 must draw heavily on assumptions. We are proposing to use information on the workload and costs in RIIO-1 as the basis for our forecast in RIIO-2.

There are several different options for using the RIIO-1 workloads as the basis for the forecast, including:

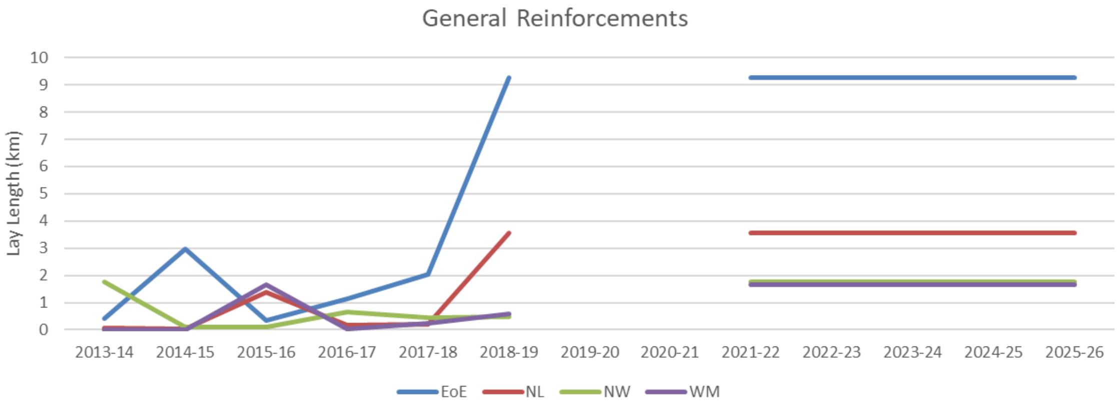
(1) The maximum workload in any year
(2) Average workloads across RIIO-1
(3) The minimum workload in any year
(4) Conservative view based on minimum workload

For all options we have calculated a workload based on RIIO-1 volumes for each network and average mix across diameter bands over RIIO-1. We have then calculated an average unit cost (using RRP data for each diameter band, uplifted to a consistent 2018/19 price base) by diameter. This is a reasonable approximation of the likely unit costs in RIIO-2 because this is the actual cost of carrying out the work in RIIO-1. The unit costs derived, and the efficiencies applied, are discussed in section 7.1.6.

7.1.1 Option 1: The maximum workload in any year

This approach would see us use the maximum length of reinforcement carried out to forecast a RIIO-2. This is a relatively high cost option.

This approach would be appropriate if national economic growth is strong and if we have a high level of confidence (at the outset) in the forecast of housing growth and power connections. We could also infer an upwards trend from the graphs shown. However, given we cannot be certain at this point in time, this option presents a risk that customer will fund more costs than necessary.



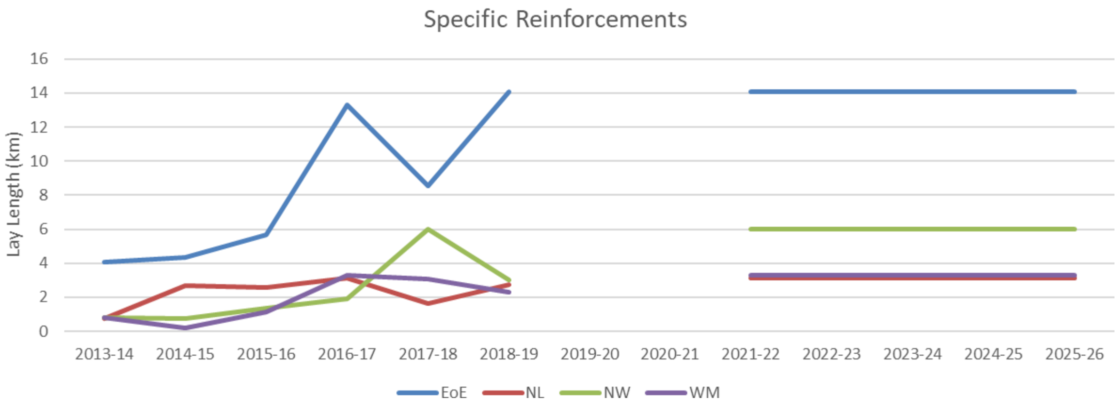


Figure 3: Max Approach to Forecasting Reinforcement volumes

Using the maximum year gives an investment length of 42.8km per annum. This has a net cost of £XXXXm over RIIO-2.

This derives the following volumes and repex profiles.

	2021/22	2022/23	2023/24	2024/25	2025/26	Total
EoE	23.3	23.3	23.3	23.3	23.3	**116.7**
Lon	6.7	6.7	6.7	6.7	6.7	**33.6**
NW	7.8	7.8	7.8	7.8	7.8	**38.8**
WM	5.0	5.0	5.0	5.0	5.0	**24.8**
Cadent	**42.8**	**42.8**	**42.8**	**42.8**	**42.8**	**214.0**

Table 3: Volumes for Option 1 (km)

	2021/22	2022/23	2023/24	2024/25	2025/26	Total
EoE	Redacted due to commercial sensitivity					
Lon						
NW						
WM						
Cadent						

Table 4: Cost profiles for Option 1 (£m)

7.1.2 Option 2: Average workloads across RIIO-1

This approach would see us use the average length of reinforcement carried out to forecast a RIIO-2.

This approach would be appropriate if we had confidence that the average volume of reinforcement experienced in RIIO-1 will continue into RIIO-2. Will it is certainly possible, we note there is a high degree of year on year variation in reinforcement investment and hence a risk that customer will fund unnecessary costs in any given year.

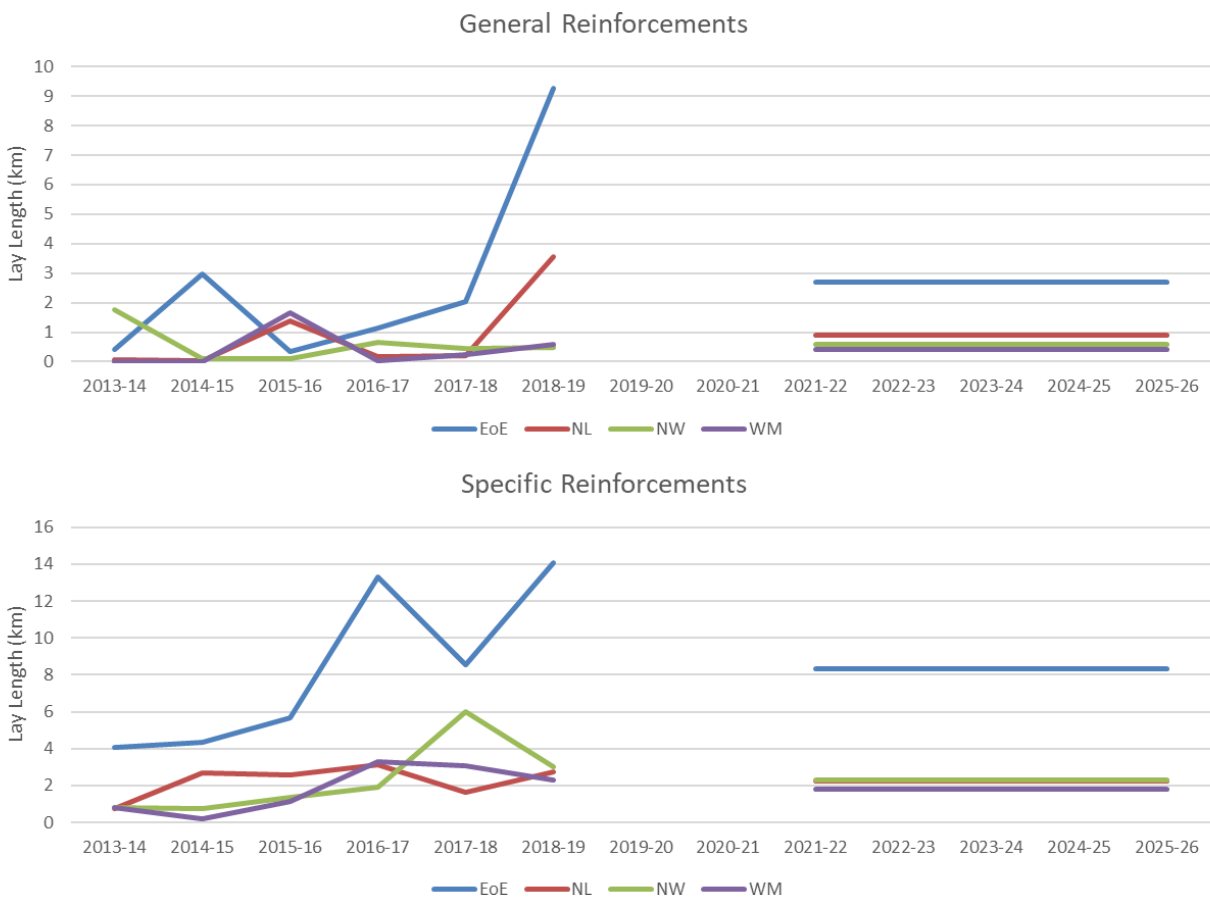


Figure 4: Average Approach to Forecasting Reinforcement volumes

Using the average year gives an investment length of 19.3km per annum. This has a net of £XXXXm over RIIO-2.

	2021/22	2022/23	2023/24	2024/25	2025/26	Total
EoE	11.0	11.0	11.0	11.0	11.0	**55.2**
Lon	3.2	3.2	3.2	3.2	3.2	**15.8**
NW	2.9	2.9	2.9	2.9	2.9	**14.5**
WM	2.2	2.2	2.2	2.2	2.2	**11.2**
Cadent	**19.3**	**19.3**	**19.3**	**19.3**	**19.3**	**96.5**

Table 5: Volumes for Option 2 (km)

	2021/22	2022/23	2023/24	2024/25	2025/26	Total
EoE						
Lon						
NW						
WM						
Cadent						

Table 6: Cost profiles for Option 2 (£m)

7.1.3 Option 3: The minimum workload in any year

This approach would see us use the minimum length of reinforcement carried out to forecast a RIIO-2.

This approach is a cautious assessment of volumes experienced in RIIO-1. While this means it is less likely that customers will over-fund reinforcement activity in RIIO-2, there is still uncertainty about the profile and location of growth (and hence the total cost of reinforcement in any year).

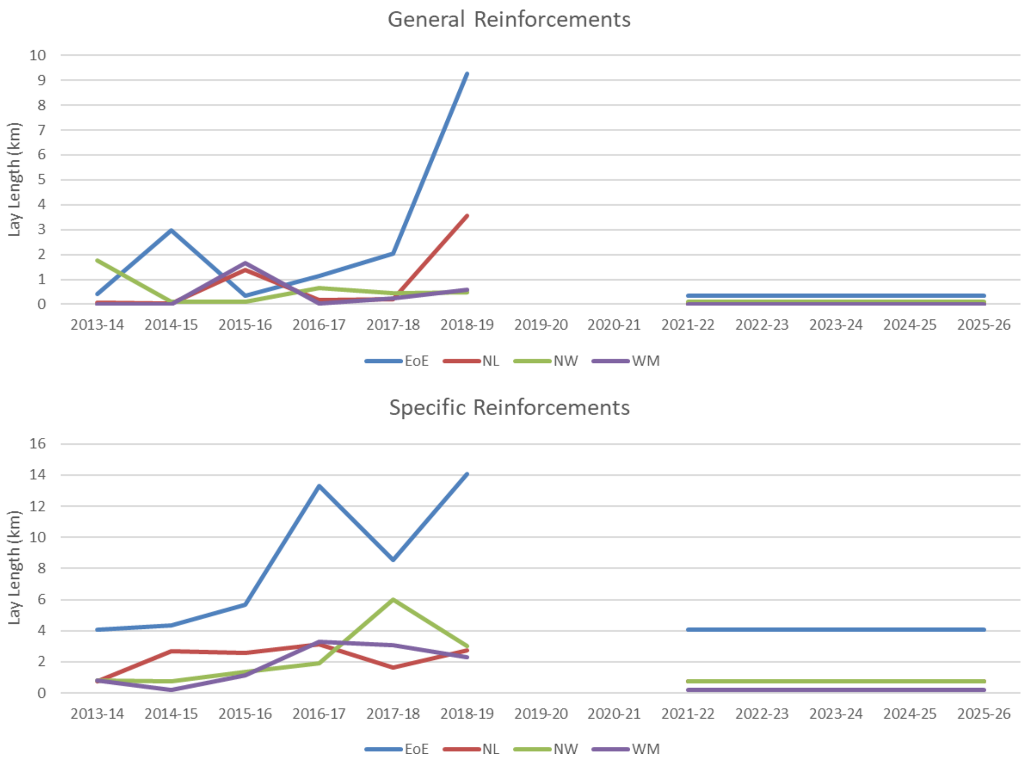


Figure 5: Minimum Approach to Forecasting Reinforcement volumes

Using the minimum year gives an investment length of 6.3km per annum. This has a net cost of £XXXXm over RIIO-2.

	2021/22	2022/23	2023/24	2024/25	2025/26	Total
EoE	4.4	4.4	4.4	4.4	4.4	**22.1**
Lon	0.8	0.8	0.8	0.8	0.8	**3.9**
NW	0.8	0.8	0.8	0.8	0.8	**4.2**
WM	0.2	0.2	0.2	0.2	0.2	**1.1**
Cadent	**6.3**	**6.3**	**6.3**	**6.3**	**6.3**	**31.3**

Table 7: Volumes (km) for Option 3 (km)

	2021/22	2022/23	2023/24	2024/25	2025/26	Total
EoE						
Lon						
NW						
WM						
Cadent						

Table 8: Cost profiles for Option 3 (£m)

7.1.4 Option 4: Conservative view based on minimum workload

This approach would see us use the 80% of the minimum length of reinforcement carried out to forecast a RIIO-2.

This approach is a very cautious assessment of volumes experienced in RIIO-1. Assuming the minimum year for the baseline almost guarantees that customers will not be over-funding reinforcement activity in RIIO-2.

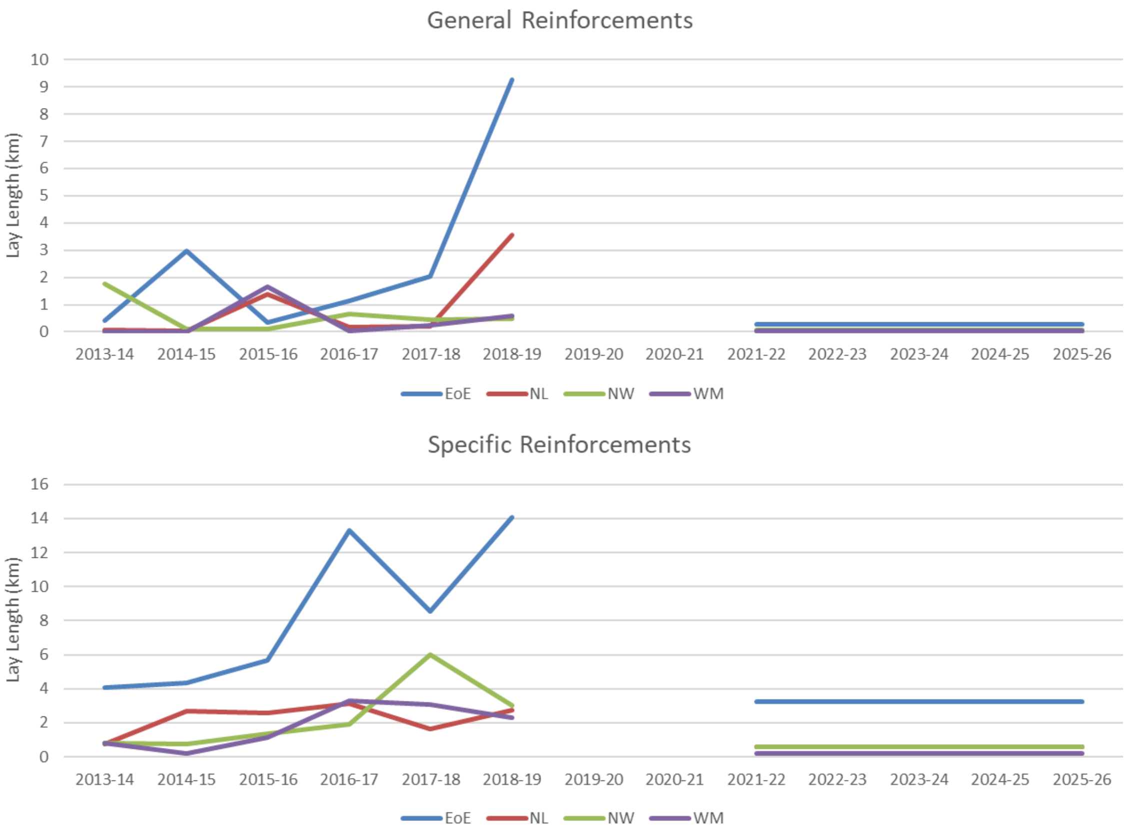


Figure 6: Conservative Approach to forecasting reinforcement volumes

Using 80% of the minimum year gives an investment length of 5.0km per annum. This has a net cost of £XXXXm over RIIO-2.

	2021/22	2022/23	2023/24	2024/25	2025/26	Total
EoE	3.5	3.5	3.5	3.5	3.5	**17.7**
Lon	0.6	0.6	0.6	0.6	0.6	**3.1**
NW	0.7	0.7	0.7	0.7	0.7	**3.4**
WM	0.2	0.2	0.2	0.2	0.2	**1.0**
Cadent	**5.0**	**5.0**	**5.0**	**5.0**	**5.0**	**25.2**

Table 9: Volumes (km): Option 4

	2021/22	2022/23	2023/24	2024/25	2025/26	Total
EoE						
Lon						
NW						
WM						
Cadent						

Table 10: Cost profiles for Option 4 (£m)

7.1.5 Options Technical Summary Table (General and Specific Reinforcement)

As discussed previously at a **programme level** there is only one feasible technical solution available. For individual issues we will consider various means of reconfiguring the network to maintain our obligations. The following table summarises the options available for forecasting workload volumes at a program level.

	Option 1: Maximum Year	Option 2: Average Year	Option 3: Minimum Year	Option 4: 80% of Minimum Year
Chosen option (only technical feasible solution)	Reinforce existing asset	Reinforce existing asset	Reinforce existing asset	Reinforce existing asset
First year of spend	2021	2021	2021	2021
Last year of spend	2026	2026	2026	2026
Specific Reinforcement Volume of interventions (Per annum)	16.3km	4.6km	0.5km	0.4km
General Reinforcement Volume of interventions (Per annum)	26.6km	14.7km	5.8km	4.6km
Design life	45 years	45 years	45 years	45 years
Total spend request (repex) (RIIO-2 Total)	Redacted due to commercial sensitivity			

Table 11: Technical Summary Table (Post Efficiency)

7.1.6 Options Cost Summary Table (General & Specific Reinforcement)

The following table summarises the **general reinforcement** repex for each option.

	Option 1: Maximum Year	Option 2: Average Year	Option 3: Minimum Year	Option 4: 80% of Minimum Year
2021/22				
2022/23				
2023/24				
2024/25				
2025/26				
Total				

Table 12: Options Cost summary table: general reinforcements

The following table summarises the **specific reinforcement** repex for each option.

	Option 1: Maximum Year	Option 2: Average Year	Option 3: Minimum Year	Option 4: 80% of Minimum Year
2021/22				
2022/23				
2023/24		Redacted due to commercial sensitivity		
2024/25				
2025/26				
Total				

Table 13: Options Cost summary table: specific reinforcements

The costs reported within this investment case for mains reinforcements are defined as being within Construction stage with a range of +/-5%.

Deriving Unit costs for general and specific reinforcements

To convert the workload for each option into a cost estimate, we used the average unit costs for each diameter band from RIIO-1 (using RRP data for each diameter band, uplifted to a consistent 2018/19 price base). This is a reasonable approximation of the likely unit costs in RIIO-2 because this is the actual historical cost of carrying out the work.

The table below sets out the average unit costs for each diameter band. We note that there a small number of unit costs which are "lumpy" and look very high compared to other networks or to neighbouring diameter bands. This is the case for diameter bands where there was only a very small amount of activity in RIIO-1 and hence a short total length (leading to high unit costs). We have left these costs in, noting that the overall output is not overly sensitive to this because only a very small proportion of costs in RIIO-2 rely on these diameter bands (because the distribution of workload across the diameter bands is assumed to be the same as for RIIO-1). The costs for specific reinforcements are "smoother" across networks and diameters. This is to be expected as there is a greater level of investment in this category and hence a longer total length over which costs are averaged. These unit costs are pre-efficiency.

	General reinforcement				Specific reinforcement			
Pipe Diameter	EoE	Lon	NW	WM	EoE	Lon	NW	WM
Less Equal to 75mm								
Greater than 75mm to 125mm								
Greater than 125mm to 180mm				Redacted due to commercial sensitivity				
Greater than 180mm to 250mm								
Greater than 250mm to 355mm								No Length
Greater than 355mm to 500mm	No Length	No Length	No Length	No Length	No Length	No Length	No Length	No Length
Greater than 500mm to 630mm	No Length	XXXX	No Length	No Length	No Length	No Length	No Length	No Length
Greater than 630mm	No Length	No Length	No Length	No Length	No Length	No Length	No Length	No Length

Table 14: RIIO-1 Reported Unit Costs (General and Specific Reinforcement, Pre Efficiency)

Efficiency

Our RIIO-2 forecasts include ongoing efficiencies flowing from our transformation activities, including from updating and renewing our contracting strategies. Our initiatives are outlined in Appendix 09.20 Resolving our benchmark performance gap. For repex activities this seeks a 5% efficiency improvement by 2025/26 on the end of RIIO-1 cost efficiency level.

7.2. Reinforcement driven by Insertion

Once we have established that a main is still required and needs replacing, we optimise the design, enabling the use of no-dig techniques such as insertion. Whether we can insert a pipe or not is the most significant driver of total scheme costs and, on aggregate, the most significant driver of cost in our mains replacement programme.

Insertion is generally the most efficient method of replacing mains. This technique, when compared to other options, dramatically reduces the amount of excavation work needed, which in turn reduces cost and disruption to the public. The method does, however, reduce the capacity of the network – the newly inserted pipe is smaller and therefore can transport less gas.

To understand the optimal level of network reinforcement to enable insertion we looked at four options:

Option 1: The level of insertion achievable without reinforcing the network or increasing pressure
Option 2: The level of insertion achievable by increasing pressure but without reinforcing the network
Option 3: The level of insertion achievable by increasing pressure and reinforcing where it is cost-beneficial
Option 4: The level of insertion achievable by increasing pressure and reinforcing the network to maximise insertion.

For each of these options, we considered the level of insertion and hence the level of reinforcement activity required. To do this, experts in our Network Strategy Team conducted a detailed study of 61 low pressure networks (multiple networks made up a distribution zone), comprising around 50% of the total tier 1 mains population, to assess the level of insertion and the average volume of reinforcement per km of mains replacement required.

We then applied this volume to the length of IMRRP we plan to complete in RIIO-2 in each of our networks.

For all options, it not possible to predict precisely how the reinforcement workload will be split across diameter bands. We have therefore used a standard unit cost for each network based on our GD1 actuals and multiplied this by the km of reinforcement required. These unit costs and the methodology used to derive them, is summarised in section 7.2.4

Further details of the proposed IMRRP, including the forecast length and profile of work for each network, is set out in Appendix 09.02 Distribution Mains and Associated services (Iron, PE, Steel & Other).

As Option 1 & 2 require no reinforcement, we have only included an option summary for Option 3 and 4 below.

7.2.1 Option 3: Increase pressure and cost beneficial reinforcement

Based on 48km of reinforcement to achieve an 86% insertion rate , we have generated the following volumes and repex profile for RIIO-2.

The profile of reinforcement driven by insertion takes account of the profile of the IMRRP. Because reinforcement activity needs to run ahead of the IMRRP delivery to minimise disruption, more of the workload is frontloaded in the earlier years of RIIO-2. The profile is a top down assessment rather than a modelled output.

	2021/22	2022/23	2023/24	2024/25	2025/26	Total
% total	27%	27%	27%	10%	10%	100%
EoE	6.7	6.7	6.7	2.4	2.4	**25.0**
Lon	1.9	1.9	1.9	0.7	0.7	**7.2**
NW	1.9	1.9	1.9	0.7	0.7	**6.9**
WM	2.5	2.5	2.5	0.9	0.9	**9.3**
Cadent	**13.0**	**13.0**	**13.0**	**4.7**	**4.7**	**48.4**

Table 15: Volumes for Option 3 (km)

	2021/22	2022/23	2023/24	2024/25	2025/26	Total
EoE						
Lon						
NW						
WM						
Cadent						

Table 16: Cost profiles for Option 3 (£m)

7.2.2 Option 4: Increase pressure and maximum reinforcement

Based on a 179km of reinforcement to allow an 88% insertion rate, we have generated the following volumes and repex profile for RIIO-2.

As per 7.2.1 the profile of reinforcement driven by insertion takes account of the profile of the IMRRP, this has been carried out using expert judgement. Because reinforcement activity needs to run ahead of the IMRRP delivery to minimise disruption, more of the workload is frontloaded in the earlier years of RIIO-2.

	2021/22	2022/23	2023/24	2024/25	2025/26	Total
% total	27%	27%	27%	10%	10%	100%
EoE	31.9	31.9	31.9	11.5	11.5	**118.7**
Lon	2.4	2.4	2.4	0.9	0.9	**9.0**
NW	8.0	8.0	8.0	2.9	2.9	**29.6**
WM	5.8	5.8	5.8	2.1	2.1	**21.8**
Cadent	**48.1**	**48.1**	**48.1**	**17.4**	**17.4**	**179.1**

Table 17: Volumes for Option 4 (km)

	2021/22	2022/23	2023/24	2024/25	2025/26	Total
EoE						
Lon						
NW						
WM						
Cadent						

Table 18: Cost profiles for Option 4 (£m)

7.2.3 Options Technical Summary Table (Insertion Reinforcement)

The table below summarises the options considered. As the cost of reinforcement needs to be seen in conjunction with the cost of the broader mains renewal programme, this is also included in the table for completeness. As can be seen in the table, the option labelled “increase pressure and CBA reinforcement” has the lowest overall net spend, taking account of both the reinforcement spend and mains renewal spend.

	Option 1: Do Nothing	Option 2: Increase Pressure Only	Option 3: Increase Pressure and Cost Beneficial Reinforcement	Option 4: Increase Pressure and Max Reinforcement
Chosen option (only technical feasible solution)	Reinforce existing asset	Reinforce existing asset	Reinforce existing asset	Reinforce existing asset
First year of spend	2021	2021	2021	2021
Last year of spend	2026	2026	2026	2026
Volume of Reinforcement (RIIO-2 Total Km)	0km	0km	48km	179km
Insertion % Achieved	76%	81%	86%	88%
Design life	45 years	45 years	45 years	45 years
Reinforcement Spend £m (RIIO-2 Total)	Redacted due to commercial sensitivity			
Mains Renewal Spend £m (RIIO-2 Total)				
Net Spend Spend £m (RIIO-2 Total)				

Table 19: Technical Summary Table

7.2.4 Options Cost Summary Table (insertion reinforcement)

The following table summarises the total costs associated with the level of mains reinforcement to allow different insertion volumes, for each option considered.

	Option 1: Do Nothing	Option 2: Increase Pressure Only	Option 3: Increase Pressure and Cost Beneficial Reinforcement	Option 4: Increase Pressure and Max Reinforcement
2021/22	Redacted due to commercial sensitivity			
2022/23				
2023/24				
2024/25				
2025/26				
Total Repex				

Table 20: Options summary table (insertion-reinforcement) £m

The costs reported within this investment case for mains reinforcements are defined as being within Construction stage with a range of +/-5%.

Deriving Unit costs for insertion-reinforcement

Because we do not know exactly which assets will need to be reinforced in RIIO-2 to allow insertion it is not possible to predict a spread across diameter bands. Therefore, to cost the RIIO-2 work we have used an average unit costs for the activity using RIIO-1 data.

In developing the cost estimates for each of the options, we have used a standard unit cost for each network based on our GD1 actuals. The resulting average unit cost for each network is summarised in the table below – note that the average cost is the same for each option.

Network	Average unit cost (£/metre) – all options
EoE	Redacted due to commercial sensitivity
Lon	
NW	
WM	

Table 21: Option cost summary table, average unit cost (£/metre)

Efficiency

Our RIIO-2 forecasts include ongoing efficiencies flowing from our transformation activities, including from updating and renewing our contracting strategies. Our initiatives are outlined in Appendix 09.20 Resolving our benchmark performance gap. For repex activities this seeks a 5% efficiency improvement by 2025/26 on the end of RIIO-1 cost efficiency level.

8. Business Case Outline and Discussion

8.1. Key Business Case Drivers Description

For general and specific reinforcement, the investment addresses customer driven network reinforcements. The benefits this investment will be that customers gas supplies will be kept secure. If we were not to carry out this investment customers would be exposed to unacceptable performance, and we would be in breach of our licence obligations. As such, we have not undertaken a full cost benefit analysis for this investment.

For reinforcement driven by insertion, (financial) cost benefit is the driver as inserting a main is cheaper than open cutting. There is a trade-off between the cost of renewal repex and the cost of reinforcement repex. Strategies that involve lower rates of insertion have lower reinforcement costs but higher renewal costs. Likewise, strategies that involve higher rates of insertion have higher reinforcement costs, but this is defrayed by lower renewal costs. Hence, the key driver of value is the amount of renewal repex that can be avoided in the IMRRP

8.2. Business Case Summary

This investment case covers mains reinforcements driven by two factors:

- **General and specific reinforcements**: Growth in demand driving the need for larger pipes
- **Insertion-reinforcements:** Additional reinforcement to allow “pipe insertion” as part of the main replacement programme reducing net costs

Both of these have been analysed differently. We have therefore discussed these two elements separately in this section.

8.2.1 General and specific reinforcements

For general and specific reinforcement, we have not undertaken cost benefit analysis for this investment as we are obliged to undertake this work in order to ensure that customers have adequate pressures. As such, we have not quantified the value of benefits for this case.

As discussed in Section 7, we have assessed a number of methods of establishing a reasonable minimum reinforcement-volume for our base plan. These are summarised below.

	Option 1: Maximum Year	Option 2: Average Year	Option 3: Minimum Year	Option 4: 80% of Minimum Year
Chosen option (only technical feasible solution)	Reinforcement of existing asset	Reinforcement of existing asset	Reinforcement of existing asset	Reinforcement of existing asset
Specific Reinf.nt Volume of interventions (Per annum)	16.3km	4.6km	0.5km	0.4km
General Reinf.nt Volume of interventions (Per annum)	26.6km	14.7km	5.8km	4.6km
Total spend request (repex) (RIIO-2 Total)		Redacted due to commercial sensitivity		

Table 22: Business case summary (general and specific reinforcements)

To protect customers from funding unnecessary costs, **it is prudent to include in the base plan only the minimum workload that can reasonably be expected**. Accordingly, our plan includes a workload equivalent to 80% of the minimum year in RIIO-1. We have selected 80% because it provides a baseline that we can be confident will almost certainly be required, ensuring customers won't be impacted through over payment. **Our chosen option is therefore, Option 4.** This new approach prevent windfall gains, but will only work in practices with an approprtaite UM to cover any increases in observed reinforecement needs.

8.2.2 Insertion-reinforcements

As discussed in Section 7, we have assessed a number of different methods of deriving a reasonable base-case volume of work for reinforcements to allow-insertions. These are summarised below.

	Option 1: Do Nothing	Option 2: Increase Pressure Only	Option 3: Increase Pressure and Cost Beneficial Reinforcement	Option 4: Increase Pressure and Max Reinforcement
Chosen option (only technical feasible solution)	Reinforcement of existing asset	Reinforcement of existing asset	Reinforcement of existing asset	Reinforcement of existing asset
Volume of Reinforcement (RIIO-2 Total Km)	0km	0km	48km	179km
Insertion % Achieved	76%	81%	86%	88%
Design life	45 years	45 years	45 years	45 years
Reinforcement Spend £m (RIIO-2 Total)				
Mains Renewal Spend £m (RIIO-2 Total)	Redacted due to commercial sensitivity			
Net combined Spend £m (RIIO-2 Total)				

Table 23: Business Case Summary Table

You will see from the above table, the net combined spend of the mains renewal programme and the mains reinforcements to allow insertion, are lowest for Option3, with a combined total of £XXXXm over RIIO-2. **Option 3 is therefore our preferred option.**

We have also assessed the benefits of varying reinforcement volumes, to improve insertion-rates, through a CBA analysis. In our CBA analysis we have assessed our **chosen Option 3** (*CBA Option 1* in the CBA template), against our baseline of reactive fix on failure. We have also undertaken a further CBA scenario, to look at the NPV of our chosen mains replacement programme (RIIO-2) without considering insertion benefits, this is noted below as *CBA Option 2*.

The tables below show the present value of costs for each network for the IMRRP investment with and without factoring in the benefits and costs of additional reinforcement to enable insertion.

Costs and benefits are discounted and shown in present value (PV) terms in line with Ofgem requirements and the HM Treasury Green Book. The costs for each option are based on the five years of investment in RIIO-2.

The table below shows the discounted present value of costs for each option to 2071. :

CBA Option No.	Option description	PV Expenditure & Costs (£m) to 2071	PV Environment (£m)	PV Safety (£m)	PV Reliability (£m)	PV Other (£m)	Total PV (£m)	NPV (£m)
0	Reactive Only							
1	Chosen Mains replacement programme + Insertion-reinforcements			Redacted due to commercial sensitivity				
2	As per CBA Option 1, without insertion-reinforcements							

Table 24: PV and NPV for scenarios

Table Notes:

- PV expenditure and costs show the discounted sum of proactive investment (replacement or refurbishment costs), maintenance, repairs and other ongoing opex costs. Proactive investment has been considered over RIIO-2. All other financial costs are considered over the full period to 2071. All financial costs are discounted using the Spackman approach.
- PV environment shows the discounted sum of leakage and shrinkage, using the base case cost of carbon.
- PV safety shows the discounted sum of the risk of fatalities and injuries, as valued using Ofgem's stated costs per fatality and cost per non-fatal injury.
- PV reliability shows the discounted sum of interruption risk, as valued using our own valuation research (e.g. the willingness to pay study into the cost of interruptions to homes and businesses).
- PV other shows the discounted sum of any other impacts, as valued using our research into the cost of property damage and transport disruption.
- Costs are presented as negative values. The total PV is the summation of the five categories of costs.
- The baseline has been specified as the minimum investment position. The NPV for each option is computed as the difference between the total PV for each option and the total PV for the baseline. A positive NPV means an option has less cost associated with it relative to the baseline and is therefore cost-beneficial. The option with the highest positive NPV is the most cost-beneficial of the options considered.

The table below summarises the cost-benefit results for each CBA option. This provides the NPV for the option (computed as the difference in total PV relative to the baseline) – to show which options are cost-beneficial or not. We also include the payback period and the ratio of NPV to RIIO-2 to understand how much NPV per £ spent in RIIO-2 the options generate.

Option No.	Option description	NPV - Relative to baseline (£m)	Cost beneficial	Payback Year	RIIO-2 spend (Replace, Refurb) (£m)	Ratio NPV to RIIO-2 replace/ refurb spend
0	**Reactive Only**	N/A	N/A	N/A		N/A
1	**Chosen Mains replacement programme + Insertion-reinforcements**	£XXXX	Cost Beneficial	2041	Redacted due to commercial sensitivity	2.15
2	**As per CBA Option 1, without insertion-reinforcements**	£XXXX	Cost Beneficial	2042		1.95

Table 25: Cost benefit summary for all scenarios

Note: The total RIIO-2 spen in the CBA above is the cost of the IMRRP, <=2" steel and associated services. This total cost does not match the cost in the business case summary table as the cost stated in this table is the cost of the mains only element of the IMRRP programme and tier 1 iron >30m.

As can be seen in the above table, the mains replacement programme is cost beneficial with and without the additional insertion-reinforcement, however the cost benefit is improved significantly with the additional reinforcement as the total costs are reduced by £XXXXm over the period improving the payback year and the NPV ratio to spend.

This CBA analysis therefore, also supports our preferred Option 3, of delivering 48km of mains-reinforcement to enable a lower-cost mains replacement programme, by enabling higher volumes of pipe-insertion.

9. Preferred Option Scope and Project Plan

Due to the uncertainty surrounding the scale and location of general and specific reinforcements, our preferred option (at a programme level) is to include in the base plan only the minimum workload that can reasonably be expected, along with an uncertainty mechanism to address workload in excess of this minimum level.

For reinforcement driven by insertion the "Increase Pressure and Cost Beneficial Reinforcement" volume provides a clear benefit compared to the alternative options.

9.1. Preferred Option

This investment case covers mains-reinforcements driven by two factors:

- **General and specific reinforcements**: Growth in demand driving the need for larger pipes
- **Insertion-reinforcements:** Additional reinforcement to allow "pipe insertion" as part of the mains replacement programme.

Our preferred option for **General and specific reinforcements is Option 4.** This option includes a workload equivalent to 80% of the minimum year in RIIO-1. We have selected 80% because it provides a baseline that we can be confident will almost certainly be required, ensuring customers won't be impacted through over payment. This approach will only be appropriate when combined with the UM.

Our preferred option for **Insertion-reinforcements is Option 3**. This option allows an 86% insertion rate, requiring 48km of insertion-reinforcements as a result. This level of mains-reinforcement and insertion rate provides the lowest overall programme cost for mains replacement over RIIO-2.

9.2. Asset Spend Profile

The annual profile of expenditure across each network for each type of reinforcement activity is shown in the tables below.

	2021/22	2022/23	2023/24	2024/25	2025/26	Total
EoE						
NL						
NW			Redacted due to commercial sensitivity			
WM						
Cadent						

Table 26: General Reinforcement Repex Spend (£m)

	2021/22	2022/23	2023/24	2024/25	2025/26	Total
EoE						
NL						
NW			Redacted due to commercial sensitivity			
WM						
Cadent						

Table 27: Specific Reinforcement Repex Spend (£m)

	2021/22	2022/23	2023/24	2024/25	2025/26	Total
EoE						
NL						
NW						
WM						
Cadent						

Table 28: Insertion Reinforcement Repex Spend (£m)

9.3. Investment Risk Discussion

We undertake reinforcement work to maintain pressure and flow across our network. This work is increasingly difficult to forecast, driven by domestic and industrial customer demand changes under the energy transition and wide ranges in forecasts for new properties. Whilst we can model potential gas demand at a regional level, it is very difficult to assess the local implications of this, and ultimately what reinforcement work this will require. As a result, we have needed to make the following material assumptions to derive our estimates for RIIO-2:

- That the number and type of interventions in RIIO-1 will be similar in RIIO-2; and
- The unit costs for different interventions will remain unchanged

To help manage this risk, we are proposing a volume driver uncertainty mechanism which would adjust the level of funding if the level of reinforcement required in RIIO-2 varies above the minimum levels assumed in this investment case. The mechanism is based on a unit cost approach (reflecting the different unit costs associated with different pipe diameters) and **includes only general and specific reinforcement activity** – it excludes reinforcement to enable insertion as we can be much more confident about the forecasts which are specifically linked to the proposed IMRRP.

Further information on the proposed uncertainty mechanism is provided in Appendix 10.08 Reinforcements.

We note that our assumptions are also based on the scenario where the future demand for gas continues, and there is no sudden change to alternative fuel supplies in the short term.

Reference	Risk Description	Impact	Likelihood	Mitigation /Control
09.26 - 001	Supply & Demand deliverability risk of Resource availability within the Gas industry	Potential cost increases in labour / commodity markets as demand is greater than supply	Low	Intelligent procurement and market testing. Apprenticeship and Training programmes to fill skills gaps
09.26 - 002	Stretching efficiency targets may not be deliverable (unit costs increase)	Outturn costs are not met increasing overall programme costs.	Low	Established market place - ability to manage the known commodity market
09.26 - 003	Unforeseen outages and failures restrict access for planned work	Programme and delivery slippage due to delay of planned outages and or site access	Low	Proactive asset management with ongoing condition surveys and response plans to prevent failures
09.26 - 004	Unseasonal weather in 'shoulder months', Autumn and Spring reduce site access/outage windows	Increased demands affecting access to sites and planned outages delay and cost increases	Low	Controlled forecasting and maintenance of flexibility to react to unforeseen events. Detailed design solutions to minimise outages and reduce exposure.
09.26 - 005	Unexpected / uncommunicated obsolescence during RIIO-2 period of equipment components	Inability to maintain equipment at full capacity with risk of impact upon supply	Low	Maintain a close relationship with equipment supply chain and manage a proactive early warning system where spares / replacements become at risk.
09.26 - 006	Legislative change - There is a risk that legislative change will impact the delivery of our work.	Potential increase in the amount of consultation and information exchange required and require us to align our plans with the safety management processes operated by 3rd Party landowner / asset owners. The potential impact is more engagement and slower delivery	Med	We have established management teams to address these issues. We have also identified UMs for key areas.

Table 29: Risk Register

10. Regulatory Treatment

This investment will not be processed through the NARMs reporting tool.

Cost variance for low materiality projects such as this will be managed through the Totex Incentive Mechanism (TIM). Increases in volume will be covered by the uncertainty mechanism set out in 10.13.

This investment is accounted for in the Business Plan Data Table 3.02 Reinforcement.