NZASP submission

Methane emissions Compressor Machinery Train December 2022

[redacted]

nationalgrid

Document control

Version	Status	Date	Author(s)	Summary of changes
0.1	Draft (trigger document)	July-22	Matthew Williams, Jai Dalal, Simon Kidd, Mark Lees, Guy Pearson, Raveena Virk	
0.2	Draft (final submission)	Sept-22	Matthew Williams, Jai Dalal, Simon Kidd, Mark Lees, Raveena Virk	Updated to take in Ofgem feedback, revised business cases, refinement of cost data, new executive summary and more complete regulatory input
0.3	Final document	Dec-22	Matthew Williams, Jai Dalal, Simon Kidd, Mark Lees, Raveena Virk	Updated to take in Ofgem feedback and first pass of sign-off comments Amendment of submission to split into three by investment theme. Common elements to all themes to be appended to individual theme submission papers.

Supporting Documents

Document	File Name
Director of Regulation Assurance Statement	NG-Asset-GT-MR-COM-001-Assurance Statement
Regulation Table Mapping	NG-Asset-GT-MR-COM-002-Table Mapping
Cost book	NG-Asset-GT-MR-CMT-001-Cost Book
[redacted] - Commercial and Technical Proposal	NG-Asset-GT-MR-CMT-002- [redacted] Proposal
[redacted] - Additional Information	NG-Asset-GT-MR-CMT-003- [redacted] Additional Information
[redacted] – Recovery System Information	NG-Asset-GT-MR-CMT-004- [redacted] Recovery System Information
[redacted] – Technical Proposal	NG-Asset-GT-MR-CMT-005- [redacted] Technical Proposal
Cost Benefit Analysis – Combined Gas Recompression Aberdeen	NG-Asset-GT-MR-CMT-006-CBA CGR ABR
Cost Benefit Analysis – Combined Gas Recompression Huntingdon/Peterborough	NG-Asset-GT-MR-CMT-007-CBA CGR PET
Cost Benefit Analysis – Zero Loss Seal Aberdeen	NG-Asset-GT-MR-CMT-008-CBA ZLS ABR
Cost Benefit Analysis – Zero Loss Seal Bishop Auckland	NG-Asset-GT-MR-CMT-009-CBA ZLS BAU
CH4RGE final deliverables – NIA 1	NG-Asset-GT-MR-CMT-010- CH4RGE NIA 1
CH4RGE final deliverables – NIA 2	NG-Asset-GT-MR-CMT-011- CH4RGE NIA 2
CH4RGE final deliverables – SIF 1	NG-Asset-GT-MR-CMT-012- CH4RGE SIF 1

CMT DAG template	NG-Asset-GT-MR-CMT-013-CMT DAG
Quantitative Risk Assessment – Compressor Machinery Train	NG-Asset-GT-MR-CMT-014-CMT QRA
Best Available Technique – Combined Gas Recompression Aberdeen	NG-Asset-GT-MR-CMT-015-BAT ABR
Best Available Technique – Combined Gas Recompression Huntingdon/Peterborough	NG-Asset-GT-MR-CMT-016-BAT CGR PET
Best Available Technique – Zero Loss Seal Aberdeen	NG-Asset-GT-MR-CMT-017-BAT ZLS ABR
Best Available Technique – Zero Loss Seal Bishop Auckland	NG-Asset-GT-MR-CMT-018-BAT ZLS BAU

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Contents

1 Executive summary

This document together with its appendices and attached supporting information comprises of National Grid Gas Transmission's (NGGT) document submission under the Net Zero Pre-construction Work and Small Net Zero Projects Re-opener (NZASP) to address methane emissions from operating the gas National Transmission System (NTS). NGGT seeks funding for the trial of methane emission reduction for the following theme:

- Compressor Machinery Train - Trials of combined gas recompression and zero loss compressor seal technology to reduce methane emissions from the compressor machinery train.

Table 1 - Compressor machinery train methane emission reduction theme submission value

RIIO-2	22/23	23/24	24/25	25/26	Total
Compressor machinery train	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Total inclusive of risk					[redacted]

NGGTs proposed investment will:

- Reduce methane emissions that arise from compressor venting
- Provide evidence for future cost-effective targeted investments to further reduce compressor venting in RIIO-3 as part of a wider roll-out of combined gas recompression and zero loss compressor seal technology following successful trial

This theme submission should be read in conjunction with the common elements document which provides the common narrative applicable to all.

2 Compressor machinery train

a. Needs case / problem statement

Problem statement

NGG have undertaken a number of activities and actions throughout T1 and T2 to reduce our emissions. However the Methane Reduction from Gas Equipment (CH4RGE) innovation project and the development of this uncertainty mechanism has shown that compressor venting is our largest contributor to whole NTS methane emissions. Therefore, to make significant reductions in our emissions performance NGGT should look to address this area of operation if technically feasible. The monetised emission reductions that could be achieved are outlined in section 2d cost benefit analysis. NGGTs innovation desktop trials and investigations to date have shown there are now engineering solutions available that are suitable for trials on the NTS which if successful would allow NGGT to make a significant positive impact.

In addition to vented emissions during normal operation, and to enable GNCC 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 such as planning, technological solutions need to be utilised to manage those which cannot. This highlights a need to trial previously identified solutions which will provide evidence to justify an informed and accurate business case for RIIO-3 investment and roll out on key units.

Formulation of scope

As part of the CH4RGE innovation project the need for methane emission reduction in the Compressor Machinery Train was identified and the types of emissions and options of capture were outlined and scored using Best Available Technique (BAT). The varied nature of operating the network to meet customers’ requirements may mean that there is not one unique solution that can resolve all methane emissions from the compressor machinery train. As such multiple high scoring solutions may be chosen to resolve the specific site issues and as such form the allowance whilst tailoring the best solutions. Certain operating conditions resulting in methane emissions, such as emergency shut down venting, were omitted from the scope. Emergency shut down conditions require natural gas to be evacuated unrestricted and as quickly as possible from the compressor casing, hence are unsuitable for capture.

b. Options and selection methodology

Compressor Machinery Train

The options for the compressor machinery train were identified through the CH4RGE Network Innovation Allowance projects Stage 1 and 2 (NIA_NGGT0164 and NIA_NGGT0174) and most recently awarded Strategic Innovation Fund (SIF) discovery project (10020609). In accordance with the standard agreed methodology the options were scored against specific criteria each with their own weighting. The criteria against which the options were scored were emissions captured, cost, energy usage, engineering complexity, legislative complexity and systems integration complexity. The scoring of the different options followed the commonly used (BAT) methodology to determine a generic indicative BAT option for reducing methane emissions from the compressor machinery train. The results of this assessment can be seen in Figure 1.

The sites and compressor units chosen for trial have been selected considering compressor venting amounts, seal leakage rates and run hours, this is further described in the delivery section.

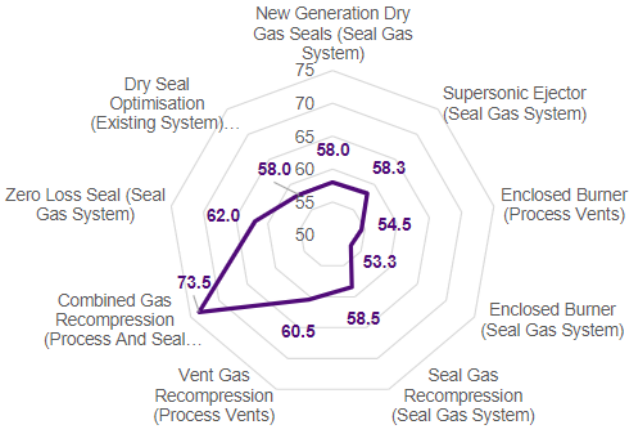

Figure 1 Spider diagram of compressor machinery train methane reduction options and there scoring following BAT assessment during CH4RGE NIA projects

Table 2 - Compressor machinery train BAT options and narrative associated with selection of the preferred

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.

c. Preferred option

Compressor venting

From the indicative generic (BAT) assessment undertaken in the CH4RGE innovation projects NGGT has identified that combined gas recompression (process and seal) or zero loss seal (seal gas system) options as being the preferred options to address compressor venting and emissions from the compressor machinery train. A unit specific BAT assessment will determine which of these two options is most suitable for compressor units on the transmission system. It is considered that for high running compressors and intermittent on/off operation with depressurisation of the compressor that the combined gas recompression solution is the best available technical solution for high running compressors with on/off operation but where gas is maintained in the casing for long periods a zero loss seal represents BAT.

By trialling the implementation of these two options in RIIO-2 NGGT will obtain experience and knowledge of these emission reduction systems reliability and capability as well as any potential impact on the reliability of the compressor unit itself. This information will provide NGGT the understanding of these emission reduction options in an operational environment to support future investment decisions and wider implementation in RIIO-3.

d. Cost benefit analysis

The analysis has been divided between the two technology solutions Combined Gas Recompression and Zero Loss Seal. The combined Capex of [redacted] is split between Combined Gas Recompression and Zero Loss seal, [redacted] and [redacted] respectively. Tables 3 and 4 summarise the cost benefit analysis of the two solutions.

The Zero Loss Seal trial however is not representative of NGGT's current agreed approach to seal replacement which is based on fix on fail. For these trials the original dry gas seal will be replaced irrespective of its current condition. On success of this trial NGGT will prioritise implementing Zero Loss Seal technologies on units requiring seal replacement ensuring life span of existing seals are maximised while increasing cost savings. Applying this approach to seal replacement will ensure maximum benefit and payback for the zero loss seal replacement.

The cost benefit analysis for the combined gas recompression has been undertaken assuming methane capture from a single compressor unit. However, there is potential for the recompression units to capture more than one unit thus increasing the methane capture and emission reduction benefit. If trials are successful this approach of a single combined gas recompression unit capturing methane emissions from multiple compressor units would be considered.

Within this theme submission, all prices are stated in 2018/19 prices. The following factors have been used in the CBA for this theme and are reflected in the CBA templates. This is an amendment to the factors in the previously submitted Common Elements paper.

Table 3 - Factors used in CBA analysis

Factor	Values
2022/23 to 2018/19 conversion[1]	1.18

[1] Ofgem RIIO-2 18/19 price base conversion. As at 25th November 2022.

Global Warming Potential of methane over 100-year horizon[2]	25
2022 Carbon values in £2020 prices per tonne of CO2 – Low Series[3]	£124
2022 Carbon values in £2020 prices per tonne of CO2 – Central Series[3]	£248
2022 Carbon values in £2020 prices per tonne of CO2 – High Series[3]	£373
USD to GBP: $1[4]	0.83
EUR to GBP: €1[4]	0.86

Table 4 - Combined Gas Recompression cost benefit analysis.

Compressor machinery train	**Option 8 – Combined Gas Recompression (Process and Seal)** **Development & trial of two OEM solutions on two compressors**
Category value (CO2e)	£11.97m
Wholesale gas value	£0.40m
Capex	[redacted]
Impact on emissions in this category	4.1%
Annual benefit & year of impact	£0.43m, from RIIO-2 year 5.
Payback period (ROI)	6 years for BAU, 9 years for HUN/ PET
Assumptions & rationale:	• Funding for delivery resource has been included in this proposal. • Opex has been capitalised for delivery of this project. • No additional funding sought for operational resource. • Where this solution is likely to be implemented, an average impact of 2.8% of this category value has been assumed per compressor: From 2021 compressor emissions pareto data NGGT has identified that 70% of emissions come from the 'top' 25 compressors, by volume, that emit methane , averaging out to 2.8% per compressor. Clearly, there is a spread, so individual compressor benefits will vary. • With the assumption that compressor usage across the entire network will not change significantly over the short

[2] Department for Business, Energy and Industrial Strategy Guidance "Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal". https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1024054/1.Valuation_of_energy_use_and_greenhouse_gas_emissions_for_appraisal_CLEAN.pdf

[3] Department for Business, Energy and Industrial Strategy Policy paper "Valuation of greenhouse gas emissions: for policy appraisal and evaluation". https://www.gov.uk/government/publications/valuing-greenhouse-gas-emissions-in-policy-appraisal/valuation-of-greenhouse-gas-emissions-for-policy-appraisal-and-evaluation

[4] Xe.com currency exchange rate as at 29th November 2022

	term, benefits of 2.8% (average per compressor) repeat annually.
Risks & further commentary	• This is proof of concept/development funding and as such carries a higher cost than a market ready proposal. This is reflected in the payback period. • This funding is for OEM pilot testing. There is a risk that the pilot test may fail or produce less benefits than expected. • Funding is only be sought for 2 OEM solutions. A further OEM trial would be needed in RIIO-3 to give solutions across the fleet. • To achieve pilot and RIIO-3 recommendations during RIIO-2, NGG may need to proceed at risk until award.

Table 5 - Zero Loss Seal cost benefit analysis.

Compressor machinery train	**Option 9 – Zero Loss Seal (Seal Gas System)** **Trial of two zero loss seals.**
Category value (CO2e)	£11.97m
Wholesale gas value	£0.40m
Capex	[redacted]
Impact on emissions in this category	3.6%
Annual benefit & year of impact	£0.44m, from RIIO-2 year 5.
Payback period (ROI)	6 years
Assumptions & rationale:	• Funding for delivery resource has been included in this proposal. • Opex has been capitalised for delivery of this project. • No additional funding sought for operational resource. • Where this solution is likely to be implemented, an average impact of 1% of this category value has been assumed per compressor: From 2021 compressor emissions pareto data NGGT has identified that 30% of emissions come from the 'bottom' 30 compressors by volume that emit methane , averaging out to 1% per compressor. Clearly, there is a spread, so individual compressor benefits will vary. • With the assumption that compressor usage across the entire network will not change significantly over the short term, benefits of 1% (average per compressor) repeat annually.
Risks & further commentary	• Technology in this area still needs to be trialled and as such carries a higher cost than a market ready proposal. This is reflected in the payback period. • This funding is for pilot testing. There is a risk that the pilot test may fail or produce less benefits than expected. • To achieve pilot and RIIO-3 recommendations during RIIO-2, NGG may need to proceed at risk until award.

Table 6 - Cost phasing for compressor machinery train preferred option in 18/19 pricing.

RIIO-2	22/23	23/24	24/25	25/26	Total
Combined gas recompression	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Zero loss seals	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Total inclusive of risk					[redacted]

A Risk Register was developed for this project in line with the Infrastructure and Projects Authority Cost Estimating Guidance. A workshop was held with Subject Matter Experts and senior engineers within NGGT to review the Risk Register which informed our Quantitative Risk Assessment (QRA).

The QRA was developed by risk engineers through the risk analysis software Predict and applies across all 4 trials. The QRA can be found with the supporting information "CMT QRA". A Monte Carlo analysis was used to produce the P80 Values. This methodology is in line with current Ofgem guidance on cost estimation.

NGGT will check costs prior to award to mitigate risks related to equipment price changes associated with exchange rate and RPE changes. NGGT will also validate quotes associated with services provided by OEMs in support of project delivery.

In addition, once project approval to proceed is received, and third-party contracts are signed, NGGT will aim to place currency hedge(s) for any non-GBP denominated costs in line with our internal Treasury department guidelines. This will help minimise the impact of currency fluctuations over the course of the project, and indirectly provide additional certainty on non-GBP based costs for the consumer.

NGGT has obtained a quote from a provider of design services for conceptual and detailed design support. The staff rates used in the quote are National Grid framework rates obtained through a competitive tender process. NGGT has undertaken a manual adjustment of the quote received reducing the activity hours as it believes there to be duplication with some activities to be undertaken by NGGT and other design service providers.

e. Delivery plan

A high-level delivery plan has been developed outlining the critical milestones required for successful project delivery from the conceptual design stage to operational test. This delivery plan is based on commissioning within RIIO-2 year 4 to allow for a year of operating within year 5 to give usable data to make an informed decision on the feasibility of full rollout in RIIO- 3.

Selected sites, shown in Table 6, have been provisionally selected. Sites are selected based on outage availability, compatibility with OEM technology and projected future use. Site selection could evolve based on several factors; network usage, criticality and optimisation of trial data.

Table 7 - Compressor machinery train delivery plan.

RIIO-2	2021 / 2022	2022 / 2023	2023 / 2024	2024 / 2025	2025 / 2026
Aberdeen A or C – Combined Gas Recompression		Develop (Detailed design, order long lead materials, FEA, FPSA)	Develop (Detailed design, FEA, FPSA)	Execute programme	Close project/ Analysis and Report Findings

Huntingdon or Peterborough – Combined Gas Recompression		Develop (Detailed design, order long lead materials, FEA, FPSA)	Develop (Detailed design, FEA, FPSA)	Execute programme	Close project / Analysis and Report Findings
Aberdeen B – Zero Loss Seal		Develop (Detailed design, order long lead materials, FEA, FPSA)	Develop (Detailed design, FEA, FPSA)	Execute programme	Close project / Analysis and Report Findings
Bishop Auckland B – Zero Loss Seal		Develop (Detailed design, order long lead materials, FEA, FPSA)	Develop (Detailed design, FEA, FPSA)	Execute programme	Close project / Analysis and Report Findings

A resource plan has been developed in conjunction with the GT&M Construction team identifying and confirming the level of resource commitment required for the project. To de-risk the programme NGGT are intending to utilise existing agreed outages and will be placing orders for long lead items. To ensure no delays in the plan and the delivery of the trials, NGGT has been funding the project since the end of the SIF funding in May 2022 for seven months until submission.

The outcomes and outputs can be measured against the delivery plan milestones via the appropriate appointed capital delivery project manager. The delivery trial will attempt to understand the impact on emissions, reliability of the solution, impact on CMT reliability and understand the challenges around its introduction on legacy compressors for RIIO-3 rollout. With conceptual design having started in RIIO-2 year 2 and planned completion in year 5.

Successful completion of the project entails the implementation and commissioning of Combined Gas Recompression and Zero Loss Seal solutions. This will then allow for a year of monitoring and data capture in year 5 informing the viability of recommended new OEM technology and solutions going forward in RIIO-3.

NGGT will subject to final design and award by the end of the RIIO-2 price control deliver:

- Two Combined Gas Recompression and two Zero Loss Seal trials on compressor machinery trains on the NTS.
- A report outlining what NGGT has learnt in the deployment of the methane emission reduction solutions for the compressor machinery train to include the impact on emissions, reliability of the solution, impact on compressor machinery train reliability and understanding gained on the challenges around integration on legacy compressors.

NGGT will report on progress within the regulatory reporting pack (RRP) Net Zero strategic narrative for the remainder of RIIO-2.

3 NZASP Funding Request

NZASP Funding Request Proposals made in this chapter are intended to apply on a non-precedential basis. This is because future policy clarifications may inform appropriate funding routes and specific regulatory treatments for subsequent project phases. It was agreed during our pre-trigger phase of this re-opener that the NZASP funding route would be adopted.

Cost recovery speed and Totex incentivisation

The CMT methane reduction options that NGGT proposes align with the priorities stakeholders and consumers told us were important in the development of our RIIO-2 business plan. Namely to “care for the environment and communities” and “facilitate delivery of a sustainable energy system”. Additionally, our proposals align with the Environmental Action Plan (EAP) theme “Our Climate Commitment” in which NGGT commits to reducing carbon emissions by 2026 and specifically establishing a baseline for methane emissions on the transmission system through improved monitoring during RIIO-2. It will progress NGGT towards the National Grid Group commitment of net zero direct greenhouse gas emissions by 2050 and aligns with the National Grid Group Responsible Business Charter and the NGGT EAP.

NGGT are seeking investment of [redacted] in Totex funding inclusive of risk determined by QRA to implement the CMT theme. To mitigate any risk of price fluctuation and to protect consumers, NGGT have agreed with Ofgem to provide updated costs, based on revised quotes, latest exchange rates, and the latest price base conversion factor revised by Ofgem, immediately prior to award. Once project approval to proceed is received from Ofgem, and third-party contracts are signed, NGGT will aim to place currency hedge(s) for any non-GBP denominated costs in line with our internal Treasury department guidelines. This will help minimise the impact of currency fluctuations over the course of the project, and indirectly provide additional certainty on non-GBP based costs for the consumer.

It has been agreed with Ofgem that our method of reporting against this re-opener will not follow a Price Control Deliverable but will instead be reported through the annual RRP.

- In line with the above and in reference to the Net Zero Pre-Construction Work and Small Projects criteria our re-opener application meets the following guidelines: Early development, design and general pre-construction work that will enable the achievement of Net Zero Carbon Targets;
    - Our proposal is aligned, as the project is related to methane reductions, and in turn reaching the UK’s Net Zero Carbon Targets, as set out in the COP 26 agreement.
- Net Zero projects that exceed the £2m materiality cap of the Net Zero and re-opener Development use-it-or-lose-it allowance (NZARD UIOLI) or are otherwise not suitable for the NZARD UIOLI;
    - Our project is above the £2m materiality cap as the funding NGGT are applying for is [redacted].
- Net Zero projects that do not meet the materiality threshold for the Net Zero Reopener;
    - This submission under CMT is submitted as a separate application in order to adhere to the materiality threshold.
- Net Zero facilitation (Green Gas and Hydrogen) projects and Hydrogen projects that are required as part of the Department for Business, Energy & Industrial Strategy Hydrogen Grid Research and Development Programme, including projects that may be interpreted as innovative – where there is a clear need, and it is appropriate for network consumers to fund;
    - Our project offers an innovative solution in the Green Gas zone for the reduction of methane emissions.

Allowed revenue and bill impacts

The impact of proposed project costs and regulatory treatment to allowed revenue and consumer bills are less than 1p per household bill and therefore have been determined to be immaterial for further analysis.

4 Glossary of terms

Acronym / term	Definition
BAT	Best Available Technique
CAPEX	Capital expenditure
CBA	Cost Benefit Analysis
COP26	UN Climate Change Conference UK 2021
EAP	Environmental Action Plan
FEA	Formal Environmental Assessment
FPSA	Formal Process Safety Assessment
FEED	Front End Engineering Design
Fugitive emissions	Gas escapes and other irregular releases of gases from a pressurized containment
GHGIM	Greenhouse Gas Investigative Mechanism
Global Methane Pledge	Pledge to take voluntary actions to contribute to reducing global methane emissions by at least 30 percent from 2020 levels by 2030
GWP	Global Warming Potential. Developed to allow comparisons of the global warming impacts of different gases
Net zero	A target of completely negating the amount of greenhouse gases produced by human activity, where there is a balance achieved between the carbon emitted into the atmosphere and the carbon removed
NGGT	National Grid Gas Transmission. Sole UK gas transmission system network operator
NIA	Network Innovation Allowance
NZARD UIOLI	Net Zero and Reopener Development use-it-or-lose-it
NTS	National Transmission System
OEM	Original equipment manufacturer
OGI	Optical Gas Imaging
OPEX	Operating expenditure
PIG	Pipeline inspection gauge
RIIO	Revenue = Incentives + Innovation + Outputs. This is the regulatory framework through which funding is set for the business. RIIO-2- covers the period from April 2021 to March 2026
SIF	Strategic Innovation Fund
QRA	Quantitative Risk Assessment
TSO	Transmission system operator
UM	Uncertainty mechanism