EJP09 DD Update: Mains CBA

Cost Beneficial Mains Replacement

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Supporting Evidence EJP09-SE-Cost Beneficial Mains Replacement (separate document)

No.	Document Name	Updates in this version
Annex A	Equipment Summaries	No change
Annex B	Diameter Band Breakdown of Chosen Option	New Annex, granular information on chosen option (to support Section 10 of this EJP)
Annex C	How We Have Selected the Right Programme	No change
Annex D	Deliverability Considerations	New annex.
Annex E	Enhanced Emissions Assessment	Updated to explain HLM/ SLM and how Cadent will embed advanced leakage management, ALD and DPLA to manage the asset health of its mains. Also discusses how, using the active leakage detection we carry our appropriate CBA tests prior to completing any proactive replacements.
Annex F	CBA Costs and Benefits Explanation	No change
Annex G	Robust and Efficient Unit Costs	Added information on average unit costs by pipe diameter.
Annex H	Detailed Options-Level Data	New annex, additional granular information on workload and costs for each programme option considered (by network and year)

1 Summary Table

Name of Project	Safety & Cost Beneficial Mains Replacement		
Programme Reference	EJP09		
Primary Investment Driver	Asset Health/Environment		
Project Initiation Year	2026 (RIIO-3 element)		
Project Close Out Year	2031 (RIIO-3 element)		
Total Installed Cost Estimate (£m)	305.17		
Cost Estimate Accuracy (%)	+/-5%		
Project Spend to date (£m)	N/A		
Current Project Stage Gate	N/A (rolling programme of Asset Health investment)		
Reporting Table Ref	CV6.02, CV6.03, CV6.04, CV6.05, CV6.08, CV6.12		
Outputs included in RIIO-3 Business Plan	Yes		
Spend apportionment (£m)	RIIO-2	RIIO-3	RIIO-4
	161	305.17	-

Table 1: Summary Table

Costs are pre-efficiency, and prices are in 2023/24 price base.

This investment case does not satisfy the criteria for late competition or early competition and pursuing a competitive approach would not be in the interests of the customer. We recognise the benefits that competition can bring to customers through efficiency and innovation. We continue to challenge ourselves as a business to ensure that we are harnessing competitive forces where they can provide these benefits. For specific detail on how we have assessed competition, please see our Main Business Plan Chapter 6 and the Workforce and Supply Chain Strategy (Appendix 17).

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2 Executive Summary

This EJP details our plan to target Repex investments to manage asset health, safety, and support our ambitions for carbon reduction. This work forms part of an overall programme of Repex work that includes EJP08-Mains IMRRP (Including Associated below 2" Steel), and our Tier 2A safety mains (EJP19). We have optimised our entire Repex programme, to deliver the best outcomes for customers, by identifying efficient and beneficial packages of work based on overall cost and risk.

Since our December submission, our Tier 2A programme of work has changed due to a planned, cross-GDN risk coefficient update, with 110km of additional mains now being replaced as part of this mandatory programme. We have re-run our investment models for this investment case, to account for these Tier 2A mains, and ensure that our programme options, do not exceed our 750km Cadent-level delivery constraint.

This updated EJP has been produced based on feedback and engagement with Ofgem during the draft determination response period. This document sets out to address the three primary concerns raised by Ofgem, summarised below in Table 2.

Ofgem feedback	Cadent response	Document / Page ref.
The preferred mains replacement programme focusses predominantly on reducing leakage, with less **focus on asset performance** (safety and asset health) which is seen as the primary driver for investment.	In response to this feedback, we have incorporated additional information in this EJP to clarify the way our proposed investment impacts on asset performance. This includes a broader range of measures for each option, illustrating how asset health is affected by the various investment options and a critical element of our optioneering. Please refer to Section 8 and 9 of this EJP.	Section 8 and 9 of this EJP.
The workloads within the chosen option are not deliverable. Insufficient evidence has been presented to **provide confidence** that the **workloads are deliverable** and will not have an adverse impact on cross-industry mains-laying activities (cost increases) or subcontract availability.	We have provided further information on the deliverability testing undertaken in preparation for the business plan submission last year. Our workload volumes are profiled to result in a gradual increase in work in relation to our RIIO-2 volumes. All options are deliverable, confirmed by our supply chain. This is discussed in Section 8 and Annex D of the supplementary evidence document.	Section 8 of EJP and Annex D of the supplementary evidence file.
The proposed active leakage detection and **advanced leakage management approach** (informed by the digital platform for leakage analytics) appears to be a mechanism for **driving additional workload**.	We have explained how our observed leakage data has been used to inform our decision making. This explains that our Hybrid Leakage Model allows us to optimise planned workload, rather than necessarily increasing the size of that workload. Our Hybrid Leakage Model selects different pipes for intervention due to more targeted information on asset health and leakage. This doesn't drive additional volume, this is determined by the benefits case, Ofgem's CBA criteria and the feedback from our customers. Refer to Section 2: Introduction.	See Section 2: introduction and Annex E of the supplementary evidence file.

Ofgem feedback	Cadent response	Document / Page ref.
	We have included Annex E in our supplementary evidence document, to explain our advanced leakage management approach, and how we use our leakage data to target proactive mains replacements.	

Table 2: Summary of Ofgem feedback and Cadent response: EJP09

We have assessed four key programme options to test and demonstrate the value of this investment, and a ‘do nothing’ option, which acts as a baseline. These options test the costs and benefits of completing different lengths of proactive mains replacement across Cadent’s four gas networks. Options vary from 230km of mains replacement (equivalent to a continuation of our RIIO-2 workload), up to 640km of mains replacement.

The following option table summarises the workload, costs and performance of all options assessed.

Option name	NPV, 2037 (£m) [1]	NPV, 2050 (£m)	RIIO-3 Repex (£m)	Avg RIIO3 Bill impact £/HH/y	Start to end of RIIO-3 performance trend			
					Contribution to leakage reductions	Gas escapes	GIBs	Supply interruptions
Option 1: 640km in RIIO-3	100.5	425.4	305.2	0.68	10%	4%	5%	9%
Option 2: 230km in RIIO-3	95.4	304.7	118.9	0.33	6.8%	-3%	-4%	1%
Option 3: 390km in RIIO-3	92.4	355.0	209.6	0.51	8.3%	0%	1%	5%
Option 4: 480km in RIIO-3	99.9	392.7	249.8	0.63	9.2%	2%	3%	7%

Table 3: Options Summary

[1] NPV is relative to the baseline option (of continue to reactively repair) and carry out no proactive replacement.

The next table then compares the alternative programme options relative to the proposed DD option (Option 2: Continue with RIIO2 approach: 230km in RIIO3) to demonstrate the incremental costs, benefits and workload of each alternative option considered.

Option	NPV, 2037 (£m) [2]	NPV, 2050 (£m)	RIIO-3 Repex (£m)	Avg RIIO3 Bill impact £/HH/y	Performance achieved compared to Option 2			
					Contribution to leakage reductions	Gas escapes	GIBs	Supply interruptions
Option 1: 640km in RIIO-3	+5.1	+120.7	+186.3	+0.35	+3.2%	-7.1%	-8.7%	-7.7%
Option 3: 390km in RIIO-3	-3.0	+50.3	+90.7	+0.24	+1.4%	-3.5%	-4.9%	-3.8%
Option 4: 480km in RIIO-3	+4.5	+88.0	+130.9	+0.30	+2.4%	-5.0%	-6.7%	-5.4%

Table 4: Option comparison to Option 2 (RIIO2 continuation)

All of these options effectively manage asset performance and deliver safety and environmental benefits by differing amounts. All options are viable and deliverable. All options except Option 2, hold asset health stable or improve asset health, with our Option 1 performing best. All options also deliver a positive net benefit relative to our baseline reactive only option, with Option 1 performing best across almost all years from 2027 to 2050.

Our chosen option (option 1: 640km of mains replacement) will see an investment of £305.17m in our network to replacement 598.35km of metallic mains, remediate 49.25km of iron mains through innovative robotic interventions, and replace circa 31,000 services, Table 5. This option delivers the best, slightly improving asset health performance , which aligns to our customers' highest priority, and also delivers 10% reduction in leakage against Cadent's scope 1 & 2 targets, a key contribution to our Environmental Action Plans. This option will increase average bills by £0.35 / household over the RIIO-3 period, relative to continuing with our RIIO-2 approach. 89% of our customers agree it is important to prevent gas leaks, especially now, so more of the gas produced can be used in homes and businesses and 65% agree that £1 per household per year is value for money.

Network	RIIO-2 Workload and Costs			RIIO-3 Workload and Costs		
	Mains replaced (km)	Services (nr)	Total Repex £m	Mains replaced (km)	Services (nr)	Total Repex £m
EE	111.63	6,678	43.40	242.40	9,299	101.88
NL	83.95	5,071	87.11	96.02	8,694	66.30

[2] NPV is relative to Option 2 (continue RIIO2 approach).

Network	RIIO-2 Workload and Costs			RIIO-3 Workload and Costs		
	Mains replaced (km)	Services (nr)	Total Repex £m	Mains replaced (km)	Services (nr)	Total Repex £m
NW	39.64	2,653	13.14	159.55	5,583	68.37
WM	52.93	4,565	15.65	149.63	7,642	68.62
Total	**288.16**	**18,967**	**159.30**	**647.60**	**31,219**	**305.17**

Table 5: RIIO-2 and RIIO-3 workload and costs

Our chosen option has changed since our December submission, due to the changes to the Tier 2A programme. A summary of the changes are:

- Our mandatory Tier 2A mains programme has increased by circa 100km driven by the coefficient update; our CBA mains replacement programme has reduced by an equivalent amount to ensure deliverability of the overall mains replacement programme.
- The length of mains remediation using robotic techniques (CISBOT) broadly remains unchanged at 49.25km vs 49.7km.
- The volume of associated services has increased from 25k to 31k.
- Investment in the assets covered by this paper has reduced by £68m from £373m to £305m.

3 Introduction

3.1 Investment Justification

This paper focuses on mains investment which is outside the Iron Mains Risk Reduction programme (IMRRP), and Tier 2A (PAST) pipes. The paper therefore excludes any works driven by our IMRRP, see EJP08-Mains IMRRP (Including Associated below=2" Steel), and Tier 2A PAST pipes (EJP19).

3.2 Investment methodology

Our investment decisions are guided by a standardised Asset Health Investment decision making process, utilising Cadent's investment decision making model (AIM).

We have followed a comprehensive process to refresh and update our risk and deterioration models and then use these to derive a range of optimised scenarios to inform decision making.

Our standard approach is described in detail in Section 5.2 and 5.4 of Appendix 10 Network Asset Management Strategy. More specific information on the mains and services model is discussed in EJP09-DD-SE-CBA Mains Replacement-Annex C.

For this EJP our approach to updating and utilising our mains and services model is summarised below:

- **Data input and preparation**: We have gathered a wide range of updated data: asset condition, installation dates, fault history, customer impact from both company and industry databases from 2008 to mid-2024. Specifically for mains, we have supplemented this data with observed leakage data from recent leakage surveys (8% of mains-length has been surveyed in RIIO-2).
- **Data cleansing and validation.** The data is cleansed, validated and infilled, ready for use to update the asset deterioration models.

- **Risk and Failure modelling:** Risk mapping is undertaken for each asset class aligned with the NARMs methodology. We define the failure modes and the associated consequences of failure, to then calculate a monetised risk using private and social costs, for each forecast failure that occurs (due to asset deterioration). Our deterioration model is also able to forecast deterioration of all mains including identifying pipes that will fail the Tier 2A PAST risk threshold.

  Specifically for the mains and services model:

  - We have updated our shrinkage and leakage model (the SLM aligned to the industry standard theoretical approach defined within NARMS) which assigns a leakage rate based on the pipes' pressure tier.
  - Using our observed leakage rates (from 10,000km of RIIO-2 leakage surveys) we have developed a hybrid leakage model (HLM), enabling a disaggregated view of emissions at pipe level[3]. The observed leakage data has shown that some pipes leak more than assumed in the SLM, other pipes leak less. The quantity of total leakage predicted by the SLM and HLM is almost identical at company level across all pipe materials. However, the HLM would target different pipes for intervention, over the SLM. Using the HLM we can target pipes with the highest risk of failure and thus pose the highest safety and leakage risk, more accurately than the theoretical SLM. The data suggests that 1.6% of the assets have 40% of the leakage using the HLM model, 2.5% of the assets have the same leakage using SLM. See EJP09-DD-SE-CBA Mains Replacement-Annex E, for more details.

- **Intervention and cost-modelling**; The model calculates intervention costs using a combination of

  - Historical cost data from previous projects
  - Asset specific factors including pipe length, diameter, material, location, surface type, depth.
  - Complexity adjustment to account for environmental and logistical challenges.

  A range of different intervention modes comprising pipe repair, robotic remediation of pipe joints, pipe replacement through insertion and open cut have all been considered. The model can calculate a robust cost estimate for an individual pipe intervention and a group of pipes. The model has the capability to identify adjacent pipes and group them into a scheme, to improve delivery efficiency and reduce delivery costs[4]. Each individual pipe or pipe-super-string has a replacement cost and an associated risk / benefit – these are used as inputs into the decision-making process. This is discussed in more detail in Section 0 of this EJP, and in EJP09-DD-SE-CBA Mains Replacement-Annex C.

- **Developed a wide range of investment scenarios;** Each scenario is built around; ***Objectives*** (minimise cost, reduce carbon, hold asset health stable) and ***Constraints*** (setting budget and deliverability limits). The model runs millions of combinations to identify the optimum cost-beneficial mains-replacement strategy based on the defined objectives and constraints. The model assesses individual pipe-lengths and pipe super-strings to identify the optimum intervention programme, to balance cost and risk. It uses the cost-benefit of each individual pipe or super-string, as part of the optimisation process, looking to identify the pipes or super-strings with the shortest payback periods. The outputs of each scenario are discussed in Section 8 & 9 of this EJP.

This investment decision making process, and our preferred option within this EJP, sets the basis for Cadent's Advanced Leakage Intervention 5-year strategy, acknowledging that this investment case will manage the asset health, safety risk and associated environmental impacts from failed gas-mains. This mains-replacement programme is delivered by our networks, in-period, using our Advanced Leakage Management Approach, comprising ongoing active leakage detection (ALD) and our Digital Platform for Leakage Analytics (DPLA). Leaks which trigger either the safety or environmental thresholds defined in Cadent's policy are issued for further investigation (Opex), but the decision to carry out a proactive mains replacement is assessed using cost-benefit analysis, aligned to the decision-making approach used within this EJP. As such only mains with a high-risk of future failure (due to age, material, condition, or past performance), will be prioritised for proactive replacement. For further information refer to EJP09-DD-SE-CBA Mains Replacement-Annex E.

[3] Leakage rates have been derived from multiple readings, at different times of day, varying network pressures and seasonal demands.
[4] The model uses "super-strings" to identify optimal packages of work.

4 Equipment Summary

4.1 Overview of the assets

Our distribution mains form a network 127,158 km in length, connecting our Local Transmission System (LTS) to homes and businesses. They run underneath every street where we supply gas to a property. The makeup of the networks is the result of over a century of investment, policy and regulation in the transportation of gas. This investment has led to an extremely safe and reliable infrastructure performance, with a standard of services of 99.999% with regards to interruptions.

Over time, there have been various approved materials to carry gas, sanctioned replacement techniques and maintenance regimes to manage the assets. A summary of the asset stock for each region is shown in Table 6 below. The network is split into diameter tiers; Tier 1: 8 inches and below, Tier 2: above 8 inches and below 18 inches, Tier 3: 18 inches and above.

Material	Tier	EE (km)	NL (km)	NW (km)	WM (km)	Total (km)
Iron	1	4,644	2,728	3,148	2,542	**13,062**
	2	1,375	927	1,186	1,308	**4,796**
	3	302	511	405	205	**1,423**
Steel	1	1,886	544	842	1,024	**4,296**
	2	644	103	280	343	**1,370**
	3	376	237	152	121	**886**
Polyethylene (PE)	1	37,569	13,891	24,966	16,284	**92,710**
	2	2,905	1,381	2,200	1,703	**8,189**
	3	88	124	132	30	**374**
Other (mainly Asbestos Cement)	1	2	0	44	0	**46**
	2	0	0	5	0	**5**
	3	0	0	1	0	**1**
Total		**49,791**	**20,446**	**33,361**	**22,253**	**127,158**

Table 6: Asset Base as per 2023/24 RRP

This paper deals specifically with:

- Tier 2 and Tier 3 iron mains within 30 metres of a building[5]
- all iron mains greater than 30 metres from a building
- steel mains over 2”
- Tier 2 and Tier 3 asbestos cement[5]
- non-metallic mains i.e. PE that needs replacement

Table 7 shows the population of mains in scope for this investment paper.

	EE (km)	NL (km)	NW (km)	WM (km)	Total (Km)
Steel	2,906	884	1,274	1,488	**6,552**
Tier 2 Iron less than 30m from a building	1,227	905	1,131	1,220	**4,483**
Tier 3 Iron less than 30m from a building	261	501	380	197	**1,339**
Iron more than 30m from a building	354	51	142	239	**786**
Polyethylene (PE)	40,562	15,395	27,298	18,016	**101,271**
Asbestos Cement	0	0	6	0	**6**
TOTAL	**45,310**	**17,736**	**30,231**	**21,160**	**114,437**

Table 7: Population of mains in-scope for this investment paper

[5] Tier 1 iron mains within 30m of a building and asbestos Tier 1 are included in EJP08

5 Problem/Opportunity Statement

Our replacement programme during RIIO-2 is primarily focused on safety but will allow us to achieve (20%[6]) reduction in Scope 1 and 2 carbon emissions vs 2021/22 baseline. Leakage from our mains and services account for 78% of our Scope 1 and 2 emissions. Our ambition is that our mains replacement programme will continue to enable us to ensure a safe network, which contributes to our net-zero ambitions.

5.1 What happens if we do nothing?

If we do nothing, the assets will deteriorate and will pose the following service risks:

- **Safety:** Assets within 30 metres of a building have the potential to cause a major incident, leading to serious injury or loss of life. Any gas leaks could lead to a fire and an explosion risk. Only mains below the safety action threshold (leak flow rate) are addressed in this paper. Above the safety action threshold, leaks are dealt with as part of an emergency response and funded via opex (see section 5.5).
- **Environmental:** Any release of gas from our mains will result in additional carbon emissions. These carbon emissions have a shadow cost to our economy of £260 per tonne of carbon dioxide equivalent (tCO2e).
- **Regulatory compliance:** As outlined in section 5.2, we must comply with PSR (1996).
- **Interruptions to supply:** A supply interruption could be caused by a major pipe failure or the need to isolate the network to repair a failed pipe.
- **Transport or business disruptions**: Any leaks or mains failures could cause traffic or business disruption whilst the main is made safe and repaired. Aligned with the NARMs methodology, this impact is not currently monetised within the model.
- **Financial:** Every escape from our network carries a cost of attending and repairing the pipe, as well as restoring any supplies turned off, or lost during the leak.
- **Reputational damage:** Continued failure or poor performance will impact on our reputation as GDN and erode customer confidence. As illustrated in the water industry, reputation is very difficult to rebuild once damaged.
- **Other:** Continued failure of the same main will cause high levels of customer disturbance, and in turn dissatisfaction e.g. repeated road closures and excavations in the same location.

5.2 Key outcomes and understanding success

This investment is designed to reduce the whole life cost of operating the network, reduce risk and deliver significant environmental benefits through reduced leakage.

Our investment in mains replacement will look to achieve the following:

- **Overall cost-beneficial**
- **Asset health performance,** consistent with our ambition to hold asset health broadly stable and ensure that gas-in-buildings, supply interruptions and numbers of reactive failures are staying at broadly stable levels.
- **Deliverability,** we must ensure that the workload is deliverable. Tier 2 and Tier 3 mains replacements require additional competencies; therefore, we must ensure that our supply chain can sustainably provide any additional volumes.
- **Bill impact of each scenario,** and consistent with our customers' willingness to pay for more aggressive carbon reductions to support net-zero ambitions, and our customer's desire to not waste valuable gas resources.

[6] Using the standard leakage model

- **Regulatory compliance:** We have legal obligations to comply with the Pipeline Safety Regulations (PSR) 1996 and Gas Safety (management) Regulations (GSMR) 1996
- **Current government policy,** which demonstrates a commitment to deliver significant methane reductions in support of 2050 net zero emissions. Cadent has chosen to strongly align with these commitments as part of its plan. Addressing leakage through proactive mains replacement is the most effective way of addressing emissions, supporting customers' needs and our company strategy.

5.3 Alignment with overall RIIO-3 investment strategy

Our mains replacement programme will contribute to our carbon reduction plans, discussed in our Environmental Action Plan, Appendix 06.

5.4 Narrative real-life example of problem

Thorpe Road, Peterborough was promoted for replacement in January 2023 due to multiple escapes, including gas in ducts, requiring remediation via deep excavation.

In the five years prior, 18 repairs had been completed on the 488m 12" Cast Iron Main following five separate public reported escapes, accumulating 89 unique operative visits and over 800 hours of total work time. Overall, the main had been repaired 86 times since 1979.

The impact of completing repairs on this main were significant due to its location in the carriageway of the A1172, a major road in central Peterborough. This was further exacerbated due to it being a major connection between the city centre and railway station with the A47, whilst also servicing City Care NHS Centre, Thorpe Road Medical Surgery and West Town Primary Academy. As a result, significant traffic management was required for each visit causing considerable disruption.

Despite the significant failure history associated with this Tier 2 main, the Mains Risk Prioritisation System (MRPS) risk score was below the safety thresholds due to the relatively low property density of the large dispersed residential homes along the main – it did not qualify for replacement as a PAST pipe.

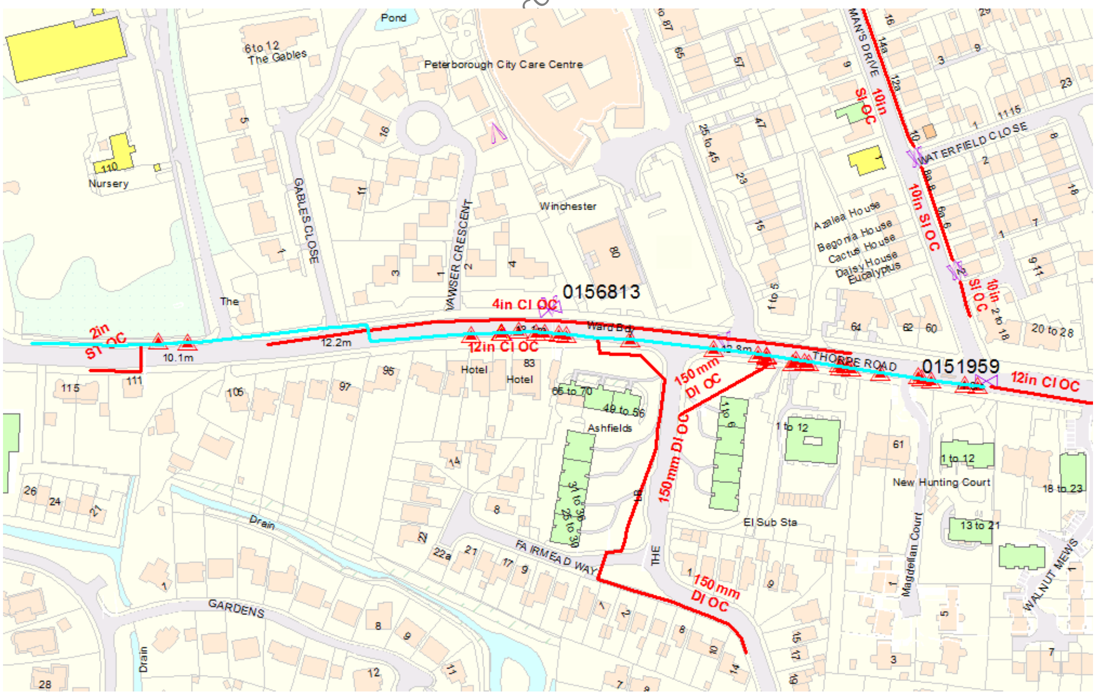

Figure 1: Thorpe Road Peterborough; leakage locations shown

The cost of replacing the main in this scheme was £211k. On the main with multiple failures, the costs of repairing them was £124k over the past five years. This gives a payback of 11 years for this scheme.

Having decided to replace the main following cost benefit analysis, delivery of scheme commenced in January 2024, a mixed scheme containing abandonment of Tier 1 IMRRP, associated <2" Steel and the identified Tier 2 main, totalling 1091m of abandonment. Final abandonment of the main was completed on the 29th of April.

5.5 Project Boundaries

This paper covers all costs associated with the replacement of mains outside of the mandated Tier 1 IMRRP, Tier 2A (PAST pipes), London Medium Pressure and Gray's MP replacement. This includes the replacement of distribution mains assets which are above the agreed safety threshold and the replacement of the mains in scope for CBA replacement as outlined in section 4.1.

This paper **does not cover** the OPEX interventions driven by our new active leakage detection procedure (introduced in 2025) following the introduction of our ongoing vehicle-based leakage monitoring. There are two thresholds which drive an Opex response as part of this operational procedure: a safety action threshold and an environmental action threshold. Further information on each threshold and Cadent's operational response is summarised below.

- **Safety Action Threshold (SAT):** Leak indications above a volume flowrate threshold are considered immediately unsafe and trigger an immediate 0800 response to locate and fix the leak via a repair.
- **Environmental Action Threshold (EAT):** Leak indications between the SAT and EAT that meet certain criteria are sent for intervention as part of an environmental strategy via a repair.

Refer to Annex E for further information on our Advanced leakage management approach, and following the initial repair, how we then prioritise mains for proactive replacement.

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6 Probability of Failure

Failure Modes: The method by which a gas main fails largely depends on the material from which the asset is made. Cast iron and spun iron pipes are brittle and therefore their failure mode is to fracture either along the pipe length or circumferentially (corrosion and joint failures are also observed). Ductile iron pipes are less brittle; therefore, fracture is less common; however, they do corrode in localised areas which can lead to gas escapes. As with ductile iron pipes, steel pipes also tend to corrode with age but are much more resistant to fracture failures.

To underpin this investment case, we have conducted a trend analysis of historical data to establish a consistent failure rate. This data has been sourced from our systems. The analysis adheres to industry best practices and aligns with the NARM methodology, ensuring a reliable assessment of asset performance and deterioration. Stakeholder validation and cross-referencing with our Network Asset Management Strategy have further reinforced the robustness of this analysis, providing a comprehensive understanding of asset degradation patterns to inform targeted investment decisions

To determine how assets perform over time in given situations, a suite of statistical models have been developed to predict the probability of failure given a set of asset attributes such as age, material, location, diameter, and length. The following failure types have been modelled: corrosion, joint failure, fracture, interference and capacity failure.

To allow the modelling approach to understand the differences between individual assets, the specific leakage history of individual assets is used to 'tune' the starting leakage value for each asset (for more details see EJP09-DD-SE-CBA Mains Replacement-Annex C). This 'tuned' approach allows us to consider all the variation that is not explained by the fixed predictors as well as any random variation between individual assets.

The following graph shows the numbers of non-IMRRP failures / km of main. Our current levels of mains replacement completed in RIIO-2 is resulting in a slightly upward trend in leaks per km.

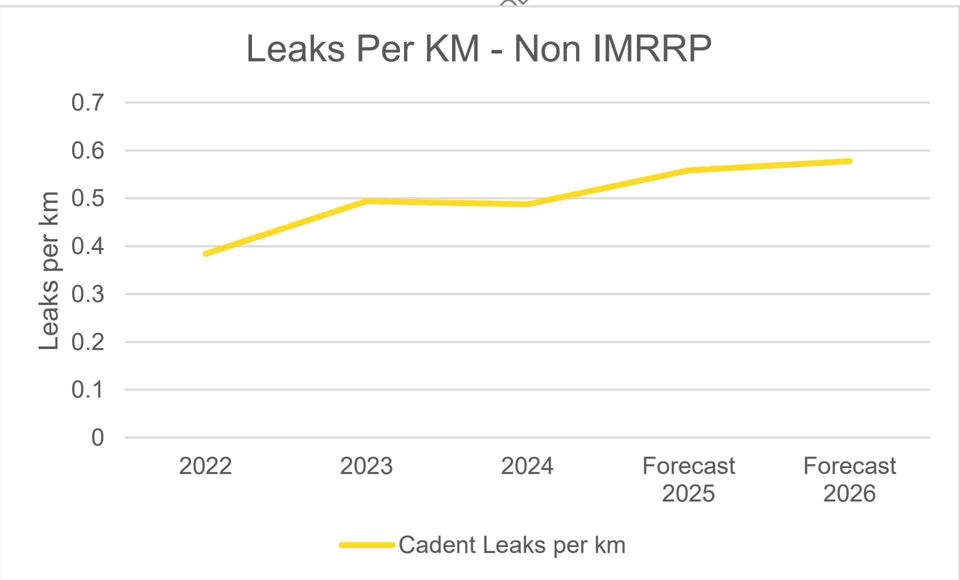

Figure 2: Non IMRRP leaks per km

6.1 Probability of Failure Data Assurance

We have high confidence in our ability to forecast the probability of failure. We have used advanced statistical techniques to derive individual asset-level deterioration rates using extensive data sets which are extracted from company systems and are subject to rigorous quality control for Regulatory Reporting Pack (RRP) reporting.

We have engaged with key stakeholders across our operational networks as well as engineering and operational subject matter experts to validate our probability of failure data. This approach gives us confidence in our ability to accurately predict asset deterioration.

Based on our investment methodology and assurance with our stakeholders, we are confident that we have applied the models correctly and that the probability of failure data in this document is accurate.

7 Consequence of Failure

7.1 Consequence of failure

As discussed, mains deteriorate with age which leads to the failure of the asset and an escape of gas from the network. There are multiple potential consequences of failure:

- **Safety:** Ignition – an explosion due to a gas-leak, leading to potential minor injuries and fatalities.
- **The financial cost of repairing the asset following a failure:** Either using a pipe collar, anaerobic sealants or enacting a short cut out and replacement. A reactive repair is less efficient and can involve road-closures and mobilising emergency response teams to manage the risk and carry out the repair. Subject to the type of repair, these are often classified as temporary, resulting in rechecks and repeat visits.
- **Gas escapes:** Failures of the asset have an environmental and a commercial impact. The volume of gas lost through leaks and shrinkage has both a shadow cost of carbon and an economic value.
- **Supply interruptions**: Gas supplies can be interrupted leaving customers without hot water or cooking facilities. Where this happens for an extended period, alternative arrangements need to be made. We have used customer willingness to pay to inform the benefit of reducing customer interruptions.
- **Traffic and business disruption.** This consequence is not monetised in the mains and services model, but repairs can result in road works causing travel delays and local issues such as noise which may occur at night. A small minority of gas escapes require persons to be evacuated from buildings and road closures.

All assets that are within 30m of a building have a risk score calculated by the MRPS. The risk score represents the number of incidents (property explosions) per annum we would expect from these assets.

Due to the success of the ongoing replacement programme that focuses on Tier 1 iron mains most of the outstanding incident risk is now outside the scope of the IMRRP.

Figure 3: Indicative MRPS Incident Rate for IMRRP and Non-IMRRP Assets

Within our modelling approach used to derive the RIIO-3 plan we have considered each failure mode and probability of failure and defined a range of potential consequences. The consequences of failure are summarised below:

Service Risk	Impact of Risk
Safety Risk	Assets within 30 metres of a building have the potential to cause a major incident, leading to serious injury or loss of life
Interruptions to supply	A supply interruption caused by the need to isolate the failed pipe or caused by a major pipe failure
Environmental Risk	Any release of gas from our mains will result in additional carbon emissions
Financial	The cost of fixing failures as they occur (e.g. repair costs) and remedying the consequences of failures (e.g. clean up and compensation)

Table 8: Service risk Consequences

We have used the Network Asset Risk Modelling (NARMs) methodology to calculate the value of the failures listed above and applied these in our RIIO-3 mains renewal modelling approach. Refer to Appendix 10 Network Asset Management Strategy for service risk framework economic valuations used for each failure mode.

The graph below shows the monetised consequence (monetised risk) of our asset base from 2025 onwards without investment, i.e. the cost of consequence increases as our failure rate increases. Without intervention our total monetised consequence increases by over 14% over the course of RIIO-3.

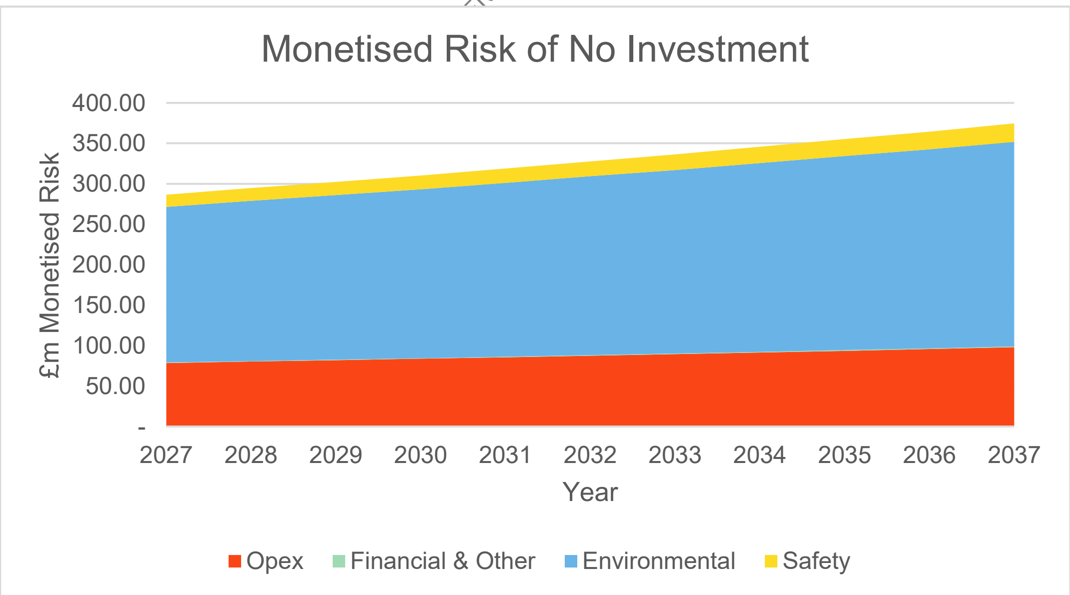

Figure 4: Monetised Risk of no proactive Investment

The total monetised risk of no proactive investment, can be further broken down as follows:

- **Opex** cost of the repair (excluding any additional costs of responding to the failure), cost of the lost gas c. 30% of monetised risk

- **Financial & Other:** Additional costs to respond to the repair, including any compensation costs associated with the failure and "**Other**[7]**"** risk through increased supply interruptions: c.1%
- **Environmental**: The shadow cost of carbon from any gas leaks or shrinkage: c. 65%
- **Safety:** The social costs of avoiding minor injuries and fatalities: c.5%

This shows that the cost-benefit is heavily driven by the shadow cost of carbon from gas-leaks and shrinkage and avoiding the reactive costs of pipeline repairs following a failure. These values are derived using the industry standard NARMs methodology.

7.2 Base case supply-demand scenario

Our licence states that we must have a network that can meet 1 in 20 year peak winter daily demand. We have reviewed the appropriateness of the FES Holistic Transition pathway as our core supply demand scenario. Due to the lack of local, specific data and reviewing our historic actual demands, holistic transition is significantly under-estimating peak demand (1 in 20 year licence obligation) and is therefore not a robust supply demand scenario for use in RIIO-3.

As such, our base case supply-demand scenario selected for this EJP, is the five-year centralised supply demand forecast which is developed with NESO taking actual demand and historic requirements from us into account. For 2030 to 2032 this forecast has assumed a regression in demand in relation to each network's forecast volumes. For further information on our review of the FES future energy scenarios refer to Appendix 10 Network Asset Management Strategy, section 3.1.

Due to the lack of local-specific data within both the FES Holistic Transition pathway and the Counterfactual pathway we have taken a top-down approach to testing the impact of future changes in demand on the "consequence of failure" and the overall cost-benefit of the investment case. This has been achieved by applying an increasing discount factor on the monetised benefits to simulate reducing customers and reducing demand relative to the base case. For this reason, we have only provided consequence of failure data for our base case supply demand scenario in this section. We discuss the results of the sensitivity testing in Section 9: Business Case Summary.

[7] These headings align to the categories used in the CBA tables.

8 Options Considered

We have choices about the replacement technique, pace and order in which we renew these assets; this section describes the development and analysis of the options we have considered in building the plan.

8.1 How we have structured this section

This section explains how we have developed the options that we have evaluated. It also presents summary analysis from our evaluation of the merits of each option.

Section 8.2 explains the standard "modes of intervention" used to develop our options.

Section 8.3 explains the "timing choices" that we have used to develop the options.

Section 8.4 explains the options (which have been constructed from the "modes of intervention" and the "timing choices") that we have evaluated.

8.2 Modes of Intervention

The HSE consider a pipe to be decommissioned only when the existing pipe has no role in the safe conveyance of gas. This means that either the pipe has been taken out of use with no substitution, or that the pipe has been replaced by another pipe that - standalone - has the integrity required to safely convey gas. Therefore, for safety-driven mains that are still required to convey gas there are only two intervention modes, which are to lay a new pipe by opencut methods and decommission the old pipe or to use the old pipe as a conduit to insert a replacement pipe.

For larger diameter, cast iron, non-safety driven cost beneficial mains, we have considered the use of robotic technologies to inspect and remediate mains whilst they are live. This is an attractive option as it allows us to maintain Tier 2 and Tier 3 iron gas mains without having to make significant excavations in the highway at high cost whilst maintaining the existing capacity the diameter of the paper provides.

The table belowTable 9 explains the intervention modes that we have considered.

Intervention mode	Overview of the intervention mode
Intervention mode 0: Repair the pipe following a failure	This option is a reactive repair following a failure. Note that operational responses to either a Safety Action Threshold or an Environmental Action Threshold leakage reading, are not included funded by this paper but are forecast within this baseline option. Refer to Section 5.5 for more information.
Intervention mode 1: Remediate pipe with robotic intervention (CISBOT)	CISBOT is an established joint remediation technique for cast iron mains with diameter 16" to 48"
Intervention mode 2: Replace the main via open cut	Replacement of the pipe by abandoning the deteriorated section and replacing with new PE pipe
Intervention mode 3: Replace the main via insertion	Replacement of the pipe by inserting a new PE pipe into the deteriorated section

Table 9: Intervention Modes

The costs for this EJP have been derived using our unit cost workbook (UCW), refer to EJP09-DD-SE-CBA-Annex G for an overview of our costing methodology and our approach to the UCW.

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Efficient Costs: Appendix 10 Network Asset Management Strategy explains that our investment cases are efficient because:

- They are derived from historic out-turn costs based on competitively tendered contracts and framework agreements in RIIO-2
- We have considered innovative methods and ways of working
- We have carried out top-down econometric benchmarking of our investment plan to evidence comparative efficiency against other GDNs

8.2.1 Intervention Mode 0: Reactive repair following a failure

	Commentary
Option Title	Reactive repair of a failure
Technical Details and Scope of option	This approach does not include any proactive replacement work. Once a failure has been identified the asset is repaired using the most appropriate method depending on the failure type.
Unit Costs of the option	Our models predict a failure rate based on assumed asset deterioration rates, and the costs per repair.
Basis of unit cost	Costs per repair have been derived based on historic repair costs captured in our systems, and varies by asset characteristics including, but not limited to, material, diameter band, and operating pressure.
What are the benefits of this option	Speed of intervention. Whilst temporary, it does stop the immediate leakage, albeit on a relatively temporary basis. There are limited benefits associated with a reactive repair in the short term, and this is assumed to be the baseline intervention option for this programme (i.e. do minimum)
Delivery timescales	Delivery timescales vary from days to months depending on the complexity of work to be delivered and the location.
Asset intervention life	This option does not extend the asset life of the pipe.
Risk Reduction assumed in modelling	Nil

Table 10: Reactive repair following failure.

8.2.2 Intervention Mode 1: Repair pipe with robotic intervention (CISBOT)

	Commentary
Option Title	Robotic Intervention (CISBOT)
Technical Details and Scope of option	CISBOT remediates lead-yarn joints by injecting anaerobic sealant from inside the main. CISBOT is a proactive technique to address leakage risk and as a means of improving the safety of our assets. This option will only be selected to address assets that have joint leakage as the predominant model of failure. If fractures or pipe barrel failures are common on the asset, direct replacement using one of the other intervention modes detailed will be selected. CISBOT is only suitable for use on iron assets
Unit Costs of the option	See EJP09-DD-SE-CBA-Annex G
Basis of unit cost	See EJP09-DD-SE-CBA-Annex G
What are the benefits of this option	The benefit of robotic intervention is the ability to remediate the pipes without significant excavations on the highway, making this technique quicker to implement and lower impact than open cut/insertion techniques. These benefits are significant when we are working in sensitive commercial areas or in areas with sensitive traffic management needs, allowing us to have flexibility on where we position our site to launch the robots. As a result, this option is particularly suited to collaborative working schemes with other utilities or local authorities
Delivery timescales	Delivery timescales vary from weeks to months depending on the length of the cohort of work to be delivered and the location. The joint spacing along the line of assets, most commonly 12ft apart, but can vary between 9 to 18ft, leads to variability in delivery timescales
Asset intervention life	15 Years[8]
Risk Reduction assumed in modelling	Following a refurbishment the joint leakage is reset to zero, this reduces the general carbon emissions by 90%

Table 11: Remediation via CISBOT

[8] The NARM intervention life supports Long Term Risk Benefit calculations. Should the intervention be implemented, this is the predicted time to elapse until another intervention of any kind is needed on the same asset (It is important to differentiate this from the accounting asset life which is used for asset depreciation analysis). See NARM commentary for further detail

8.2.3 Intervention Mode 2: Replace the main via open cut

	Commentary
Option Title	Replace the main via open cut
Technical Details and Scope of option	Replacing a tier 1 main via open cut typically involves digging trenches to expose the old pipe, removing it and replacing it with a modern plastic pipe that is more durable. Gas services need to be temporarily shut off during the work and connections made to safely restore services after. Once the pipe is installed and tested any excavations are backfilled. We try to minimise disruption while enabling improved safety and reliability of the gas network
Unit Costs of the option	See EJP09-DD-SE-CBA Mains Replacement-Annex G
Basis of unit cost	See EJP09-DD-SE-CBA Mains Replacement-Annex G
What are the benefits of this option	The primary benefit to replacing mains via opencut is the replacement of an ageing, poorly performing main. Open cut allows pipes of the same size or larger to be installed which maintains or increases network capacity. Note that upsizing pipe would only be carried out if it unlocked more insertion opportunity elsewhere and was cost beneficial. When combined with other works we achieve benefits in efficient delivery of larger cohorts of work
Delivery timescales	Delivery timescales vary from weeks to months depending on the length of the cohort of work to be delivered and the location. Complexity arises when working in urban areas where there are areas of dense service connections and busy roads requiring traffic management
Asset intervention life	45 Years[9]
Risk Reduction assumed in modelling	Following a replacement, the asset life is reset to zero, and therefore the risk is reduced to reflect a new asset

Table 12: Replacement via open cut

[9] The NARM intervention life supports Long Term Risk Benefit calculations. Should the intervention be implemented, this is the predicted time to elapse until another intervention of any kind is needed on the same asset (It is important to differentiate this from the accounting asset life which is used for asset depreciation analysis). See NARM commentary for further detail

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8.2.4 Intervention Mode 3: Replace the main via insertion

	Commentary
Option Title	Replace mains via insertion
Technical Details and Scope of option	Replacing a gas main via insertion typically involves pushing a modern plastic pipe that is more durable inside the old metal pipe. Gas services need to be temporarily shut off during the work. We try to minimise disruption while enabling improved safety and reliability of the gas network
Unit Costs of the option	See EJP09-DD-SE-CBA Mains Replacement-Annex G
Basis of unit cost	See EJP09-DD-SE-CBA Mains Replacement-Annex G
What are the benefits of this option	The primary benefit to replacing Tier 1 iron mains via opencut is the replacement of an ageing, poorly performing main. This technique is generally cheaper than open-cut replacement however high insertion rates will impact the capacity of the network and may require reinforcement to ensure capacity is maintained
Delivery timescales	Delivery timescales vary from weeks to months depending on the length of the cohort of work to be delivered and the location. Complexity arises when working in urban areas where there are areas of dense service connections and busy roads requiring traffic management
Asset intervention life	45 Years[8]
Risk Reduction assumed in modelling	Following a replacement the asset life is reset to zero, and therefore the risk is reduced to reflect a new asset

Table 13: Replacement via insertion

8.3 Timing choices

In developing the options for the RIIO-3 period we have considered and contrasted the following options:

- Doing nothing
- Acting in a reactive way, when circumstances dictate the need for an intervention
- Proactively planning a programme of work

8.4 Programme Options

We have developed a range of programme options using our Asset Investment Model.

Our baseline scenario assumes that all proactive work stops at the end of RIIO-2, and we then reactively repair all pipework thereafter (across all Tiers), with only our mandatory Tier 1 and Tier 2A proactive programmes continuing throughout RIIO-3.

We have then developed a range of different options, focussing on maximising the net present value of each programme option, based on different annual delivery constraints.

8.4.1 How the model optimises each programme option.

We have used our Asset Investment Model to optimise which pipes are replaced/repaired to meet the objectives and constraints set.

Prior to any optimisation, millions of potential "pipeline work-packages" are created, these work packages can be individual pipe lengths or connected sections of pipework developed into more sizeable piece of mains-replacement work (using the super-strings functionality discussed in Annex C in the supplementary evidence). The model calculates the costs and benefits for each potential pipeline work-package and assesses the optimum blend of these work-packages to meet the objectives and constraints set.

Specific potential work-packages are identified for CISBOT robotic repairs, based on the straightness and the size of pipe (CISBOT is not appropriate for all pipe sizes and pipeline configurations). CISBOT is designed to address joint leakage, not the structural integrity of the pipe, with this technique only used for assets that demonstrate this failure mode and no pipe barrel integrity faults. For all other pipe replacement, the model assumes that the work will comprise a blend of open cut and insertion when developing the costs.

The model assesses millions of combinations of different pipe replacement "work-packages" to develop an optimum programme to achieve the objectives and constraints set.

8.4.2 Programme options considered.

The following programme options have been developed and run through our modelling approach.

IMRRP is a mandatory programme of work and therefore represents our baseline scenario from which to compare our CBA benefits. We have selected five options to test; Baseline IMRRP delivery, and four options with varying volumes of cost beneficial mains replacement from which have analysed the benefits to inform our decision.

Options		Description
B	**Reactive repair following a failure**	This is the baseline used in our CBA tables and assumes that no proactive mains-replacement is delivered. Any mains failures (gas-escapes) drives a repair-only, opex intervention, which does not extend the life of the asset. This is the mandatory baseline option for the CBA tables.
1	**640km in RIIO3**	Delivers circa 640km of Cost-Beneficial Proactive Mains Replacement in RIIO-3. There are workload constraints in year 1 and 2 of the plan to ensure deliverability. This option allows up to 50km of CISBOT intervention. This option allows the model to select the workload based on the most cost-benefit mains
2	**RIIO2 approach: 230km in RIIO3**	This option mirrors our RIIO-2 chosen option of 10km of cost-beneficial mains per year in each network. This is used as a continuation of the current RIIO-2 mains replacement strategy. This option does not include CISBOT robotic mains rehabilitation as an intervention strategy.

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Options		Description
3	390km in RIIO3	Delivers circa 390km of Cost-Beneficial Proactive Mains Replacement in RIIO-3. This broadly aligns to 15km of mains replacement per year in Cadent's five regions, however workload in EA, EM and NL is < 15km in year 1 to ensure deliverability. This option allows up to 50km of CISBOT intervention.
4	480km in RIIO3	Delivers circa 480km of Cost-Beneficial Proactive Mains Replacement in RIIO-3. This broadly aligns to 20km of mains replacement per year in Cadent's five regions , however all networks have workload constraints < 20km in year 1, and EA and NL have continued workload constraints in year 2, to ensure deliverability. This option allows up to 50km of CISBOT intervention.
5	Unconstrained volumes	Delivers all mains which are cost beneficial with a payback (non-Spackman) by 2050. The model has no workload constraints for CISBOT robotic interventions. This option has been developed with our emissions reduction ambitions in mind, to measure what reductions could be achieved if the resource and funding was available to do so.

Table 14: Programme scenarios considered.

The options have been assessed using our modelling capability; details on the approach are in EJP09-DD-SE-CBA Mains Replacement-Annex C.

Outputs from our modelling approach have been validated through engagement with our network engineering and delivery functions. We have also tested each option for deliverability, considering the volume of work, asset characteristics and current, and forecasted, supply chain. Note all options have had some level of workload constraint in year 1 and 2 of RIIO-3 to ensure deliverability.

By the end of RIIO-2, our Tier 1 and 2 delivery-partners are delivering between 23 and 25 km/yr. Our Tier 3 delivery-output is an average of 2 km/yr. Our current delivery partners have additional capacity and can deliver +30% on these average workload volumes in RIIO-3 year 1. These considerations have been used to inform workload constraints within each programme option.

Tables notes: the next section presents detailed performance, cost and workload data for each option. Please note the following points:

- **Nrs of reactive repairs**: numbers of gas escapes (leaks). Cadent has an obligation to repair a leak once identified if it is above environmental or safety action threshold.
- **Opex**: the cost of reactively repairing the pipe following a gas-escape. There are additional costs considered in the CBA of costs of the lost gas (lost income from being able to sell the gas), which are not included in the table.
- **Any performance changes noted** are based on the level of change in each performance measure during RIIO-3 and are relative to the starting RIIO3 position.
- **NPV:** This is the net present value calculated within the CBA data tables, reported at company-level.

8.4.3 Baseline option: Reactive only response to mains failures

This option is our baseline option for use in the CBA data tables and assumes a reactive response to mains failure and does not consider any interactions between our mandatory mains replacement programmes (IMRRP and Tier 2A) and any wider mains-replacement workload.

The following tables sets out the performance levels and failure-rates of this baseline option.

	Nrs of reactive repairs (nr of gas-escapes)	Opex £m
EE	13551	74.92
NL	12299	66.23
NW	13368	52.75
WM	13237	50.79
Total	**52454**	**244.69**

Table 15: Baseline: Workload and Opex costs

	Start of RIIO-3	End of RIIO-3	Performance change in RIIO-3	Commentary
Carbon Loss (tCO_2e)	389934	417091	+7%	Increasing gas emissions
Gas Escapes (nr)	9494	11200	+18%	Increasing gas escapes / reducing safety
Gas in Buildings (nr)	1201	1480	+23%	Increasing GIBS / reducing safety
Supply interruptions (customer nrs)	6642	7830	+18%	Increasing number of supply interruptions.

Table 16: Baseline: Performance levels

	2027	2031	2037	2045	2050
NPV (£m)	-296.52	-1463.90	-3163.87	-5358.21	-6702.69

Table 17: Baseline NPV (CBA tables)

This option doesn't proactively replace any mains and shows reducing performance during RIIO-3 across all asset risk measures.

8.4.4 Programme Option 1: 640km of mains replacement in RIIO-3

This option allows the model to select up to 640km of mains replacement at a Cadent level.

To ensure deliverability the model has been given several constraints:

- The workload in this option is an increase to our RIIO-2 programme; to allow for a smooth transition into these higher volumes the workload has been profiled to build over years 1 and 2 and remain level over years 3, 4 and 5.
- The CISBOT intervention volume is limited to a maximum of 50km over the RIIO-3 period due to supply chain constraints highlighted to us through our supply chain engagement processes.
- There is no annual network-level minimum-workload constraint, the model can choose the most cost beneficial pipes.

To derive these year 1 to 3 workload constraints, early non-shortlisted programme options were analysed, looking at volumes of Tier 2 and 3 pipework by network. Tier 2 and 3 mains replacement require a higher supply chain competency and further training needs, so requires effective management to ensure there is adequate delivery capacity. An in-depth review was carried out of existing supply chain capacity, to optimise Tier 1 to 3 workload throughout RIIO-3. Refer to EJP09-DD-SE-CBA Mains Replacement-Annex D for a more in depth discussion on the factors considered within the deliverability review.

The benefit of this option is that it allows the model to maximise the amount of benefit that can be achieved across the whole Cadent asset base without needing to satisfy any minimum workload constraint set, by network.

The model identifies individual pipes and pipe-strings that are cost-beneficial (not using the Spackman approach) before 2040, in other words the sum of the benefits outweighs the costs within 8 - 13 years.

	Km of mains replaced	Km of Mains refurbished (CISBOT)	Service interventions (nr)	Nr of reactive repairs	Repex £m	Opex £m
EE	226.88	15.52	10,532	12107	101.88	70.90
NL	72.57	23.42	9,379	10640	66.30	62.61
NW	156.57	2.90	7,223	11469	68.37	50.87
WM	142.34	7.28	8,264	12233	68.62	48.75
Total	598.35	49.12	35,398	46449	305.17	233.12

Table 18: Option 1: Workload and costs.

	Start of RIIO-3	End of RIIO-3	Performance change in RIIO-3[10]	Commentary
Carbon Loss (tCO2e)	389934	317798	-18%	Good levels of reduction
Gas Escapes (nr) / reactive repairs	9494	9135	-4%	improving safety, due to slight reduction in overall number of gas escapes.

[10] % change based on % increase relative to starting levels of emissions at the beginning of RIIO-3.

	Start of RIIO-3	End of RIIO-3	Performance change in RIIO-3[10]	Commentary
Gas in Buildings (nr)	1201	1141	**-5%**	improving safety, due to slight reduction in overall number of GIBs
Supply interruptions (customer nrs)	6642	6035	**-9%**	Reduction in nrs of supply interruptions

Table 19: Option 1: RIIO-2 to 3 Performance levels

This option reduces the overall number of gas escapes, GIBs and levels of supply interruptions (customers impacted).

	2027	2031	2037	2045	2050
NPV (£m)	8.14	44.06	100.45	278.28	425.42

Table 20: NPV relative to baseline: Option 1.

This option shows £100m of benefit relative to the baseline option in 2037 (11year payback period)

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8.4.5 Programme Option 2: RIIO2 Approach, 230km in RIIO-3

In this option we have modelled up to 10km of CBA mains replacement per network per year (20km allowed in the Eastern region given its size) which is a continuation of our RIIO-2 approach. This allows us to test the delta with the unconstrained model and understand how much benefit would be reduced for a smaller volume delivered. This option does not include CISBOT remediation to drive consistency in approach to our RIIO-2 strategy.

	Km of mains replaced	Km of Mains refurbished (CISBOT)	Service interventions (nr)	Nrs of reactive repairs	Repex £m	Opex £m
EE	96.73	-	4,579	12532	42.72	72.83
NL	47.23	-	4,938	11010	33.27	64.32
NW	46.01	-	2,610	11915	22.21	52.14
WM	40.64	-	2,011	12664	20.73	50.17
Total	**230.61**	**-**	**14,138**	**48122**	**118.94**	**239.45**

Table 21: Option 2: Workload and Cost

	Start of RIIO-3	End of RIIO-3	Performance change in RIIO-3	Commentary
Carbon Loss (tCO2e)	389934	352215	-10%	Reasonable improvement in volumes of gas lost.
Gas Escapes (nr) / reactive repairs	9494	9812	+3%	Reducing performance, gas escapes increasing
Gas in Buildings (nr)	1201	1245	+4%	Reducing performance, GIBs increasing.
Supply interruptions (customer nrs)	6642	6544	-1%	Broadly stable performance on supply interruption numbers.

Table 22: Option 2: RIIO-2 to 3 Performance levels

This option has decreasing performance on gas escapes and GIBS, with a corresponding reduction in safety benefits delivered. Supply interruption numbers are broadly stable.

	2027	2031	2037	2045	2050
NPV (£m)	6.11	34.99	95.44	215.63	304.71

Table 23: NPV relative to baseline: Option 2.

This option has a good NPV relative to the baseline in 2037 but allows gas escapes and GIBS to increase in number with a resulting reduction in safety.

8.4.6 Programme Option 3: 390km in RIIO-3

This scenario delivers circa 390km of Cost-Beneficial Proactive Mains Replacement in RIIO-3. This broadly aligns to 15km of mains replacement per year in Cadent's five regions, however workload in EA, EM and NL is < 15km in year 1 to ensure deliverability. This option allows up to 50km of CISBOT intervention.

	Km of mains replaced	Km of Mains refurbished (CISBOT)	Service interventions (nr)	Nrs of reactive repairs	Repex £m	Opex £m
EE	142.08	15.55	6,727	12341	72.80	71.89
NL	65.59	23.23	8,163	10704	61.51	62.69
NW	71.21	2.87	3,558	11771	38.19	51.66
WM	65.53	7.29	3,122	12512	37.13	49.52
Total	**344.41**	**48.94**	**21,570**	**47328**	**209.63**	**235.76**

Table 24: Option 3: RIIO3 Workload and Costs

	Start or RIIO-3	End of RIIO-3	Performance change in RIIO-3	Commentary
Carbon Loss (tCO2e)	389934	339691	**-13%**	Improvement in volumes of gas lost.
Gas Escapes (nr) / reactive repairs	9494	9482	**0%**	stable performance, gas escapes stable
Gas in Buildings (nr)	1201	1186	**-1%**	broadly stable performance, GIBs stable
Supply interruptions (customer nrs)	6642	6290	**-5%**	Improving performance, supply interruptions numbers decreasing.

Table 25: Option 3: RIIO-2 to 3 Performance levels

This option has a broadly stable performance on gas escapes and GIBS and therefore delivers a stable safety performance.

	2027	2031	2037	2045	2050
NPV (£m)	7.99	37.02	92.39	238.15	354.98

Table 26: NPV relative to baseline: Option 3.

This option has a good NPV relative to the baseline in 2037 and holds gas escapes and GIBS at stable levels.

8.4.7 Programme Option 4: 480km in RIIO-3

Delivers circa 480km of Cost-Beneficial Proactive Mains Replacement in RIIO-3. This broadly aligns to 20km of mains replacement per year in Cadent's five regions , however all networks have workload constraints < 20km in year 1, and EA and NL have continued workload constraints in year 2, to ensure deliverability. This option allows up to 50km of CISBOT intervention.

Region	Km of mains replaced	Km of Mains refurbished (CISBOT)	Service interventions (nr)	Nrs of reactive repairs	Repex £m	Opex £m
EE	179.73	15.55	8,126	12235	87.16	71.37
NL	72.38	23.12	9,061	10654	65.69	62.60
NW	93.22	2.90	4,636	11650	48.90	51.35
WM	87.54	7.27	4,239	12422	48.06	49.18
Total	**432.87**	**48.84**	**26,062**	**46961**	**249.81**	**234.51**

Table 27: Option 4: RIIO3 Workload and Costs

	Start of RIIO-3	End of RIIO-3	Performance change in RIIO-3	Commentary
Carbon Loss (tCO2e)	389934	328961	-16%	Improvement in volumes of gas lost.
Gas Escapes (nr) / reactive repairs	9494	9340	-2%	Improving performance, gas escapes slightly reducing

	Start of RIIO-3	End of RIIO-3	Performance change in RIIO-3	Commentary
Gas in Buildings (nr)	1201	1165	-3%	Improving performance, GIBs decreasing.
Supply interruptions (customer nrs)	6642	6183	-7%	Improving performance

Table 28: Option 4: RIIO-2 to 3 Performance levels

This option slightly improves performance on gas escapes and GIBS and improves performance on numbers of customers suffering supply interruptions.

	2027	2031	2037	2045	2050
NPV (£m)	8.51	41.79	99.92	261.71	392.66

Table 29: NPV relative to baseline: Option 4.

This option has a good NPV relative to the baseline in 2037, and slightly improves performance for gas escapes and GIBS, and therefore delivers good safety benefits.

8.4.8 Programme Option 5: Unconstrained workload, including CISBOT.

This scenario identifies all mains that are cost-beneficial by 2050. There are no constraints on the volume of work via CISBOT, open-cut and insertion, and no defined expenditure limits. This option was included for illustrative purposes, but has been discounted on deliverability grounds, due to the significant step-change in workload from RIIO-2 to RIIO-3. This option was not short-listed for further consideration.

Region	Km of mains replaced	Km of Mains refurbished (CISBOT)	Service interventions (nr)	Nr of reactive failures	Repex £m
EE	310.54	155.04	13,897	12,595	195.15
NL	275.24	218.29	24,642	8,642	284.80
NW	308.66	132.24	17,481	10,643	183.08
WM	303.39	204.54	24,179	8,450	211.11
Total	**1,197.82**	**710.11**	**80,198**	**40,330**	**874.15**

Table 30: Option 5: Workload and Costs

8.5 Technical Summary Table: Programme Options

	Option 1	Option 2	Option 3	Option 4	Option 5[11]
Description	640km in RIIO-3	RIIO2 Approach: 230km in RIIO3	390km in RIIO3	480km in RIIO3	Unconstrained volumes
First year of spend	2026	2026	2026	2026	2026
Last year of spend	2031	2031	2031	2031	2031
Volume of reactive repairs	53454	46449	48122	47328	40,330
Volume of work (km mains replacement)	598.35	230.61	344.41	432.87	1197.82
Volume of work (km mains repaired via CISBOT)	49.12	-	48.94	48.84	710.11
Volume of work (no. services)	35,398	15,408	21,570	26,062	80,198
Total Repex Mains Replacement (£m)	277.59	118.94	182.12	222.29	569.7
Total Repex CISBOT (£m)	27.58	-	27.52	27.52	304.44
Total Opex (£m)	233.12	239.45	235.76	234.51	213.17
Total RIIO-3 Spend (£m)	538.29	358.39	445.39	484.32	1087.31
Decision	Short-listed for CBA	Short-listed for CBA	Short-listed for CBA	Short-listed for CBA	Not shortlisted.

Table 31: Summary of Programme Options

[11] Note that Option 5, unconstrained workload volumes, was not shortlisted for detailed CBA and performance reviews. Option 5 was discounted because the workload was considered undeliverable

9 Business Case Outline and Discussion

9.1 Key Business Case Drivers Description

As set out above, we have an absolute duty to keep customers safe. There is evidence that assets outside the scope of the IMRRP now pose a level of risk which is comparable or greater than those in scope of the IMRRP. Customers want a safe and reliable network. Customers do not distinguish between an iron and a steel, tier 1 or a tier 2 or 3 main when it comes to keeping them safe.

Our aim in developing the RIIO-3 plan is to deliver maximum value to consumers.

Selecting mains on a CBA basis allows us to renew pipes that have significant operating, or societal costs associated with them. Mains that have repeated leaks can have either low or no MRPS risk scores (for example if they are more than 30m from a property) and therefore may not be selected as a safety pipe.

Our cost benefit approach for mains, aligns with the NARMs methodology, but utilises observed leakage levels recorded from our extensive leakage surveys.

This cost benefit approach considers the following performance levels and the associated monetised risk[12]:

- **Gas in buildings** (and resulting fatalities and minor injuries because of explosions)
- **Reactive failures** – driving expensive and disruptive reactive repairs with associated financial impacts
- **Supply interruptions / numbers of customers interrupted**, because of reactive failures – we have used willingness to pay figures based on customer research to establish monetised benefit to avoid these interruptions.
- **The environmental benefits of reducing gas-losses,** through reducing leaks and shrinkage**.**

Our modelling has looked to select the most cost beneficial mains to replace, based on a range of workload constraints (either annual workload constraints or total cadent-level workload constraints).

We have then considered the following factors to inform our preferred option:

- **Overall cost benefit** and NPV of each scenario
- **Asset health performance**, with our ambition to hold asset health broadly stable and ensure that gas-in-buildings, supply interruptions and numbers of reactive failures are staying at broadly stable levels. This is supported by the findings from our Multiple Angle Customer research completed in 2024, which showed that safety and resilience were non-negotiable and that customers place a high premium on the safety and resilience of the network. There is trust in us to operate a resilient network so customers felt that the chances of a large-scale loss of supply would already be low.
- **Reduction in gas losses,** and how this supports and contributes to our overall environmental ambitions associated with scope 1 and 2 emissions.
- **Deliverability,** we must ensure that the workload is deliverable. Tier 2 and Tier 3 mains replacements require additional competencies; therefore, we must ensure that our supply chain can sustainably deliver increased workload.
- **Impact on stubs volumes and costs;** Our Repex programme is designed holistically for maximum efficiency, eliminating unnecessary stub work when both tier 1 and related tier 2 or 3 mains are replaced together. Therefore, any reduction of our ALIP intervention will increase our stub intervention volume from our forecasts; for the mains CBA programme option of 231km aligned to RIIO-2 volumes, this would equate to 2.65% more live stubs.
- **Bill impact of each scenario**, and our **customer's willingness to pay** for more aggressive carbon reductions to support net-zero ambitions, and our customer's desire to not waste valuable gas resources. This aspect has been supported by more targeted customer research, which has shown that 89% agree it is important to prevent gas leaks, especially now, so more of the gas produced can be used in homes and businesses; 81% agree the gas industry needs to learn from the water industry and make changes today; 65% agree that £1 per HH per year is value for money.
  Our Multiple Angle Research (2024) demonstrated that environmental factors are important to customers, with them being supportive of plans to reduce emissions, work towards net-zero and introduce biomethane. There is some scepticism that the government and companies do not take decisive action, so we have an opportunity to demonstrate and show leadership in this space.

[12] Refer to EJP09-DD-SE-CBA Mains Replacement-Annex E more details.

Additional considerations outside of the model include:

- **Regulatory compliance:** We have legal obligations to comply with the Pipeline Safety Regulations (PSR) 1996 and Gas Safety (management) Regulations (GSMR) 1996.
- **Customer Satisfaction**: Continued failure of the same main will cause high levels of customer disturbance, and in turn dissatisfaction.
- **Transport disruption**: Recurring mains-failures cause higher levels of traffic disruption with the associated social impacts, due to the necessary reactive repairs.
- **Current government policy**, which demonstrates a commitment to deliver significant methane reductions in support of 2050 net zero emissions. Cadent has chosen to strongly align with these commitments as part of its plan, and addressing leakage through proactive mains replacement will significantly support these ambitions.[13]

Refer to the Investment Methodology contained within the Network Asset Management Strategy for more information on how we have developed and valued the monetised risk.

9.2 Business Case Summary

This section sets out the CBA of investment to replace mains not covered by the IMRRP. Replacement of these assets has a safety, financial and societal benefit.

The tables show the present value of costs for each network for the investment. 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-3.

As discussed, the mandated IMRRP workload has been modelled alongside the delivery of our other mains replacement work to optimise our plan and benefit from unit cost efficiencies of delivering work as part of larger schemes. Therefore, the unit cost estimates for CBA work are contingent on the delivery of IMRRP.

[13] Environment Agency Methane Action Plan 2024 to 2026

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9.2.1 Summary of results

The following table presents net present cost and net present value of our programme options relative to the baseline option (in 2037), alongside the RIIO-3 workload and costs.

Scenario No.	Description of Scenario	Data for 2037 (Relative to Baseline option) £m		RIIO-3 Data (Workload and Cost)				
		Net Present Cost	Net Present Value	Mains replacement (km)	Services (nr)	Repex £m	Reactive repairs (nrs)	RIIO-3 Opex £m
Option 1	640km in RIIO-3	425.24	100.45	647	35,398	305.17	46449	233.12
Option 2	RIIO2 approach: 230 km in RIIO-3	398.77	95.44	231	15,408	118.94	48122	239.45
Option 3	390km in RIIO-3	414.15	92.39	393	21,570	209.64	47328	235.76
Option 4	480km in RIIO-3	419.50	99.92	481	26,062	249.81	46961	234.51

Table 32: CBA and workload / costs for programme options.

Guidance notes on above tables:

- The above table is based on the data in the Summary tab from the CBA Data Tables
- NPVs (Relative to baseline, £m): This shows the Net Present Value of the option relative to the baseline considering all costs and monetised benefits discounted at the appropriate rates. The NPV is annualised over a period of 50 years using the Ofgem template 2027 to 2050.
- Net Present Costs: Is the sum of the Opex, Repex and pass-through costs (financial loss of gas) for each option.

This graph (Figure 5) shows that the greater the length of replacement delivered, increases the NPV over time, at both 2037 and 2050. All options have a positive NPV relative to the baseline. Option 1 (640km) delivers £5m additional benefit in 2037 relative to continuing our RIIO-2 approach, and £121m additional benefit in 2050.

All options have a very similar NPV from 2027 to 2037, but the options that replace a longer mains-length deliver a greater benefit over the longer term. (Between £50m and £100m more by 2050)

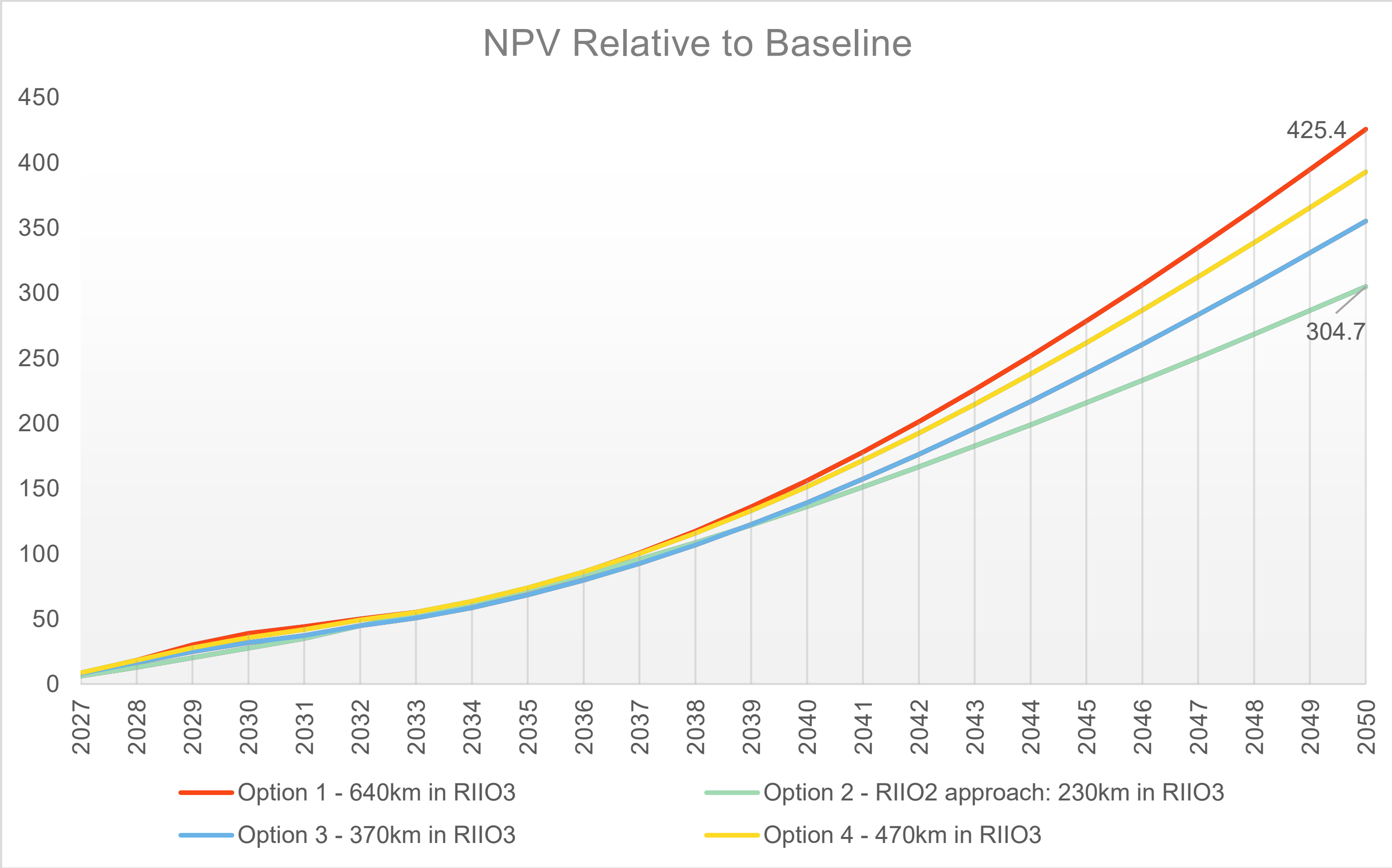

Figure 5: NPV relative to baseline option

When we compare the performance levels of each programme option, by considering levels of escapes (reactive repairs), gas-in building numbers (GIBs) and supply interruptions, we can see that all options except option 2, have stable or improving asset-health and safety performance. Note, all options are deliverable (see discussions in Section 8 and Annex D of the supplementary evidence), so deliverability has not formed part of the final decision-making process.

Option name	NPV (£m) - 2037	NPV (£m) - 2050	Mains replacement (km)	RIIO-3 Repex (£m)	Nrs of Gas in Buildings	Gas Escapes / nrs of reactive repairs	Supply interruptions: Nrs of customers impacted	Reduction in gas [14]	CO_2 saved (kTCO2e)[15]	Bill impact (end RIIO-3) £/household	Executive summary
Option 1: 640km in RIIO-3	100.45	425.42	648	305.17	4%	5%	9%	18%	342[16] (10.0 %)[16]	£1.96	The highest NPV, with slight reductions in safety / asset performance.
Option 2: 230km in RIIO-3	95.44	304.71	231	118.94	-3%	-4%	1%	10%	234 (6.8%)	£0.94	The lowest NPV of all options (except in years 2037 where it slightly outperforms option 3 for a single year), with moderately high reductions in safety / asset performance.
Option 3: 390km in RIIO-3	92.39	354.98	393	209.63	0%	1%	5%	13%	316 (8.3%)	£1.45	The third best NPV (except in 2037, where option 2 slightly outperforms for a single year), with moderate reductions in safety / asset performance.
Option 4: 480km in RIIO-3	99.92	392.66	481	249.81	2%	3%	7%	16%	283 (9.2%)	£1.84	The second best NPV, with moderate to low reductions in safety / asset performance.

Table 33: Business case summary: Option comparison

[14] % reduction based on starting RIIO-3 position, and calculated the % reduction from the RIIO-3 starting and ending position.
[15] [15] Total kTCO2e saved for each scenario
[16] % contribution to scope 1 and 2 emission targets.

The following table provides a detailed discussion on the pros and cons of each programme option.

Option	Engineering justification	Stakeholder support summary	GDN / Company View
Option 1: 640km in RIIO-3	Levels of gas escapes and GIBs are improving during RIIO-3 by 4 – 5% . This option provides the best safety benefits of all options considered. Relative to baseline, this option mitigates an additional 339 GIBs and 2065 gas escapes by the end of RIIO-3. By the end of RIIO-3, this option will result in 359 fewer gas escapes/yr and 60 fewer GIBs/yr than the start of RIIO-3. Supply interruption levels improve by 9% and is therefore improving system resilience.	Customers have confirmed that their priority is a safe and resilient network. This option delivers an improvement in safety benefits. Customers are aware this will cost more and are willing to pay more for the environmental benefits and reducing gas wastage.	**This is our preferred option,** it delivers an ambitious but deliverable volume of mains replacement and is therefore the most expensive of all options considered. This option does deliver the best NPV and supports our net zero obligations of reducing our methane emissions by 10%. This aligns to both the government's policy and our ALIP strategy discussed in the Environmental Action Plan. Customers have stated they are supportive of targeting leakage and saving gas.
Option 2: 230km in RIIO-3	Levels of gas escapes and GIBs are deteriorating during RIIO-3 by 3 – 4%. This option provides the lowest safety benefits of all options considered. By the end of RIIO-3, this option will result in 318 more gas escapes/yr and 44 more GIBs/yr than the start of RIIO-3. Supply interruption levels are improving by 1.5%, which will result in 97 fewer customers suffering supply interruptions / yr.	Customers do not want a reduction in safety or resilience measures. Customers also support paying more for the environmental benefits and reducing gas wastage. This option does not align with what our customers want.	This delivers a consistent amount of mains replacement to RIIO-2 and is the most affordable of all options considered. This option has the lowest NPV relative to all options (except in 2037 only) and contributes the lowest carbon saving to Cadent's scope 1 and 2 emissions targets (6.8%). Customers have stated they are supportive of targeting leakage and saving gas. This is not our preferred option.
Option 3: 390km in RIIO-3	Levels of gas escapes and GIBs are broadly stable / slightly improving during RIIO-3 by c. 1%. Relative to baseline, this option mitigates an additional 293 GIBs and 1718 gas escapes by the end of RIIO-3. By the end of RIIO-3, this option will result in 12 fewer gas escapes/yr and 15 fewer GIBs/yr than the start of RIIO-3. Supply interruption levels are reducing by 5.3%, which results in 351 fewer customers suffering supply interruptions / yr.	Customers do not want a reduction in safety or resilience measures; this option has an improved performance relative to option 2. Customers also support paying more for the environmental benefits and reducing gas wastage.	This delivers 160km of additional mains replacement compared to RIIO-2 and is the second most affordable of all options considered. This option has the second lowest NPV relative to all options (except in 2037 only) and contributes the second lowest carbon saving to Cadent's scope 1 and 2 emissions targets (8.3%). Customers have stated they are supportive of targeting leakage and saving gas. Whilst this is a viable and beneficial option, this is not our preferred option due to the increased benefits presented in Option 1.

Option	Engineering justification	Stakeholder support summary	GDN / Company View
Option 4: 480km in RIIO-3	Levels of gas escapes and GIBs are improving during RIIO-3 by 2 - 3%. This option provides the second best safety benefits of all options. Relative to baseline, this option mitigates an additional 314 GIBs and 1860 gas escapes by the end of RIIO-3. By the end of RIIO-3, this option will result in 154 fewer gas escapes/yr and 36 fewer GIBs/yr than the start of RIIO-3. Supply interruption levels are reducing by 6.9%, which will result in 459 fewer customers suffering supply interruptions/ yr.	Customers do not want a reduction in safety or resilience measures; this option has an improved performance relative to option 3. Customers also support paying more for the environmental benefits and reducing gas wastage.	This option delivers 250km (nearly double) of additional mains replacement compared to RIIO2 and is the 2nd most expensive option. This option has the 2nd best NPV of all options and contributes to Cadent's overall scope 1 and 2 carbon emissions by 9.2%. Whilst this is a viable and beneficial option, this is not our preferred option due to the increased benefits presented in Option 1.

Table 34: Option discussion

All the options except Option 2, deliver stable or improving safety and supply interruption performance. As noted in Section 6 of this document (Figure 2: Non IMRRP leaks per km), our leaks per km are showing an increasing trend during RIIO-2, and this would reduce by a further 4 - 5% during RIIO-3, if we continued with our RIIO-2 approach. Our customers have told us that safety and network resilience is their primary concern.

We have assessed the average bill impact between the most expensive and most affordable options (option 1 and 2) and have shown that this is an average of £0.35p / household across RIIO-3. This has been supported by more targeted customer research, which has shown that 89% agree it is important to prevent gas leaks, especially now, so more of the gas produced can be used in homes and businesses; 81% agree the gas industry needs to learn from the water industry and make changes today on targeting leakage; 65% agree that £1 per HH per year is value for money.

Our proposed programme addresses asset health deterioration whilst balancing deliverability and the impact on the bill. The alternative options presented also deliver clear benefits to the areas that are important to our customers.

We have undertaken a range of sensitivity tests (based on the key risks identified for this investment) to understand how the above options are impacted by changing key parameters and assumptions. The following table summarises the results and conclusions:

Sensitivity Test	Results / Discussion	Conclusions
Test 1: Cost uncertainty: costs + 10%	Increasing the unit costs of proactive mains replacement workload, reduces the NPV of all options. The CBA of all options from 2027 through to 2040 are very similar, in 2031 they are £32m +/- £3m. In 2037, option 2 slightly outperforms the other options, but by 2040 option 1 outperforms all options again. From 2040 onwards Option 1 (640km is the best NPV relative to baseline). In the early years Option 2 has a slightly better NPV relative to baseline than the other options	Considerable deliverability and commercial reviews have taken place to ensure that we have the supply chain in place and can source the materials needed to deliver all programme options without driving significant price increases. If a 10% cost increase does occur, which Cadent believes is highly unlikely, Option 1 in the very short term has the higher NPV, but by 2040 option 2 delivers more value, and by 2050, will still have delivered £100m greater monetised benefit than option 1.
Test 3: No Cisbot	Cisbot is a cost-effective pipeline rehabilitation option. It has a lower intervention cost per metre but has a shorter asset life of 15yrs (vs 45yrs for mains-replacement). Including Cisbot, as a part of a blended proactive mains replacement strategy increases the NPV of the option slightly in 2037, relative to a mains-replacement-only option.	Cadent's chosen intervention programme delivers additional benefits through inclusion of Cisbot, relative to a mains replacement strategy that only considers open-cut or insertion intervention modes.
Test 5: Shadow cost of carbon	The relative ranking of the options is materially impacted by the shadow cost of carbon. In 2037, the low-carbon estimate results in Option 2 (RIIO2: 230km) having the best NPV relative to baseline, and the 640km having the lowest NPV relative to baseline. Option 1 (640km) outperforms the other options in 2046, with all options having a good NPV relative to baseline.	This demonstrates that the NPV and the monetised benefit from saving gas significantly drives the NPV of all options. All options have a positive NPV by 2040, even using the lower carbon estimate. However, the lower carbon cost does not align to current government valuations.
Test 6: FES Holistic Transition; reducing future demand	A reducing gas demand aligned to the FES holistic pathway, does reduce the future NPV relative to baseline of all options. The relative ranking of each option does not change, but the 2037 NPVs relative to baseline range between £67m and £62m, the 2050 benefits are c. 60% less than the core-CBA calculations.	This test does not change the relative ranking of each option but does materially reduce the long-term monetised benefits of each option.
Test 8: Include traffic disruption social costs	This option calculates a conservative social cost of traffic disruption caused by the gas-escapes and resulting reactive repairs. The more proactive mains replacement completed, the	The social cost of traffic disruption improves the NPV of the options which remove the largest number of reactive repairs by

Sensitivity Test	Results / Discussion	Conclusions
	lower the resulting reactive repairs are, and the higher the monetised benefit from avoiding traffic disruption. This shows that the social cost of avoiding traffic disruption materially improves the NPV relative to baseline. The NPV in 2037 for Option 1 increases from £100.4m to £219m, and Option 2 (RIIO2 approach) increases from £95m to £150m.	the greatest amount. Option 1 has a materially higher NPV relative to baseline in 2037 to all other options.

Table 35: Discussion on sensitivity testing results

The sensitivity tests show that Option 1 is the best option (NPV) when testing for the impacts of traffic disruption and FES Holistic transition. A 10% increase on unit costs and the lower-carbon costs are the only two sensitivity tests that impact on the relative ranking of option 1 in the short term. By mid 2040s option 1 under these tests has an NPV comparable to Option 2 (RIIO-2 approach). We do not consider a 10% cost increase likely (based on the risk mitigations already in place for RIIO-3).

Other sensitivity tests were considered but were deemed immaterial for the following reasons:

- **Test 2: Delivery constraints**: All options have had a comprehensive deliverability review to mitigate the risk of any future delivery constraints.
- **Test 4: Asset life deterioration rates**: This test is like Test 6, in that we apply an increasing deterioration rate in future years to model increasing deterioration.
- **Test 7: Willingness to pay assumptions**: We have included the willingness to pay for customers to avoid supply interruptions. Supply interruptions contribute < 1% to the overall benefit for this programme so is immaterial

Our preferred option is Option 1 (640km of mains replacement in RIIO-3), because this delivers the best NPV relative to baseline and results in a slightly increasing levels of asset resilience and safety performance, and our customers are supportive of doing more to tackle leakage. We also note, that including the social benefits of avoiding traffic disruption from high levels of reactive repairs, improves the NPV of this option significantly.

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10 Preferred Option Scope and Project Plan

10.1 Preferred Option

The preferred programme option is option 1, which comprises the replacement of 647km of mains over the RIIO-3 period.

Volume of Mains Replaced (km)						
Region	2026/27	2027/28	2028/29	2029/30	2030/31	**Total**
EE	28.57	39.44	63.31	59.35	51.73	**242.40**
NL	14.54	16.15	22.77	21.77	20.79	**96.02**
NW	17.91	25.89	42.44	42.97	30.34	**159.55**
WM	16.86	24.08	39.02	39.21	30.46	**149.63**
Total	**77.87**	**105.55**	**167.54**	**163.31**	**133.32**	**647.60**

Table 36: Option 1 - Mains volume (inclusive of CISBOT)

For a detailed diameter band breakdown by network and year, please refer to EJP09-DD-SE-CBA Mains Replacement-Annex B.

Volume of Mains Refurbished CISBOT (km)						
Region	2026/27	2027/28	2028/29	2029/30	2030/31	**Total**
EE	3.83	3.17	2.86	2.82	2.84	**15.52**
NL	4.70	4.69	4.69	4.69	4.68	**23.45**
NW	0.60	0.60	0.60	0.60	0.59	**2.98**
WM	1.79	1.77	1.77	1.72	0.25	**7.29**
Total	**10.91**	**10.22**	**9.92**	**9.83**	**8.36**	**49.25**

Table 37: Option 1 - CISBOT only volume

Volume of Service Interventions (number)

Region	2026/27	2027/28	2028/29	2029/30	2030/31	Total
EE	493	1,467	2,887	2,569	1,884	**9,299**
NL	1,486	799	2,328	2,204	1,877	**8,694**
NW	467	1,223	1,829	1,455	611	**5,583**
WM	472	1,434	2,379	2,331	1,027	**7,642**
Total	**2,917**	**4,923**	**9,423**	**8,559**	**5,398**	**31,219**

Table 38: Option 1 - Services volume

10.2 Asset Health Spend Profile

£m						
Region	2026/27	2027/28	2028/29	2029/30	2030/31	**Total**
EE	15.41	17.97	26.06	23	19.44	**101.88**
NL	12.79	11.48	14.72	14.9	12.42	**66.3**
NW	9.94	13.67	18.57	16.48	9.71	**68.37**
WM	11.2	12.89	18.27	15.93	10.34	**68.62**
Total	**49.33**	**56.02**	**77.61**	**70.3**	**51.91**	**305.17**

Table 39: Option 1 - Repex cost

10.3 Investment Risk Discussion

There is minimal investment risks associated with this investment case. The replacement of the mains assets covered in this paper will be incorporated into our wider REPEX activity to deliver efficiencies at a holistic programme level. We have engaged our supply chain to determine capability, capacity and to calibrate our unit cost estimates to deliver the work with positive responses on all fronts.

Costs, largely driven by workload, follow a similar pattern to volume across the RIIO-1 and RIIO-2 periods. However, we see an upward trend in RIIO-3 costs compared to RIIO-1 and RIIO-2. The increase in costs reflects several factors including an increase in work complexity (see EJP09-DD-SE-CBA Mains Replacement-Annex G), which we have thoroughly assessed and understood throughout the RIIO-2 period. These insights have been incorporated into the RIIO-3 costings. Through analysis conducted, we have been able to evaluate the scope and challenges of works over the regulatory period, enabling us to factor these considerations into the RIIO-3 plan (see EJP09-DD-SS-CBA Mains Replacement-Annex E).

Our understanding of costs across networks and regions has significantly expanded during RIIO-2. By leveraging proprietary AI-driven cost modelling, estimating, and efficiency tools, we can track cost variations across regions and demonstrate the benefits of our procurement process, including both commercial and economic advantages, as well as cost certainty.

In collaboration with our supply chain partners, we have rigorously tested our cost assumptions to ensure visibility and accuracy. This helps strengthen our ability to confidently justify the foundations of our cost forecasting. Additionally, these assumptions are supported by external cost benchmarking, assurance processes, governance audits, and real-life target costing to validate the robustness of our methodology and ensure the integrity of the costings.

10.4 Project Plan

The workload in this option is an increase to our RIIO-2 programme; to allow for a smooth transition into these higher volumes the workload has been profiled to build over years 1 and 2 and remain level over years 3, 4 and 5.

10.5 Key Business Risks and Opportunities

Risk Reference	Risk	Impact	Likelihood	Mitigation	Sensitivity test?
R-01	**Faster / slower reduction in gas-demand than predicted**	More or less reinforcement required / differing levels of asset decommissioning possible	**Low**	Develop in-house capability to model future energy scenarios to provide greater certainty. Programme selected has a short payback period, reducing the risk of stranded investment	Yes: Test 6
R-02	**Greater / reduced levels of biomethane available to meet demand**	More or less reinforcement required within the network to accommodate new supply, or reduced decommissioning of assets possible	**High**	Prioritise reinforcement projects that fail to meet our 1:20 year peak demand licence obligation now and throughout RIIO-3	No
R-03	**Higher levels of attrition of competent workforce** (difficulty retaining competent skills sets) – high competition across other sectors, inconsistent workload	Costs increase due to higher demand / reduced competition, or there is a delay in the delivery of the plan	**High**	Where affordable and deliverable, look to manage variability in workload where-ever possible. Continuation of long-term resource planning and recruitment, as defined in Workforce Resilience Strategy appendix	Yes: Test 1 & 2

Risk Reference	Risk	Impact	Likelihood	Mitigation	Sensitivity test?
R-04	**High level of competition** in supply chain	Costs increase due to higher demand reduced competition, delay to workload, or lack of supply chain capability / framework agreements in place	**High**	Early supply chain engagement to secure resources, but competition across other utilities	Yes: Test 1 & 2
			Low	Advanced bulk-purchase of long lead or high demand / low availability materials including consideration of storage facilities	
R-08	**Unit Cost Certainty:** We have lower certainty around some unit rates due to reduced delivery experience	Costs could be higher or lower than predicted for specific investment cases	**Medium**	Market testing performed to on sample work programmes to gain cost certainty	Yes: Test 1

Table 40: Key Risks

In accordance with the sensitivity tests in Section 9 the supply demand scenario has no significant impact on the EJP.

Relative to Risk-03 and Risk-04, Cadent has undertaken a significant amount of work to ensure that there will be sufficient resources with the required competency and training from within Cadent and its supply chain. Refer to EJP-DD-SS-CBA Mains Replacement-Annex D for more details on the deliverability review undertaken.

10.6 Outputs included in RIIO-2 Plans

No outputs from RIIO-2 are being proposed for carry-over into RIIO-3. There are no named projects or risk of double funding between RIIO-2 and RIIO-3.

11 Regulatory Treatment

Please refer to each network NARM BPDT and the associated NARM commentary for further detail on the single year and Long-Term Risk Benefit outputs for each NARM funding category.

12 Glossary

Abbreviation/term	Meaning
HSE	Health & Safety Executive
IMRRP	Iron Mains Risk Reduction Programme
MRPS	Mains Replacement Prioritisation System
RRP	Regulatory Reporting Process
GiB	Gas in Building(s)
PSR	Pipeline Safety Regulations
GSMR	Gas Safety (management) Regulations
NPV	Net Present Value
CBA	Cost Benefit Analysis

Table 41: Glossary