national gas transmission

ENGINEERING JUSTIFICATION PAPER (EJP)

OFFICIAL- SENSITIVE

Network Decarbonisation

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Version: 1.0

Issue: Final

December 2024

RIIO-GT3 NGT_EJP21

Contents

1 Summary Table

Table 1: Summary table for Network Decarbonisation EJP

Name of Project	*Network Decarbonisation Investments*		
Scheme Reference	*NGT_EJP21_Network Decarbonisation_RIIO-GT3*		
Primary Investment Driver	*Net Zero*		
Project Initiation Year	*FY2028*		
Project Close Out Year	*FY2034*		
Total Installed Cost Estimate (£m, 202023/24)	**UM: 224.84**		
Cost Estimate Accuracy (%)	+/- 50%		
Project Spend to date (£)	*0*		
Current Project Stage Gate	*Stage 4.0*		
Reporting Table Ref	*11.6*		
Outputs included in RIIO-T2 Business Plan	*No*		
Spend apportionment	**GT2 (£m 2023/24)**	**GT3 (£m 2023/24)**	**GT4 (£m 2023/24)**
	0	154.03	70.80

2 Executive Summary

2.1.1 This paper requests £224.8m (2023/24) through an Uncertainty Mechanism (UM) reopener in RIIO-GT3.

2.1.2 This is for investment on the National Gas Transmission (NTS) to reduce our carbon emissions and contribute to meeting the goal of net zero emissions by 2050. It proposes investment on 12 of our compressor units (17% of the fleet) to reduce emissions from the compressor engine and vent stack, and flaring of gas that would have otherwise been vented during our recompression operations.

2.1.3 Achieving net zero by 2050 will ultimately require a shift to a hydrogen or methane-hydrogen based NTS. However, with continued reliance on methane transmission for the foreseeable future to ensure security of supply for customers, technological solutions are required which can be installed easily as new or retrofitted to existing equipment.

2.1.4 Most of our major emission sources (85%) come from compressor fuel combustion and venting emissions from compressors and pipelines, therefore the options considered focus on reductions in these areas.

2.1.5 We have considered a range of portfolio options including compressor decarbonisation technologies [Autotune DLE, CH4RGE (Methane Reduction for Gas Equipment) zero loss seals, CH4RGE recompression, Dry seals, Hydrogen fuel gas] and pipeline decarbonisation technologies i.e., flaring to reduce emissions from pipeline venting. Selected investments were based on technology maturity and best emissions reduction.

2.1.6 We have considered replacing high running gas units with Variable Speed Drives (VSDs). This would help massively in helping us achieve our decarbonisation targets. This is still in early-stage development and would require more detailed Cost Benefit Analysis (CBA) assessments to select the right unit/location for VSD installation. We have included a UM with a high-level indicative cost of a new unit as a placeholder while this theme matures.

2.1.7 This is a new area of investment as our RIIO-T2 plan did not include any network decarbonisation investments. There was, however, a Net Zero Pre-Construction Work and Small Projects Re-opener (NZASP) that aimed to reduce methane emissions from the National Transmission System (NTS). This project requeste[redacted] for funding for CH4RGE recompression and zero loss seals trials in RIIO-T2. The results of those trials will influence this funding request in RIIO-GT3.

2.1.8 These investments have been carefully aligned with the rest of our plan, particularly our **IDP03 – Network Capability** which determines the long-term future of our compressor units.

2.1.9 The profile of network decarbonisation investment for RIIO-GT3 is shown in Table 2.

Table 2: RIIO-GT3 funding request for network decarbonisation (£m, 2023/24)

Network Decarbonisation	FY28	FY29	FY30	FY31	FY32	FY33	FY34	Total	Funding Mechanism
Autotune DLE	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	UM Reopener
VSD Installation	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	UM Reopener
Mobile flaring for recompression	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	UM Reopener
Purchase mobile flare	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	UM Reopener
CH4RGE recompression [redacted]volumes)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	UM Reopener
CH4RGE Zero Loss seals [redacted]volumes)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	UM Reopener
Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	224.84	UM Reopener

3 Project status and request summary

3.1.1 All the investments proposed in this EJP are in the earliest stage of our investment development process, ND500 stage 4.0. We will request funding to finance these projects from start to finish, however due to the greater level of uncertainty with the investments discussed in this paper, we will utilise uncertainty mechanisms to make the request.

3.1.2 This is a new area of investment as our RIIO-T2 plan did not include any network decarbonisation investments. Innovation projects from RIIO-2 net zero reopeners are underway to trial compressor decarbonisation technologies. The results of this should help supply critical information for future UM submissions.

4 Introduction

4.1 Document purpose

4.1.1 National Gas Transmission is a key enabler for the UK government to reach its net zero goals. We are therefore committed to developing a business model that is consistent with the objectives of the Paris Agreement. We have a commitment to achieve net zero by 2050 with an ambition of 2040 for scope 1 and 2 emissions.

Business plan commitments and plan interactions

4.1.2 The scope of this document is relevant to our Environmental Action Plan commitment. A description of these and our other commitments is provided in the **NGT_A03_Environmental Action Plan_RIIO_GT3**.

4.1.3 This document outlines the approach taken to identify internal factors that drive the need to invest in decarbonising the NTS. It also describes the options considered and the decision-making process taken to determine final investments being proposed for RIIO-GT3 and beyond. These proposals will interact with other Investment Decision Packs (IDPs):

- **IDP03 – Network Capability –** Compressor decarbonisation interventions discussed in this paper can affect / will be affected by any work that gets completed as detailed in those EJPs if these interventions are scheduled on the same site. Delays in a preceding project will affect delivery of the next project.
- **NGT_EJP17_Pipeline_RIIO-GT3 –** Pipeline decarbonisation total investment spend is dependent on the number of recompression outages that happen in RIIO-3. These outages are influenced by In-line (ILI) inspections and digs to remediate any defects on the pipeline where any change in the number of digs, will affect total number of interventions required.
- **NGT_EJP07_Control Systems_RIIO-GT3 –** Autotune DLE discussed later in this EJP, will require modifications to the control systems on compressor sites so needs to be factored into delivery of control systems interventions. It is preferrable where a compressor station is selected for Autotune DLE, that this will be deployed first before any control systems modifications.

5 Problem/Opportunity Statement

Why are we doing this work?

Glide Path

5.1.1 Achieving net zero by 2050 will ultimately require a shift to a hydrogen or methane-hydrogen based NTS but in the short and medium term, with continued reliance on methane transmission for the foreseeable future, technological solutions are required which can be installed easily as new or retrofitted to existing equipment.

5.1.2 The end goal of net zero emissions by 2050 may well be achieved by methane alternatives, however every tonne of CO2e contributes to climate change. The pathway to 2050 is as important as the end goal and that requires reducing emissions as quickly as possible.

5.1.3 We have therefore developed a glide path which sets out emissions targets we need to reach each year to meet the 2050 target. We have then looked at the impact our proposed investments across the entire plan have in helping us to meet those targets and identified whether we are currently going to fall short. This glidepath contains a target of 21% reduction in scope 1 and 2 emissions by end of RIIO-GT3 compared to FY23.

Consumer Impact

5.1.4 We sought domestic end-consumer feedback on specific topics that would shape the RIIO-GT3 business plan submission to OFGEM. One of the main areas of focus was decarbonisation and net zero, where customers were questioned if they thought it was important. Some quotes are as below.

5.1.5 "I think its important for the next generations, and to preserve the planet, which I don't think we're doing a very good job on; and we need to lower these carbon footprints."

5.1.6 On Government targets to decarbonise by 2050, consumers said the following "26 years is a long way and I think people have tendencies to wait until the last minute to take action. I don't know how long something like net zero would take so I'm not sure that 2050 is the right or wrong date but maybe there should be lots of smaller deadlines in-between that we need to hit targets by, to sort of follow along on the journey, rather than one big date at the end where everything needs to be done by then."

5.1.7 On net zero costing the average consumer more on their energy bill, consumers said the following. "So, it's like the worry of are our bills going to go up even higher, because it might not just be NGT that need to raise their cost. It might be other parts of that as well."

5.1.8 These comments highlight that customers understand why net zero is important and want a cost-effective phased approach to reaching those targets. This paper aims to propose some decarbonisation technologies that can assist with those targets. For more information on customer and stakeholder engagement on net zero, see NGT_A16_Stakeholder Engagement and Decision Log_RIIO_GT3.

Emission Sources

5.1.9 Scope 1 and 2 emissions come from our activities. Scope 1 are direct emissions, for example from fuel combustion from running the compressor fleet. Scope 2 emissions are indirect, for example those emissions associated with the production of the electricity we use. Our major emission sources and proportion of total emissions are shown in Table 3. These are all as of FY22/FY23 as that is our internal baseline year used to develop the Glidepath to net zero and associated emissions targets.

Table 3: Proportion of major emission sources as of FY22/23

Emission Source	% of Total Emissions
Energy consumption (excluding electricity)	0.1
Transport	0.5
Fugitive emissions	6.7
Venting emissions (including compressors and pipelines)	20.7
Compressor fuel combustion	64.2
Electricity consumption	7.8.
Total	**100**

5.1.10 The majority of the emissions (85%) come from compressor fuel combustion and venting emissions (highlighted above). Therefore, we are focussing on reduction of these to hit our decarbonisation targets. Combustion produces Carbon Dioxide (CO_2) which has a global warming effect and venting releases Methane (CH_4) into the environment which has a Global Warming Potential (GWP) 28 times higher than CO_2. Venting can be from compressor units, from pipework during recompression operations or from valves.

5.1.11 It is imperative we reduce our emissions internally to meet our net zero ambitions and reduce our impact on the environment. These emissions also affect our internal Unaccounted-for Gas (UAG) which has a consumer cost impact from procurement to replace lost gas.

Compressor Fleet Emissions

5.1.12 The compressor fleet are high contributors to emissions across the NTS. It is important therefore that our business plan for RIIO-GT3 attempts to reduce or remove these emissions by investing in our assets across the fleet.

5.1.13 Gas-driven compressors release emissions into the atmosphere via two routes during normal operation. The first is from the engine/generator releasing combustion products of methane (Carbon dioxide CO_2, Carbon monoxide CO, Nitrous oxides NO_x). The second is through the vent stack where Methane that leaks through the internal seals passes through. Figure 1 below shows the schematic of a gas driven compressor.

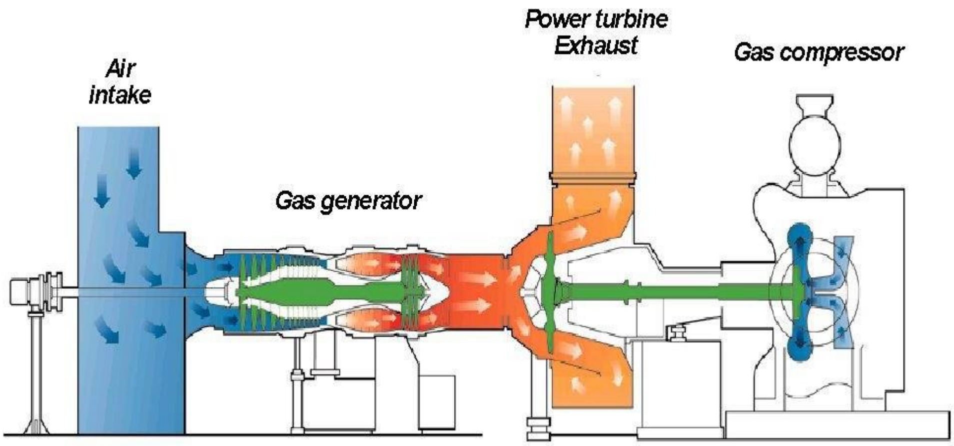

Figure 1: Compressor schematic showing engine and vent stack.

5.1.14 Electrically driven units do not have any emissions from the engine but still suffer from gas leaking through the unit seals and escaping through the vent stack. This makes them the cleanest units overall and not a priority to decarbonise. All other gas units suffer from emissions at the point of combustion and venting (leaks through the seal and vents) and could benefit from technologies that decarbonise both.

5.1.15 In addition to vented emissions during normal operation, and to enable the National Control Centre (NCC) to ensure the NTS demand and supply are balanced, there is a need for critical compressor units to be held in "pressurised stand-by". This results in methane emissions being emitted from compressor seals. Whilst some reduction can be achieved through strategies to reduce venting, technological solutions need to be utilised to manage those which cannot.

5.1.16 The volume of emissions created by any given unit depends upon many factors including its type and the volume of running hours. For more details, see **Appendix 1.** Across the fleet, we have reviewed the technologies available for each unit type and the impact they have on emissions.

5.1.17 Although our [redacted] previously known as [redacted]) are significant contributors to emissions, they are primarily being addressed via investments set out in our **IDP03 – Network Capability.** This is due to their non-compliance with emissions limits set in the Medium Combustion Plant Directive (MCPD). As a result, we are proposing to reduce the running hours of key non-compliant units by re-wheeling other more efficient units. We are also investigating retrofit emissions abatement technology. These investments will contribute to our wider emissions reduction goals but are not duplicated within this EJP.

5.1.18 DLE (Dry Low Emissions) units tend to be run in preference over the [redacted] units as they emit significantly less gas at the point of combustion. These will be the primary target of decarbonisation efforts due to their higher running hours and bulk emissions overall.

[redacted] Combustion Instability

5.1.19 [redacted]. They are some of the highest running hour machines (as shown in **Appendix 1**) and can suffer from high emissions and combustion instability due to climate, asset ageing and fuel gas variations. As a result, for better performance, seasonal mapping could be introduced twice a year to address the seasonal swing in ambient temperature between summer and winter months.

5.1.20 Seasonal mapping can be difficult due to the amount of conflicting work needed on the engines yearly. Seasonal mapping is also not the most optimal for emission control as soon as the temperature changes, the combustion map is invalidated and emissions increase.

5.1.21 An alternative approach would be automated mapping which has the following benefits:

- Optimisation of combustion efficiency.
- Improved fuel efficiency.
- Reduced emissions.
- Continuous compliance with emissions regulations.
- Eliminates seasonal mapping.
- Avoids high combustor acoustic and premature unit damage.
- Allows for better fuel flexibility with respect to hydrogen and other gases.

Venting During Recompression Activities

5.1.22 As part of pipeline operations where intrusive work is required on the pipeline, the standard approach is to vent all the gas in the isolated section of pipe. Recompression provides an environmentally friendlier way of reducing gas in the pipeline by redirecting it to other parts of the network.

5.1.23 This does not remove all emissions as some gas still needs to be vented; current operational recompression rigs can only recompress gas down to [redacted]. New recompression rigs that were purchased in RIIO-T2 and will be operational in RIIO-GT3 can recompress gas in the affected section to [redacted]. This is an improvement from old rigs, but gas still needs to be vented. [redacted] are the most economical stopping points for recompression for the old and new rigs respectively.

5.1.24 Reduction of the harmful release of Methane into the environment is essential for us to achieve our net zero commitment.

What circumstances would change the need for this project?

5.1.25 For investments discussed in this paper, there is still a great level of uncertainty. Therefore, we have proposed using a net zero UM reopener.

5.1.26 If Government changes the targets for net zero to an earlier date, we will have to ramp up our efforts to decarbonise leading to more investment deployment.

5.1.27 For investments specific to decarbonising the compressor fleet, other factors such as supply/demand patterns on the NTS and future compressor run hours could determine whether a unit is selected to have decarbonisation technology applied to it as emissions savings often correlate to running hours.

5.1.28 Repurposing of pipelines (e.g., for hydrogen or Carbon Capture Utilisation and Storage (CCUS)) could also have a significant impact on decarbonisation and therefore might affect the requirement for other decarbonisation investments discussed in this paper.

What are we going to do with this project?

5.1.29 Install various technologies that aim to reduce emissions from our two biggest sources (compressor fuel combustion and venting).

What makes this project difficult?

5.1.30 None of the proposed investments are significantly challenging to deliver in isolation. However, the combination of multiple investments across network zones combined with broader asset health investment and construction projects approved in RIIO-T2 for delivery in RIIO-GT3 means that scheduling of outages whilst maintaining sufficient network capability is extremely challenging.

5.1.31 The current national and international geopolitical situation is creating significant uncertainty in prices and availability of materials and labour which makes estimating project delivery costs more challenging.

5.1.32 Striking the balance between implementing new technology on high usage units to get the most emissions reduction, but not affecting transmission capability and impacting consumers negatively in the process.

What are the key milestones?

5.1.33 To support 21% reduction in scope 1 and 2 emissions by end of RIIO-GT3 compared to FY23, therefore providing positive environmental benefit to end consumers. The target is from our board endorsed decarbonisation strategy and emission reduction glidepath for how emissions reduction commitments will be achieved.

5.1.34 Table 4 shows key milestones for projects. There is a high level of uncertainty around these investments, so dates are not known at this stage.

Table 4: Key milestones for projects

Network Development Stage Gates	Sanction Dates
T0	TBC
T1	TBC
F1 (Scope Establishment)	TBC
T2	TBC
F2 (Option Selection)	TBC
T3	TBC
F3 (Conceptual Design Dev/Long Lead Items)	TBC
T4	TBC
F4 (Execute Project)	TBC
T5	TBC
ACL (Available for Commercial Load)	Completion by the end of RIIO-GT3
T6	Completion by the end of RIIO-GT3
F5 (Reconcile and Closure)	Completion by the end of RIIO-GT3

How will we understand if the project has been successful?

5.1.35 Overall project success will be confirmed when investments discussed in the preferred option are implemented and achieve our targets (21% reduction) on scope 1 and 2 emissions in RIIO-GT3 and onwards. As always, projects should be completed safely and to time, quality, and cost.

5.2 Related Projects

5.2.1 There are key interactions between compressor decarbonisation investments and other significant investments across the NTS. These interactions and the boundaries between areas are discussed below.

- **Asset Health:** Scheduling of conflicting work and avoiding wasted effort. For example, not replacing a seal due to asset health reasons and then going back to replace it again for compressor decarbonisation reasons. For more information on compressor asset health, see NGT_EJP04_Rotating Machinery_RIIO-GT3.
- **Control Systems:** Often adjustments to compressors for net zero reasons may include an element of control system reprogramming and therefore this will be optimised with system replacement where possible. The timing and location for replacement of control systems has been developed in conjunction with these proposals to ensure value for money to consumers whilst also ensuring our network is sufficiently protected from external threats. For more information on control systems, see NGT_EJP07_Control Systems_RIIO-GT3.
- **Compressor Fleet:** Where we are constructing new units as a result of previous submissions, technologies would not be implemented on back up units until new ones are fully proven to ensure resilience. Consideration to install technologies on compressors will depend on other technologies e.g., re-wheels and Avon DLE (both discussed in IDP03 – Network Capability).

- **Emissions compliance:** We are investing in our compressor fleet to comply with legislation put in place which sets out the standards which we are required to meet to minimise the impact of any industrial activities on environmental and public health (discussed in IDP03 – Network Capability. These investments will have an emissions benefit contributing to net zero which is factored into our glide path assessment, but any funding request is not duplicated in this paper.
- **Hydrogen:** Repurposing of pipelines to transmit Hydrogen or a blend of Hydrogen and Methane is out of scope for RIIO-GT3. However, progress in that space could affect which compressors are selected for decarbonising technologies.
- **Decommissioning:** Units planned for decommissioning have still been assessed if they are currently operational as there could be enough savings to justify intervention if done soon enough.

5.2.2 For pipeline decarbonisation investments, the use is driven by outage and recompression requirements on pipeline sections based on inline inspections and the subsequent remediation digs. This work is primarily driven by PSSR legislation and the intervals system (see the NGT_EJP17_Pipeline_RIIO-GT3 for more detail).

5.3 Project Boundaries

5.3.1 The scope of this document is RIIO-GT3 investments where the primary driver is to decarbonise the NTS. Funding requests for any other investments that have a decarbonisation benefit but where that is not the primary driver (e.g., asset health on valves and pipework to prevent leaks) will sit within the relevant EJP.

5.3.2 This document does not include any investments related to transition to Hydrogen from natural gas. These would help with net zero targets but are not listed here.

5.3.3 Implementation of decarbonisation solutions has been considered for the [redacted]. Implementation of decarbonisation solutions could be very cost beneficial for the [redacted]) due to their high forecast run hours. However, [redacted] are expected to be decommissioned in 2030 once three newly installed units are operational. It is critical that they remain operational until that point and therefore there is no opportunity to implement decarbonisation technologies and the opportunity for benefit is limited. Similarly, although [redacted] is intended to be retained long-term, the interventions have also not been considered because of the operational risk presented by installing new technology on a unit which is critical in the short-term. The site is expected to contribute to meeting emissions targets by continuing to prioritise operation of the electric driven compressors and the addition of new efficient gas-driven units. Opportunities for further decarbonisation will be reviewed in the next price control once the new units are commissioned.

6 Project Definition

6.1 Supply and Demand Scenario Discussion and Selection

6.1.1 Under our licence, we are required to plan and develop the pipeline system to meet the peak aggregate daily demand.

6.1.2 The FES 2023 Falling Short scenario has been used for the assessment to date. This scenario was selected as it provides the worst-case demand forecast. There is progress on decarbonisation compared to today, however it is slower than in the other scenarios and fails to meet the UK net zero target by 2050.

6.1.3 As a prudent operator, the system should be planned for the worst-case scenario to ensure we remain compliant with our licence.

6.2 Project Scope Summary

6.2.1 **NOTE:** Due to the early stage of development of investments discussed in this paper, decisions on where these investments will happen are still uncertain and engineering scopes are still being confirmed. This paper is outlining the possible investments we may request in future UMs once trials have been completed allowing us to complete analysis and justification as well as cost estimation.

6.2.2 Investments are proposed to reduce the highest source of emissions on the NTS due to compressor fuel combustion, leaks through the compressor vent stack and venting during recompression.

6.2.3 For compressor decarbonisation investments, implementation will depend on success of innovation trials in RIIO-T2 and will most likely be prioritised for units with high forecast running hours in RIIO-GT3. They are also dependent on individual unit and site assessments and outage efficiencies (i.e., technologies could be installed at one or all units on a site depending on these assessments).

6.2.4 For pipeline venting investments, decarbonisation will aim to happen whenever a pipeline is shut down and recompressed to prevent venting of Methane.

7 Options Considered

Do Nothing (Counterfactual)

7.1.1 For many of these network decarbonisation investments, the options are to 'do nothing' or to implement a proposed change or new technology. If we do nothing, then there will be no impact to current operation and no investment cost.

7.1.2 Doing nothing will result in higher levels of emissions than if we implement any of these net zero investment options. This would have a detrimental impact upon the environment and could result in failing to meet our net zero target.

7.1.3 Whether the cost of investing is justified by the impact it will have on emissions must be decided on a case-by-case basis for each investment type and asset.

Installing Dry Gas Seals, CH4RGE Zero Loss Seals and CH4RGE recompression Options

7.1.4 Compressor shaft seals prevent high pressure process gas in the compressor from migrating along the mechanical drive shaft where it exits the compressor casing. Several compressor shaft seal technologies are in use, reflecting the different age of assets and different Original Equipment Manufacturers (OEMs).

7.1.5 Historically, compressor shaft seals were 'wet' oil-based systems which remain in use on many older units on the NTS. These lead to higher natural gas emissions (via the oil degassing vent) than modern 'dry' gas-based systems which use process gas plus nitrogen or compressed air as a leak barrier. Dry gas systems also remove the potential for oil leaks into the pipeline.

7.1.6 When the compressor units are pressurised (when in operation or on standby), small quantities of seal gas (process gas) leaks from the seals. Annually, on average, wet seals accounted for [redacted] of seal leakage emissions across the network with the remaining [redacted] attributed to Dry Gas Seals (DGS). This highlights the issue as compressors with a wet seal only account for [redacted] of the fleet.

7.1.7 Methane Reduction from Gas equipment (CH4RGE) is a RIIO-T2 innovation project aimed at reducing emissions from the Compressor vent stack. Two major technologies explored as part of CH4RGE include CH4RGE Zero loss seals and CH4RGE vent stack recompression. Zero loss seals replace the process gas with a nitrogen only gas barrier, thereby eliminating process gas losses from the seal, giving a significant reduction in emissions over both existing dry gas and wet seals. CH4RGE recompression aims to capture natural gas that has leaked through the seals and would have escaped through the vent stack. Trials are still ongoing and are aimed to be delivered at Aberdeen compressor station in RIIO-T2. Benefits for these options are therefore:

- Reduced emissions from leaks through the seal and vent stack.
- If the seal is replaced with a more emissions efficient type, this would reset the life of the asset leading to decreased defect rates in the short term.

7.1.8 The progressed options to reduce the emissions from these two sources are summarised in Table 5. **Appendix 2** shows the wider BAT assessment from CH4RGE innovation trials in RIIO-2 that these progressed options were selected from. They are arranged in order of increasing cost, increasing emissions reduction benefit, and decreasing uncertainty of technology implementation.

7.1.9 Only viable options were costed and considered. Discounted options were not progressed for estimation.

Table 5: Seal emissions options

Option	Option status	Description	Option cost per train (£m 2023/24)
Operational process changes of the wet seal	Already progressed	Changes made by Operations site teams to reduce the number of pressurised hours and thus significantly reduce emissions without physical intervention.	N/A
Upgrade wet seal to dry gas seal	Progressed	Option installs new generation dry gas seals with reduced losses compared to existing.	[redacted]
Upgrade wet / dry seal to Zero Loss seal	Progressed	Option involves installing zero loss seals. Zero loss seals eliminate seal gas losses. Could be preferred option depending on unit specific Best Available Technique (BAT) assessment.	[redacted]
Combined gas recompression system	Progressed	Option captures both seal gas losses and compressor casing operational process vents. Could be preferred option depending on unit specific BAT assessment.	[redacted]

<u>Assumptions</u>

7.1.10 Units with highest fugitive seal emissions to be targeted as a priority and it is not beneficial for redundant units planned for decommissioning.

7.1.11 Zero loss seals and recompression could be delivered on one site per year. This may increase as the interventions and technologies become more familiar.

7.1.12 It is best to install CH4RGE recompression to all the units in a compressor station at once for cost saving efficiencies as they could share a recompression system.

<u>Challenges</u>

7.1.13 CH4RGE recompression and zero loss seals are undergoing trials and as such carry greater uncertainty.

7.1.14 Upgrading to either Dry Gas Seal or Zero Loss Seals comes with the increased risk of damage to the Gas Compressor during strip or rebuild due to the invasive nature of modification work required.

7.1.15 Dry seals (including 'Zero loss' seals) require on-site compressed air and nitrogen generation to produce the barrier gas. This system requires specialised equipment, which must be safely maintained and operated.

Autotune DLE

7.1.16 This intervention involves installing automated engine efficiency optimiser Autotune DLE for [redacted] units which operate in part load.

7.1.17 This is an add-on to the existing LM installation that does not interfere with control system settings, day-to-day operation or engine maintenance schedules. It automatically optimises the gas turbine combustion during part load operation by continuously balancing fuel, bleed air, combustion dynamics and emissions in a closed loop to achieve optimum combustion efficiency constantly. This is shown in Figure 2 below.

[redacted]

7.1.18 It does this by continuously processing the appropriate ring flame temperature adjustments to the control system. Over time, it will remember and reuse previously calculated optimum settings and uses a self-learning algorithm. It learns from the specific machine on which it is implemented.

7.1.19 This technology has been proven around the world but has not yet been tested on the NTS.

7.1.20 The benefits of this installation are:

- Improved combustion and fuel efficiency
- Reduced exhaust emissions (NOx, CO, and CO2)
- Elimination of seasonal DLE mapping and high combustor acoustics
- Extended life of hot section hardware

7.1.21 An innovation trial is in development which will result in a greater understanding of the benefits and challenges of implementing this on our fleet.

Assumptions

7.1.22 This investment offers the greatest value on high usage units.

7.1.23 Implementation will be easier if units are grouped by operating logic type.

7.1.24 It is assumed that we could implement this technology on one site per year. This may increase as the interventions and technologies become more familiar.

Challenges

7.1.25 Refinement of the scope and cost is reliant upon the planned innovation trial.

7.1.26 It is best to install Autotune DLE to all the units at once for cost saving and outage efficiencies.

7.1.27 Even though Autotune DLE does not affect the control system settings, it still requires integration with existing control systems on the site. All systems that can control a unit need to be cyber secure, so the system will have to be cyber tested at our [redacted] This is factored into RIIO-T2 trials.

Hydrogen Fuel Gas

7.1.28 There are options being investigated through innovation trials to allow gas turbines to utilise Hydrogen within their fuel gas. Use of Hydrogen would reduce the emissions, particularly if using green hydrogen produced from renewable electrolysis. This option can be considered in a methane-only network plan as the unit would continue to transport methane while only the fuel gas is changed to Hydrogen. This provides an opportunity to decarbonise that is agnostic to a NTS transition to Hydrogen. Benefits of this technology include:

- Up to ~20-25% by volume Hydrogen in a Hydrogen-Methane blend is considered simpler as fewer equipment upgrades are required.
- If 20% Hydrogen blends are used, emissions reduction benefit is around 7-8% compared to natural gas.
- If 100% Hydrogen is used as the fuel gas, 100% combustion emission reduction is possible, but this would require modifications to the unit to be able to use pure Hydrogen as the fuel.
- Hydrogen fuel gas ready units can still take natural gas as fuel providing added flexibility and resilience.

7.1.29 At the moment, several approaches could be taken to supply hydrogen including delivering hydrogen via a tanker, siting electrolysis and storage on a compressor station, piped hydrogen from a nearby hydrogen production facility.

7.1.30 The potential for implementation of these technologies will vary by unit type and generation of unit. For more information, please see Table 6 below.

Table 6: Hydrogen fuel gas feasibility results by unit type

Unit Type	Hydrogen Fuel Gas Feasibility
[redacted]	25% blend has been trialled in Europe
	5-10%
	100% Hydrogen demonstrated in France
	100% Hydrogen possible

7.1.31 These options are in the early stages of development and investigation with various innovation projects looking to get a better understanding of their potential. None of them are currently underway on the NTS.

Assumptions

7.1.32 The greatest benefit will be seen on high fuel gas usage units or units with highest cost of fuel (if hydrogen production is involved).

7.1.33 Implementation of an electrolyser coupled with a heat recovery system could be efficiently delivered in combination with exhaust replacement.

Challenges

7.1.34 The early development stage of these options means that although they could offer significant benefit, there is not enough information currently available to support an investment proposal.

7.1.35 Depending upon the technology selected, Hydrogen transportation distances may make it uneconomical for many sites or there may not be enough space on the site to accommodate Hydrogen production.

7.1.36 High usage is needed to gain the greatest benefit but also introduces greater risk if unfamiliar technology is being implemented on a critical unit.

New Units

7.1.37 Replacing existing gas driven compressors (particularly older types) would result in a significant reduction in the emissions produced. Benefits of new units include:

- Electrically driven units would eliminate the burning of fuel gas.
- New gas-driven compressors usually produce lower emissions than older models.

7.1.38 As with our RIIO-T2 emissions compliance projects which proposed construction of new units, significant work is needed to understand the capability and resilience requirements of new units which then determine the design parameters and cost of options. This can then be assessed using BAT and Cost Benefit Analysis (CBA) techniques to determine the optimal solution.

Assumptions

7.1.39 New units proposed to address any driver will be BAT and therefore contribute to reducing emissions.

7.1.40 Electric drives will only be considered for sites with sufficient gas-driven back-up.

7.1.41 Construction of the unit will likely be completed in the price control period following RIIO-GT3 based on experience of regulatory timelines and construction challenges associated with commissioning new units. UM is to allow for all aspects of installing a VSD including Front End Engineering Design (FEED) studies, improved cost estimates, detailed design and construction.

7.1.42 Electrifying too many units poses a security of supply risk. Currently, all compressor stations except for [redacted] have full gas turbine back-up capacity. Having gas back-up ensures we can continue to flow gas in emergency situations (e.g., during a site power cut or black start where electricity supply is affected network wide). These factors rule out replacement of gas driven units on six sites which already have electric drives.

7.1.43 Outages tend to be longer with Variable Speed Drives (VSDs). This is because problems can be difficult to fix in-house and specialists have to be flown in to resolve the issue, or the unit has to be transported overseas. This also leads to higher-than-expected costs.

7.1.44 The cost of installing a new electrical compressor is high due to the requirement for a high voltage power connection in addition to all the usual costs of a new unit. The unit must have high running hours and emissions to justify replacement with a new VSD.

7.1.45 The most expensive option overall and generally will only be suitable at sites where they have enough run hours to pay back consumer investment.

Mobile Flaring for Recompression

7.1.46 Mobile flaring burns natural gas that would have otherwise been vented during pipeline recompression without any residue and in a climate friendly manner. It is important to note the recompression units will be run as much as is economically possible to reduce any emissions to the environment in the first place. Benefits include:

- By releasing Carbon dioxide which has a smaller global warming potential than Methane.

- They also provide location-independent and flexible deployment options as well as short mobilisation times.
- Due to increasing work to be delivered in RIIO-GT3, more pipeline outages and recompression activities are expected than in RIIO-T2. This makes mobile flaring more important than ever before.

Mobile flaring at Moffat

7.1.47 During a Non-Routine Operation (05/01/2024 – 23/02/2024) at [redacted] offtake, a section of pipeline was oversaturated with odorant. The gas had to be vented or flared to prevent oversaturated gas spreading to the rest of the Network. Due to the olfactory nuisance, the gas was flared rather than vented.

7.1.48 Relevant sections of pipeline were isolated, flared and re-pressurised, then the odorant level was retested. The process was repeated 20 times to bring odorant level back into specification. Total emissions can be seen in Table 7 below.

Table 7: Mobile flaring at [redacted] emissions

Flaring emissions	
Total gas burnt during flaring (tonnes)	46.7
Total emissions with flaring (tCO2e)	120
Total emissions if vented (tCO2e)	1167
Emissions avoided by flaring (tCO2e)	**1047**

Assumptions

7.1.49 Due to the relative inexperience of us using mobile flaring technology for recompression, internal use is expected from the second year of RIIO-GT3 at the earliest. This is to allow time for design of the mobile flare and lead times for delivery, completion of safety studies including Hazard Identification (HAZIDs) and Hazard and Operability Studies (HAZOPs), training of personnel to use the flare.

Challenges

7.1.50 Lead times for delivery could be longer than anticipated to ensure flare is compliant with all relevant safety legislation and industry standard.

7.1.51 Significant stakeholder engagement will be required to address the public perception of flaring.

7.2 Option Costs

7.2.1 In considering available investments, our objective has been to develop a plan that balances cost, carbon reduction and deliverability.

7.2.2 All investments are new so there are no interventions that can be mapped to RIIO-T2 Unique Identifiers (UIDs). Therefore, all costs have been estimated using first principles, including sourcing quotations from our supply chain to calculate the estimated cost of completion (ECC). These are shown in Table 8.

7.2.3 Majority of the investments in this paper are at such an early stage that we have been unable to cost these in detail which is why UMs are being utilised. Costs for these are only indicative (+/- 50% accuracy except for CH4RGE recompression and zero loss seals) and are shown in the Table 8 below.

Table 8: Indicative option cost summary

Investment	Investment Unit Cost (£m 2023/24)	Unit of Measure	Costing Methodology	Data points	Overall value in RIIO-GT3 plan (£m 2023/24)
Replace wet compressor seals with dry seals	[redacted]	Per asset	Mix of assumptions and real data	0	0
Install Autotune DLE	[redacted]	Per compressor	Mix of assumptions and real data	0	[redacted]
Hydrogen fuel gas	[redacted]	Per compressor	Mix of assumptions and real data	0	[redacted]
Installing a VSD	[redacted]	Per compressor	Mix of assumptions and real data	0	[redacted]
Mobile flaring for recompression	[redacted]	Per project	Mix of assumptions and real data	0	[redacted]
Purchasing of mobile flare	[redacted]	Per project	Mix of assumptions and real data	0	[redacted]

CH4RGE recompression	[redacted]	Per compressor	Mix of assumptions and real data	0	[redacted]
CH4RGE zero loss seals	[redacted]	Per asset	Mix of assumptions and real data	0	[redacted]
Total					224.84

CH4RGE Zero loss seal & CH4RGE recompression cost breakdown

7.2.4 See Table 9 below to show development of cost of CH4RGE zero loss seals and CH4RGE recompression. These have been done in more detail compared to other interventions considered. Please note these are still indicative and will be improved further in a future re-opener. The costs shown in below table is to deliver 1 volume of each intervention.

Table 9: Cost breakdown of CH4RGE zero loss seals & recompression

CH4RGE Zero Loss Seals			CH4RGE recompression		
Item	**Cost (£ 2023/24)**	**% of total installed cost**	**Item**	**Cost (£ 2023/24)**	**% of total installed cost**
Surveys	[redacted]	[redacted]	Surveys	[redacted]	[redacted]
Design	[redacted]	[redacted]	Design	[redacted]	[redacted]
Labour	[redacted]	[redacted]	Labour	[redacted]	[redacted]
Materials	[redacted]	[redacted]	Materials	[redacted]	[redacted]
Plant & Equipment	[redacted]	[redacted]	Plant & Equipment	[redacted]	[redacted]
Project Management	[redacted]	[redacted]	Project Management	[redacted]	[redacted]
Testing & Commissioning	[redacted]	[redacted]	Testing & Commissioning	[redacted]	[redacted]
Handover (close out)	[redacted]	[redacted]	Handover (close out)	[redacted]	[redacted]
Risk & contingency allowance	[redacted]	[redacted]	Risk & contingency allowance	[redacted]	[redacted]
NGT Management	[redacted]	[redacted]	NGT Management	[redacted]	[redacted]
Overheads	[redacted]	[redacted]	Overheads	[redacted]	[redacted]
Total Installed Cost	[redacted]	[redacted]	**Total Installed Cost**	[redacted]	[redacted]
Cost Estimate Accuracy	+/-30%		Cost Estimate Accuracy	+/-30%	

7.3 Options Technical Summary table

Table 10 shows the technical summary table for all options that allows for comparison between them. Operating costs are assessed for options vs current state of assets e.g., replacing a wet seal with a dry or zero loss seal will have no change to operating costs as seals are maintained at the same rate. These operating costs have not been costed due to early stage of investments. **NOTE:** Due to uncertainty in investments, project start, and project commissioning dates of intervention options could change.

Table 10: Option technical summary table

Option	Project Start Date	Project Commissioning Date	Project Design Life (years)	Option Operating Cost vs Current	Unit cost (£m 2023/24)	Cost estimate accuracy
Do Nothing (Counterfactual)	N/A	N/A	N/A	N/A	0	N/A
Replace wet compressor seals with dry seals	FY29	FY33	40	No change in maintenance. Decrease in operating gas	[redacted]	+/- 50%
Install CH4RGE Recompression System	FY28	FY30	15	Increase due to maintenance of recompression	[redacted]	+/- 30%
Install Auto-tune DLE innovation	FY30	FY33	15	No change in maintenance. Decrease in operating gas	[redacted]	+/- 50%
Hydrogen fuel gas	FY29	FY32	20	Increase due to maintenance of new assets e.g., electrolyser	[redacted]	+/- 50%
Install CH4RGE Zero Loss Seals	FY29	FY33	15	No change in maintenance. Decrease in operating gas	[redacted]	+/- 30%
Installing a VSD	FY30	FY34	25	No change	[redacted]	+/- 50%
Mobile flaring for recompression	FY30	FY32	10	Increase due to maintenance of flare	[redacted]	+/- 50%
Purchasing of mobile flare	FY29	FY31	10	N/A	[redacted]	+/- 50%

8 Business Case Outline and Discussion

8.1 Option Analysis and Selection

Installing Dry Gas Seals, CH4RGE Zero Loss Seals and CH4RGE recompression

8.1.1 From generic BAT assessment undertaken in the CH4RGE innovation projects, we have identified that combined gas recompression (process and seal) or zero loss seal (seal gas system) options are the preferred options to address compressor venting and emissions from the compressor machinery train. Please see **Appendix 2** for unit specific BAT assessment will determine which of these two options is most suitable for compressor units on the NTS. The option selected may vary depending on forecast running hours (as a direct reflection of emissions produced) and economic viability to carry out upgrades.

8.1.2 Trials are still underway in RIIO-T2 to understand the challenges with deploying CH4RGE recompression and zero loss seals.

8.1.3 Due to zero loss seals having better emissions reduction, zero loss seals will usually be the preferred option over dry seals. However, if the CH4RGE trials disprove the viability of zero loss seals then dry gas seals would become the preferred option.

Autotune DLE

8.1.4 This technology only applies to [redacted] units so there are ten eligible units in our compressor fleet, shown in Table 11.

Table 11: Eligible units for autotune DLE

[redacted]

8.1.5 With an estimated rollout of autotune DLE technology to one unit per year, five are expected to be deliverable in RIIO-GT3. This is based on efficiencies of delivering the investments on sites with multiple [redacted] Volumes of rollout could be reduced if challenges are faced in ongoing innovation trial, delays due to UM timelines, or if we are unable to install technology at multiple units on a site due to outage constraints or other coinciding work on the site (e.g., asset health work which makes it difficult to also simultaneously install autotune).

8.1.6 Based on forecast running hours, plus efficiencies of delivering the technology on multiple units on a site, recommended units for autotune DLE are [redacted]

Hydrogen Fuel Gas

8.1.7 There is not enough information currently to support a specific intervention. Therefore, the recommendation is to progress development through planned Innovation projects and revisit at a later date depending on outcome of the trials.

8.1.8 No funding is being recommended in RIIO-GT3 plan.

New Units

8.1.9 Replacing the duty of one or more gas driven units that have high forecast running hours with a VSD will provide high benefit in terms of emissions reduction. The UM reopener is to allow for all aspects of installing a VSD including Front End Engineering Design (FEED) studies, improved cost estimates, detailed design and construction. **NOTE:** This is still in a very early stage of development so costs and scope of work to install VSD is to be reviewed in the future reopener.

8.1.10 A good candidate could be either of [redacted] units which have high forecast run hours till 2050. Replacing one of these would support the electric units at [redacted] to support north to south gas flows as well as potentially taking duty from other sites within the zone.

8.1.11 Actual suitability will be based on ability to connect to the electricity grid as well as forecast run hours and other factors.

Mobile Flaring for Recompression

8.1.12 Due to an instance of mobile flaring being done in RIIO-T2, it is considered achievable to get one designed for repeated use in RIIO-GT3. The number of times it would be utilised would be based on expected number of recompression outages in RIIO-GT3. This was assumed to start in the second year of RIIO-GT3.

8.1.13 The estimated number of recompression outages are shown in Table 12 below but could change in delivery.

Table 12: Forecast recompression outages in RIIO-GT3

Measure	FY28	FY29	FY30	FY31	Total
Number of recompression outages / mobile flare usages	[redacted]				

8.2 Key Business Case Drivers Description

8.2.1 All options presented in this paper are driven by environmental ambitions to decarbonise the NTS and be net zero in terms of emissions by 2050. To reduce emissions quickly, we have developed a glidepath which sets out emissions targets we need to reach each year.

8.2.2 Highest emission activities on the NTS were identified as compressor fuel combustion and various venting emissions including pipeline venting and escape of emissions through the compressor vent stack.

8.2.3 Investments were identified which could reduce these major emission areas and get us closer to our environmental ambitions.

CBA Assumptions

8.2.4 **NOTE:** This CBA is included for completeness. At this stage, scopes, volumes and costs are not yet clearly defined. A future CBA will likely be required to determine number of decarbonisation interventions and where they would be best suited in the case of compressor decarbonisation interventions.

8.2.5 The CBA used to assess investment options was based on applying the benefits of the interventions to the forecast compressor run hours from the relevant zonal CBA from the compressor fleet IDP, as well as the planned pipeline outages.

8.2.6 Intervention benefits were modelled based on either a reduction of combusted carbon from compressor running (i.e., Autotune DLE), or by reducing vented natural gas volumes from compressors and pipelines (CH4RGE Zero loss seals, CH4RGE recompression, mobile flaring). All emissions were converted into CO_2 equivalent, the carbon cost assessed and the difference from "do nothing" option entered as a benefit.

8.2.7 As part of inflight RIIO-T2 funded innovation projects, zero loss seals and recompression are being installed at several locations. The effect of this was modelled in both the counterfactual and the outcome, meaning no benefit is being considered in the CBA from RIIO-T2 funded work.

8.2.8 Intervention benefits are location specific (See assumed locations in **Appendix 1**) and are based on unit type, seal type and forecast run hours but can be summarised as per Table 13 below.

Table 13: Intervention benefits used in the CBA

Intervention	Combustion Effect	Venting Effect
Mobile flaring	Conversion of the vented methane volume from pipeline outages into a volume of combusted CO_2	
CH4RGE zero loss seals	N/A	Emissions from seal dynamic and static leakage set to zero
CH4RGE recompression	N/A	Reduction of total compressor venting emissions by 98%
Autotune DLE	3.5% reduction in CO_2 per run hour	N/A

8.2.9 Delivery was assumed to happen from FY28 onwards as the proposed funding mechanism for all investments is a UM reopener. Interventions were assigned based on probable locations; however, the outcome of the trials will determine suitability and location.

8.3 Supply and Demand Scenario Sensitivities

8.3.1 For the investments targeting emissions from compressor venting and combustion from compressor running, individual investment benefits are based on individual compressor run hours. If demand is lower, we would expect compressor run hours to decrease relative to zonal supply and demand, with overall forecast carbon emissions reducing proportionally. The inverse is true where if demand is higher, we would expect higher compressor running hours which would lead to more benefit as there would be greater emissions reduction.

8.3.2 For the CBA, the contribution from these investments would have a lower Net Present Value (NPV) as there is less benefit per annum under lower demand scenarios as there are fewer run hours and hence less emissions. This would have the additional effect of increasing the payback period, especially when looking at specific investment.

8.3.3 For example, in a high demand scenario a CH4RGE recompression system for a unit may pay back in 10 years as it needs to mitigate the emissions from the process and seal venting associated with its running hours. Under a lower demand scenario, it might take 15 years for the same running hours to be forecast and the emissions to accrue. Investments will be targeted to high running units where the benefit is greatest.

8.3.4 For mobile flaring, the use is driven by outage and recompression requirements on pipeline sections based on inline inspections and the subsequent remediation digs. This is legislation driven and not demand driven in the short term. Most of the benefit in the RIIO-GT3 plan comes from the immediate introduction of flaring with recompression to combust vented natural gas into CO_2 which has a much smaller carbon footprint.

8.4 Business Case Summary

8.4.1 In developing our plans and making our decision, we have been fully cognisant of the need to develop plans that are value for money and deliverable while trying to decarbonise as quickly as possible.

8.4.2 We have assessed two portfolio options in a CBA and the volumes of investments are described in Table 14 below. The cost of installing a VSD was removed from the CBA as it is still very speculative at this stage and might not even be required depending on speed and success of implementation of other decarbonisation technologies.

8.4.3 All investments were seen to be cost beneficial in terms of cost versus emissions reduction.

8.4.4 **Option 1: Deliverable Business Plan:** Forecast glidepath target in 2031 is not achieved by Network Decarbonisation CAPEX alone, but indicative investments are easier to deliver. This is the preferred option as the glidepath will be achieved through the following:

- If a VSD is installed in place of a high running gas unit. Allowance requested will allow a decision on this to be made.
- Through other CAPEX investments which have a CO_2 reduction benefit that are discussed outside of this paper.
- OPEX activities that reduce emissions.

8.4.5 **Option 2: Net Zero 2031:** Unconstrained plan in terms of deliverability, aims to recommend investments that will meet decarbonisation targets through Network Decarbonisation CAPEX.

Table 14: Portfolio options volumes of investment.

Investment Options	Option 1 volume	Option 2 volume
Install CH4RGE Recompression System	[redacted]	
Install Auto-tune DLE innovation		
Install CH4RGE Zero Loss Seals		
Mobile flaring for recompression		
Purchasing of mobile flare		

8.4.6 In line with the HM Treasury Green Book and RIIO-GT3 business plan guidance, we have appraised these portfolio options utilising NPV calculated at the 20-year point. The analysis evaluates the value of proposed investments in RIIO-GT3, Present Value (PV), PV Benefits, NPV, Cost Benefit (CB) ratio, payback period after end of RIIO-GT3 and payback year of each option; presented in Table 15.

Table 15: Business case summary considered over a 20-year period.

Business Case Parameters	Baseline	Option 1	Option 2
Option title	Counterfactual (Do Nothing)	Deliverable Business Plan	Net Zero 2031
Supply and Demand Scenario Description	FES 2023 Falling Short	FES 2023 Falling Short	FES 2023 Falling Short
Project Commissioning date	FY34	FY34	FY34
Total Installed cost (£m 2023/24)	0	120.79	214.51
Cost estimate accuracy	N/A	+/-50%	+/-50%
Project Operating Lifespan	N/A	45	45
Payback year	N/A	2031	2029
Project NPV (£m 2023/24)	N/A	52.18	37.71
Project PV Costs (£m 2023/24)	N/A	115.82	211.24
Project PV benefits	N/A	63.63	173.53
CB Ratio	N/A	0.55	0.82

8.4.7 In Figure 3, we have plotted the cumulative payback period for the different options presented in Table 15 based on the cumulative discounted net benefit.

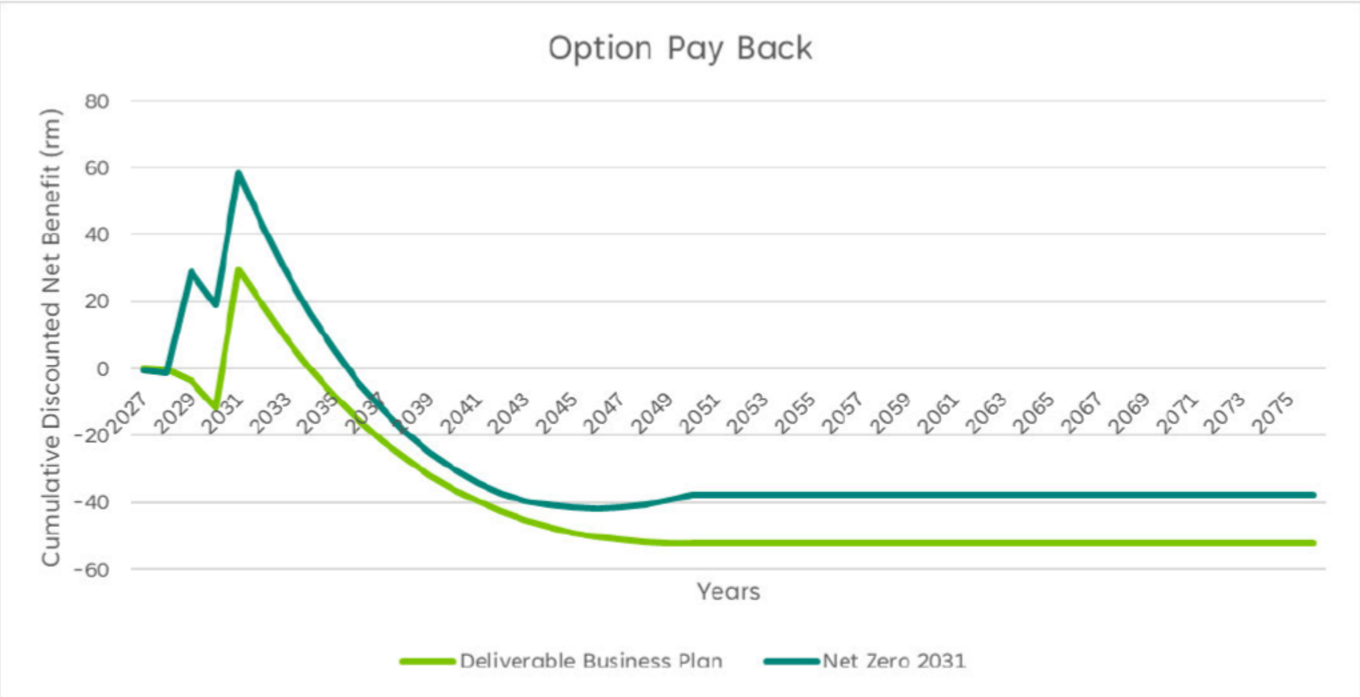

Figure 3: Payback period for different options.

8.4.8 Option 1 was selected as the preferred option overall, despite it not meeting our emissions target in 2031 (difference shown in Table 16 below). This was due to a lower initial cost for consumers as well as factoring in deliverability, as investments required to keep up with net zero ambitions would not be deliverable in RIIO-GT3.

8.4.9 This is the most pragmatic option with technologies still undergoing trials which creates uncertainty in deployment and other investments outside the scope of this paper providing emissions reduction benefits.

Table 16: Option 1 emissions through RIIO-GT3

Measure	FY27	FY28	FY29	FY30	FY31
Emissions (Kilotonnes)	756	496	625	467	624
Target (Kilotonnes)	430	417	405	392	380
Gap (Kilotonnes)	**326**	**79**	**220**	**75**	**244**

9 Preferred Option Scope and Project Plan

9.1 Preferred Option

9.1.1 Overall, we request funding as summarised in Table 17.

Table 17: Funding request

Funding Mechanism	Total (£m 2023/24)
UM reopener	**224.84**

9.1.2 A whole network approach has been taken and the optimal solution that balances reducing emissions, cost and deliverability has been selected. If accepted, this should get us closer to our net zero goals in 2050. Two pilots are underway in RIIO-T2 for CH4RGE recompression and CH4RGE zero loss seals each.

9.1.3 Interventions for network decarbonisation are summarised in Table 18. We currently have low confidence in volumes and costs presented in this paper and, as such, are requesting funding for investments through a net zero UM reopener. This is due to awaiting outcome of innovation trials for the technologies listed. Uncertainty with technologies and timelines are presented below:

- CH4RGE recompression and zero loss seals - Two pilots are underway in RIIO-T2 for CH4RGE recompression (Peterborough and Aberdeen Compressor Stations) and two for CH4RGE zero loss seals (Bishop Auckland, second site pending). The trials aim to understand the challenges of introducing CH4RGE technologies and seeing the emissions reduction benefit. These trials should continue until late 2026, so December 2027 is the earliest we could have a fully-fledged proposal for these technologies.
- Autotune DLE – Trials for installing Autotune are set to begin in the middle of 2025 at the earliest, with no clear timeline for completion. If the Autotune trail is successful, it is expected that a proposal for implementing it across the network would be available in December 2027.

9.1.4 For mobile flaring, more refined cost estimates and clarity with expected number of recompression outages in RIIO-GT3 are required. These should be confirmed by the end of this year and can also fit in a Jan 2027 re-opener.

Table 18: Preferred option interventions

Intervention	RIIO-GT3 Volume	RIIO-GT3 Total Cost (£m 2023/24 prices)	Funding Mechanism
Install CH4RGE Recompression System	[redacted]	[redacted]	UM
Install Auto-tune DLE innovation	[redacted]	[redacted]	UM
Install CH4RGE Zero Loss Seals	[redacted]	[redacted]	UM
Network decarbonisation UM (Installation of VSD)	[redacted]	[redacted]	UM
Mobile flaring for recompression	[redacted]	[redacted]	UM
Purchasing of mobile flare	[redacted]	[redacted]	UM
Total	**97**	**224.84**	**UM**

Uncertainty Mechanism Details

9.1.5 We are proposing three windows for a net zero UM to request funding to implement these decarbonisation technologies in RIIO-GT3.

- **January 2027** – This window will be to request funding for purchase of two mobile flares to decarbonise pipeline venting operations and using the flares during operation. In this window, we will be able to refine the cost of purchasing a flare that suits the wide range of scenarios in the NTS (including design and safety studies). We will also have a refined view of recompression outages and flaring costs so can give an accurate view of how many times the flares would be used and what is the cost per use.
- **January 2028 –** This window will be to request funding for implementing compressor decarbonisation technologies such as CH4RGE recompression, CH4RGE zero loss seals, Autotune DLE pending successful trials in RIIO-T2. In this window, we will refine volumes and costs of the interventions with new CBAs carried out to determine the most beneficial locations to implement the technologies based on future supply and demand patterns and compressor running hours. This window will also be used to request funding to carry out exploration of VSD installation. Site chosen will be based on future CBAs and site-specific assessments.

- **January 2029 –** This is an additional window we are requesting for contingency i.e., delays in innovation trials or if new decarbonisation technologies are discovered and we would like to implement them.

9.1.6 These UM windows are licensee triggered.

9.2 Project Spend Profile

9.2.1 Please see Figure 4 below for project spend profile from 2028 to project completion. These are only indicative at this time and could change based on outcomes of trials in RIIO-T2, which UM window we submit investments in and [redacted]

9.3 Efficient Cost

9.3.1 Costs provided are indicative as none of these technologies are developed enough to support a baseline funding request and, therefore, further work will be done on costs to support a UM reopener submission.

9.4 Project Plan

9.4.1 As there is uncertainty in development and delivery of these interventions, there is no project plan at this stage. The project plan will be developed in the future with the outcomes of different UM windows outlined above.

9.4.2 Key Business Risks and OpportunitiesTable 19 shows all risks and opportunities that could affect project delivery.

Table 19: Opportunities and risks that could affect project.

No.	Risk	Mitigation (based on current view)
1	Delays in starting projects due to UM submission timelines and regulator decision making. This would result in a lower volume of work being delivered and therefore less environmental benefit being realised.	Swift proposal development following information from trials, continuous engagement from us with Ofgem to enable quicker decisions to be made whether to allocate funding for the work through a re-opener.
2	Unforeseen challenges resulting in innovation trials for CH4RGE and Autotune DLE overrunning.	Efficient project planning with robust risk assessments carried out to pre-empt any unforeseen challenges. Regular communication with suppliers and delivery contractors to ensure innovation projects are delivered in time and to a high quality.
3	Hydrogen transition changes the criticality of compressors, modifying their run hours and expected decarbonisation targets. This would lead to an increase in cost, due to additional rework, including CBAs, site assessments, testing etc.	Efficient network and investment delivery planning which includes agile approaches to deliver work for methane and hydrogen networks when required.
4	Introduction of stricter environmental policy would mean we would have to accelerate decarbonisation efforts. This would lead to an increased spend request due to increased volumes and higher costs to expedite implementation.	Ensure we hear quickly if there are any potential changes or new policies i.e., regular engagement with government and environmental regulators.

5	Inability to secure outages for trials prior to completion due to other conflicting work which increases costs due to re-planning work.	Communication across the business to understand project scheduled during this period (e.g., asset health, emissions compliance, control systems), work out interdependencies and create a schedule to inform most efficient delivery.
6	Our costs have been built through unit cost analysis and estimates from the market, however there is a risk that costs of materials may increase due to macro-economic conditions and customer and stakeholder demand	This shall partly be mitigated through the CPI-H inflation and real price effect mechanisms within our RIIO-GT3 regulatory framework

Supply / Demand Risks

9.4.3 For the investments targeting emissions from compressor venting and combustion from compressor running, individual investment benefits are based on individual compressor run hours. If demand is lower, we would expect compressor run hours to decrease relative to zonal supply and demand, with overall forecast carbon emissions reducing proportionally. This means fewer running hours on compressors and less emission reduction technologies are required to hit the net zero target. The reverse would be true for a high demand scenario.

9.4.4 For mobile flaring, the use is driven by outage and recompression requirements on pipeline sections based on inline inspections and the subsequent remediation digs. detail) and will not vary based on demand in the short term.

9.5 Outputs included in RIIO-T2 Plans

9.5.1 This is a new area of investment as our RIIO-T2 plan did not include any network decarbonisation investments. There was, however, a Net Zero Pre-Construction Work and Small Projects Re-opener (NZASP) that aimed to reduce methane emissions from the National Transmission System (NTS). This project requested [redacted] for funding for CH4RGE recompression and zero loss seals trials in RIIO-T2. The results of those trials will influence this funding request in RIIO-GT3.

10 Appendices

[redacted]

10.1.1 Please see accompanying spreadsheet for compressor unit information and emissions.

10.2 Appendix 2 BAT assessment from CH4RGE trials

10.2.1 Table 20 below shows the indicative generic BAT assessment from our CH4RGE trials.

Table 20: BAT assessment of options from RIIO-T2 CH4RGE innovation trials.

Option	Preferred	Narrative
Option 1 – Do nothing	No	Not preferred as solutions exist to reduce this methane emission source and it is the greatest source of methane emissions from operating the NTS.
Option 2 – New Generation Dry Gas Seals (Seal Gas System)	No	Option installs new generation dry gas seals with reduced losses compared to existing.
Option 3 – Supersonic Ejector (Seal Gas System)	No	Option installs a supersonic ejector to capture dry gas seal losses.
Option 4 – Enclosed Burner (Process Vents)	No	Option burns process vent gas in an enclosed burner resulting in an emission of carbon dioxide rather than natural gas and therefore reducing the environmental impact of the vented emission. Not a zero-emission option.
Option 5 – Enclosed Burner (Seal Gas System)	No	Option burns seal gas losses in an enclosed burner resulting in an emission of carbon dioxide rather than natural gas and therefore reducing the environmental impact of the vented emission. Not a zero-emission option.
Option 6 – Seal Gas Recompression (Seal Gas System)	No	Option implements recompression technology to capture natural gas from compressor seal losses only.
Option 7 – Vent Gas Recompression (Process Vents)	No	Option implements recompression technology to capture natural gas from compressor process vents only.
Option 8 – Combined Gas Recompression (Process and Seal)	Yes	Option captures both seal gas losses and compressor casing operational process vents. Could be preferred option depending on unit specific BAT assessment.
Option 9 – Zero Loss Seal (Seal Gas System)	Yes	Option captures seal gas losses only. Could be preferred option depending on unit specific BAT assessment.
Option 10 – Dry Seal Optimisation (Existing system)	No	Optimise existing dry gas seals to reduce seal leakage. No impact on compressor casing emissions.

[redacted]

10.3.1 Please see accompanying spreadsheet for assumed sites for delivered work (subject to change)