



NZASP Submission
**Methane emissions
Detection & Analytics
October 2022**

NGGT METHANE REOPENER APPLICATION
DETECTION & ANALYTICS – OCTOBER 2022.

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 – single UM document)	Sept-22	Matthew Williams, Jai Dalal, 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	Oct-22	Matthew Williams, Jai Dalal, 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
D+A Data Assurance Guidance Document	NG-Asset-GT-MR-D&A-001-D&A DAG
D+A Submission Cost Build Up	NG-Asset-GT-MR-D&A-002-D&A Submission Value
D+A Periodic Monitoring Outsourcing Quote	NG-Asset-GT-MR-D&A-003-D&A Periodic Monitoring Outsourcing Quote
D+A Periodic Monitoring Equipment Maintenance	NG-Asset-GT-MR-D&A-004-D&A Periodic Monitoring Equipment Maintenance
D+A Continuous Monitoring Quote Supplier 1	NG-Asset-GT-MR-D&A-005-D&A Continuous Monitoring Quote Supplier 1
D+A Continuous Monitoring Quote Supplier 2	NG-Asset-GT-MR-D&A-006-D&A Continuous Monitoring Quote Supplier 2
D+A Continuous Monitoring Quote Supplier 3 - Opex	NG-Asset-GT-MR-D&A-007-D&A Continuous Monitoring Quote Supplier 3 - Opex
D+A Continuous Monitoring Quote Supplier 3 - Capex	NG-Asset-GT-MR-D&A-008-D&A Continuous Monitoring Quote Supplier 3 - Capex
D+A Continuous Monitoring Quote Supplier 4	NG-Asset-GT-MR-D&A-009-D&A Continuous Monitoring Quote Supplier 4

NGGT METHANE REOPENER APPLICATION
DETECTION & ANALYTICS – OCTOBER 2022.

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Contents

Document control	1
Supporting Documents	1
Reviewers.....	2
Management approval.....	2
Contents.....	3
1 Executive summary	4
2 Periodic fugitive monitoring.....	5
a. Needs case/problem statement	5
b. Options and selection methodology	6
c. Preferred option.....	9
d. Costs.....	11
e. Delivery plan.....	13
3 Continuous fugitive monitoring.....	14
a. Needs case/problem statement	14
b. Options and selection methodology	15
c. Preferred option.....	18
d. Costs.....	18
e. Delivery plan.....	20
4 NZASP Funding Request	21
5 Glossary of terms	22

1 Executive summary

This document together with its appendices and attached supporting information comprises 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 of [REDACTED] for expanded fugitive methane detection and subsequent repair and monitoring of detected gas escapes under the investment theme title ‘Detection and Analytics’.

- Detection and Analytics - An expansion of its periodic fugitive monitoring programme and an implementation of new continuous fugitive monitoring systems at selected above ground installations.

Table 1 - Detection and Analytics theme submission value

RIIO-2	22/23	23/24	24/25	25/26	Total
Detection and analytics	£0m	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]

NGGTs proposed investment will:

- Enable the establishment of a robust measurement-based fugitive methane emission performance baseline
- Facilitate meaningful trending and monitoring of fugitive methane emission performance
- Enable minor fix and repair of detected fugitive gas escapes
- Provide evidence for future cost-effective targeted investments in RIIO-3 to address methane emissions from fugitive sources

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

2 Periodic fugitive monitoring

a. Needs case/problem statement

Problem statement

NGGTs understanding of the fugitive element of its methane emission performance is based on a periodic fugitive survey programme which consists of four-yearly surveys of its compressor stations and terminals only. This survey programme started in 2008 when a one-off fugitive survey was introduced as an improvement condition (IC) in NGGTs permits to operate from the Environment Agency and Scottish Environment Protection Agency. Figure 1 shows the most recent fugitive emission performance of compressor stations and terminals on the NTS from NGGTs current periodic monitoring programme. The red line shows the cumulative contribution of each of these installations.

NGGT, outside of compressors and terminals, undertakes no formal detection and quantification of fugitive escapes. This provides a gap in NGGTs visibility and understanding of its fugitive methane emission performance.

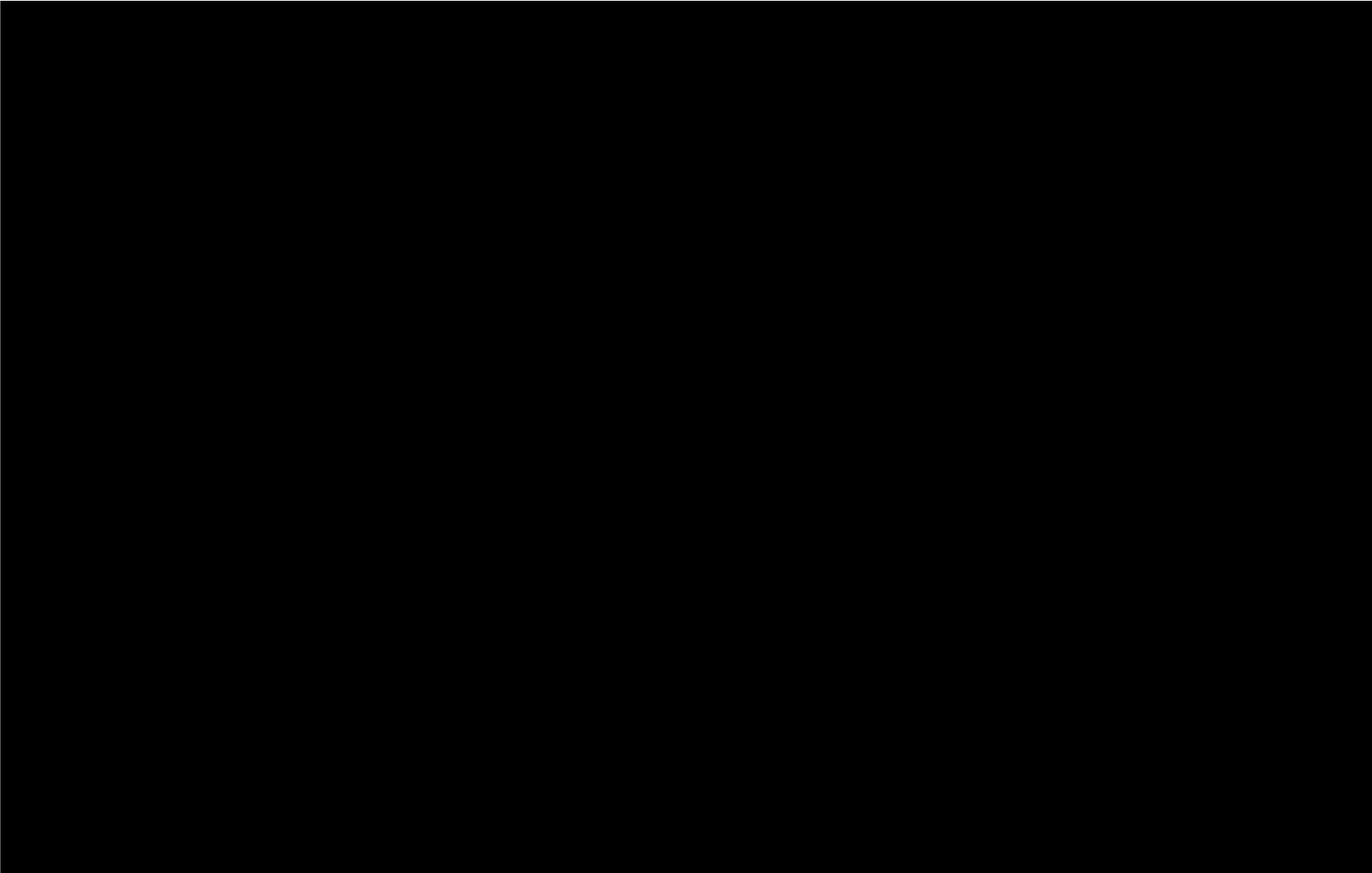


Figure 1 - Compressor and terminal periodic fugitive survey programme results.

Formulation of scope

Analysis of fugitive surveys undertaken to date shows that, on average across all surveys conducted, 14% of all fugitive emission sources identified are responsible for 50% of emissions. Therefore, by undertaking more frequent surveys, NGGT can identify these high fugitive emission sources faster and intervene sooner, thereby improving performance.

NGGT METHANE REOPENER APPLICATION DETECTION & ANALYTICS – OCTOBER 2022.

In addition, the current frequency of surveys at compressors and terminals does not allow for meaningful trending of methane emission performance at these installations. Results of total site fugitive emissions between surveys are highly variable and do not show the downward trend in fugitive emissions that literature suggests should be achieved through an effective gas escape detection and repair programme. For NGGT to demonstrate a reduction in fugitive emissions linked to the survey programme - and be able to trend this performance reduction through time - more frequent surveys are required.

The studies of Cheadle et al 2022¹ and Ravikumar 2020² show the fugitive emission reductions and trending of performance that can be achieved by a more frequent monitoring programme. These studies suggest annual reductions of fugitive methane emissions of between 4% and 22% could be achieved.

NGGTs current periodic fugitive survey programme covers compressors and terminals and, because of this, NGGT has no visibility of its fugitive methane emission performance at the other 509 Above Ground Installations (AGIs) on the NTS. NGGT wishes to address this gap in its understanding of its methane emission performance within this uncertainty mechanism submission. NGGT proposes there is a need for a proportional risk-based expansion of its programme, beyond compressors and terminals, to close this gap in understanding and reduce future reliance on estimation and assumption.

Through its membership of the Gas Transmission Benchmarking Initiative (GTBI), NGGT benchmarked its current periodic fugitive monitoring programme against other European Transmission System Operators (TSO). Other European TSOs undertake periodic fugitive monitoring at smaller above ground installations. Networks like NGGTs, show a potential doubling of fugitive emissions once all above ground installations are monitored. European TSOs are directly impacted by the proposed regulation of methane emissions, which mandates periodic fugitive inspection (LDAR) on a frequency between every six and 24 months for transmission system assets.

b. Options and selection methodology

NGGTs selection criteria and identification of its preferred option, is one that delivers a measurement based above ground network methane emission performance baseline by the end of the RIIO-2 period. Within this option, based on the current periodic gas escape detection programme, the level of periodic detection employed is proportional to the risk of fugitive emissions that NGGT could reasonably expect to identify based on both its experience from the programme and its view on the likelihood of identifying fugitive gas escapes at sites not previously surveyed.

As part of this theme, it is also important for NGGT to consider repair of gas escapes identified. There is recognition that funding for repairs should only be considered where Opex is needed. Where Capex investment is required this will be included in RIIO-3 asset health investments. If NGGT does not repair minor gas escapes, there will be an ever-increasing gas escape monitoring effort as surveys are completed and gas escapes identified. In addition to ever-increasing gas escape monitoring, NGGT will also be building an ever-increasing repair effort. A more efficient and environmentally beneficial use of this Opex effort is to repair where possible, rather than leave these gas escapes until RIIO-3.

There is a large variation in the size of above ground installations on the NTS. The smallest is a typical block valve and the largest is a terminal. The number of potential gas escape sources, and therefore the gas escape potential risk, is proportional to site size and the number of pressure holding assets on the site. Therefore, we propose to monitor and survey the largest sites, and those with the most pressure holding assets, at a greater frequency.

NGGT will follow its current methodology for periodic fugitive gas escape detection following BS EN 15446 for screening, followed by gas escape rate quantification using ground-based measurement techniques for accessible gas escapes and optical gas imaging (OGI) techniques for elevated sources. NGGT investigated the use of optical gas imaging cameras for elevated fugitive emission sources in the Monitoring of Realtime Fugitive Emissions (MoRFE) Network Innovation Allowance project.

¹ Arvind P Ravikumar et al 2020 Environ. Res. Lett. 15 <https://doi.org/10.1016/j.envc.2022.100563>

² Lucy C. Cheadle et al 2022 Environmental Challenges. Volume 8. 2022 100563 <https://doi.org/10.1088/1748-9326/ab6ae1>

NGGT METHANE REOPENER APPLICATION
DETECTION & ANALYTICS – OCTOBER 2022.

The options NGGT proposes follow its existing methodology, with the addition of OGI for survey of elevated sources. The presented options provide differing AGI survey coverage options and if repairs and monitoring are undertaken for detected gas escapes. Survey coverage options means the type of AGI to be surveyed. Where repairs are not undertaken, monitoring of gas escapes will continue until funding is available to allow intervention and subsequent repair.

In summary, the criteria NGGT has used in its selection of the preferred option is:

1. A proportional implementation approach of periodic fugitive site monitoring based on the number of pressure holding assets, combined with experience of gas escape performance from NGGTs current periodic survey programme.
2. The need to monitor gas escapes post-identification to comply with NGGTs gas escape management policies and procedures.
3. Cost efficiency of repair against monitoring post-gas escape identification.

The options NGGT has considered for an expanded periodic fugitive monitoring programme that address the gaps in its visibility and understanding of its fugitive emission monitoring performance are as outlined in Table 1. There is no Capex required as NGGT already has RIIO-2 baseline allowance for periodic gas escape detection equipment.

Table 2 - Periodic fugitive emission monitoring options.

Option	Preferred	Narrative
Option 1 – Maintain current periodic fugitive detection program for compressor stations and terminals.	No	<p>Not preferred as NGGT does not have full visibility of methane emission performance across its asset base. By choosing not to undertake investment in improved periodic fugitive monitoring, NGGT will not gain additional visibility of its fugitive methane emission performance outside of compressors and terminals. Without robust detection and quantification of emissions across its asset base, NGGT is unable to establish its full performance and drive down emissions with targeted investments. When NGGT benchmarks itself against other European transmission system operators, a measurement-based periodic detection programme across the entire transmission asset base has been implemented, for example by GasUnie and GRTGaz.</p> <p>This option does not align with the principles of the proposed European Union regulation³ on methane emissions, which mandate periodic gas escape detection and repair across all transmission system above ground assets.</p> <p>This option does not align with the opportunity identified in BEIS commissioned report by Fraser Nash⁴ on future fugitive hydrogen emissions in a future hydrogen economy. The report recommended work to improve the estimates for natural gas emissions from the NTS.</p>

³ Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on methane emissions reduction in the energy sector and amending Regulation (EU) 2019/942 <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2021:805:FIN>

⁴ Fugitive hydrogen emissions in a future hydrogen economy <https://www.gov.uk/government/publications/fugitive-hydrogen-emissions-in-a-future-hydrogen-economy>

NGGT METHANE REOPENER APPLICATION
DETECTION & ANALYTICS – OCTOBER 2022.

<p>Option 2 – Implement enhanced periodic fugitive gas escape detection from assets at NGGTs largest above ground installations on the transmission system including repair and monitoring of detected gas escapes until repair has been implemented.</p>	<p>No</p>	<p>NGGT could look to prioritise periodic detection across its largest AGIs in the first instance, however this is not the preferred approach.</p> <p>NGGT has never undertaken formal gas escape detection outside compressors and terminals and therefore feels that an intensive programme of survey through the remainder of the RIIO-2 period, to establish its performance across the entire transmission system, is the correct approach.</p>
<p>Option 3 – Implement enhanced periodic fugitive gas escape detection from assets at all above ground installation on the transmission system. Do not repair or monitor any gas escapes identified.</p>	<p>No</p>	<p>An enhanced capability will give visibility of fugitive methane emission performance at assets other than compressor stations and terminals and, coupled with continuous fugitive monitoring, will give a complete picture of methane emission performance across the transmission system. Implementation of periodic monitoring will bring NGGT up to the equivalent levels of monitoring undertaken by other European TSOs.</p> <p>NGGT will incorporate the improved understanding of its methane emission performance into its asset health replacement programmes and the prioritisation tools used within these. However, undertaking no monitoring of detected gas escapes is not compliant with NGGTs policies and procedures. Additionally, where an Opex repair can be undertaken, it is better use of consumers money to do this and realise some emission reduction, rather than build up an increasing gas escape monitoring and repair burden if no repairs are undertaken.</p>
<p>Option 4 - Implement enhanced risk based proportional periodic fugitive gas escape detection programme at all above ground installations on the transmission system. Undertake Opex repair of gas escapes identified for example where an injection of grease is required. Apply a gas escape monitoring programme to gas escapes where a Capex investment is required to resolve.</p>	<p>Yes</p>	<p>As per Option 3, except that gas escapes identified requiring Opex will be repaired. NGGT proposes an Opex allowance so that gas escapes identified from the enhanced gas escape detection programme can be repaired, while at the same time NGGT establishes its performance across the wider network. Where no funding is available to resolve and repair a gas escape, Opex is included in the requested allowance for gas escape monitoring until funding can be identified. Capex investments linked to gas escape resolution will be built into RIIO-3 asset health plans.</p>
<p>Option 5 – Procure periodic fugitive monitoring services from a third party</p>	<p>No</p>	<p>Required outcomes and deliverables would be achieved but at additional cost. NGGT outsources its current survey programme and has used quotes from this to determine what the Opex cost would be if the Option 4 programme was delivered externally. NGGT estimates the cost to be 100% greater than that of a programme delivered in-house. There is also an opportunity to undertake Opex repair in conjunction with periodic monitoring. With an outsourced</p>

NGGT METHANE REOPENER APPLICATION
DETECTION & ANALYTICS – OCTOBER 2022.

		programme efficient gas escape resolution by NGGT staff at the same time as identification would be lost.
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c. Preferred option

Periodic fugitive monitoring

NGGTs preferred option is to implement an enhanced risk-based proportional periodic fugitive gas escape detection programme at all AGIs on the transmission system. Additionally, this option will undertake Opex repair of gas escapes identified and apply a gas escape monitoring programme to any gas escapes where additional funding and investment is required to resolve. Capex required for gas escape resolution will be requested in RIIO-3, as availability of data to support robust cost estimates improves, and therefore evidence for a Capex allowance for repair. It is expected that greater certainty on gas escape repair costs will evolve as NGGT undertakes additional gas escape monitoring and more repairs.

A proportional risk-based approach to NGGTs proposal has been adopted by looking at the number of pressure holding assets at NGGTs different asset types. NGGT will undertake a phased approach to this monitoring, undertaking annual monitoring of compressors, terminals, and multi-junctions, and a third of its remaining above ground assets, in each of the three remaining years of RIIO-2. This proportional risk-based approach ensures that by monitoring 21% of NGGTs above ground asset base, it is monitoring 83% of pressure holding assets on the NTS on an annual basis. Periodic monitoring is a manual process requiring Opex to carry out this activity.

In addition to the Opex survey effort, NGGT wishes to apply for funding within this category for Opex repair and temporary monitoring of gas escapes identified, where the repair cannot be implemented without Capex investment - as such, NGGT has requested an Opex allowance for the continued monitoring of detected gas escapes. This is in line with NGGTs gas escape monitoring policies and procedures which balance the operational cost of implementation against the safety and environmental risk of asset failure which a gas escape monitoring programme seeks to mitigate. In addition to the survey effort, the cost build-up for the preferred option is as per Figure 2 below.

The cost build-up in Figure 2 is based on NGGTs best available data from its existing fugitive survey programme and a number of informed assumptions. Additional detail on assumptions used in NGGTs cost build-up can be found in Table 3.

NGGT will maintain the gas escape threshold of its current periodic fugitive monitoring programme of compressors and terminals. In its current survey programme, a gas escape is defined as a measurement of methane of 10,000 parts per million or greater measured at 1 centimetre from a component. NGGT follows BS EN 15446 for screening of components following this threshold. The US Environmental Protection Agency (EPA) equivalent standard to BS EN 15446, EPA Method 21, sets a typical gas escape threshold of 10,000 ppm, which NGGT has adopted. The threshold is the gas escape/no gas escape definition that NGGT will use in its proposed gas escape detection programme, however this will be reviewed for RIIO-3 based on the methane emission performance identified from the expanded gas escape detection programme.

For gas escapes found to be above this threshold, a gas escape rate determination will be undertaken to determine total site fugitive mass emission rate. Potential gas escape sources at height will be screened using optical techniques (such as optical gas imaging) and an estimate of the gas escape rate included in total site mass emission estimates.

NGGTs proposed level of periodic detection of fugitive emissions is typical of that currently undertaken by other TSOs across Europe and aligns with the methane emissions regulation proposed by the European Commission and the monitoring provisions within. Implementation of periodic monitoring, as proposed, will provide NGGT with visibility of fugitive emissions from across its asset base and allow NGGT to establish a performance baseline during the remaining RIIO-2 period. NGGT will review and optimise its periodic monitoring approach for RIIO-3, taking onboard what it has learnt. Application of continuous monitoring will also form part of this optimised approach for fugitive gas escape detection and monitoring.

NGGT METHANE REOPENER APPLICATION
DETECTION & ANALYTICS – OCTOBER 2022.

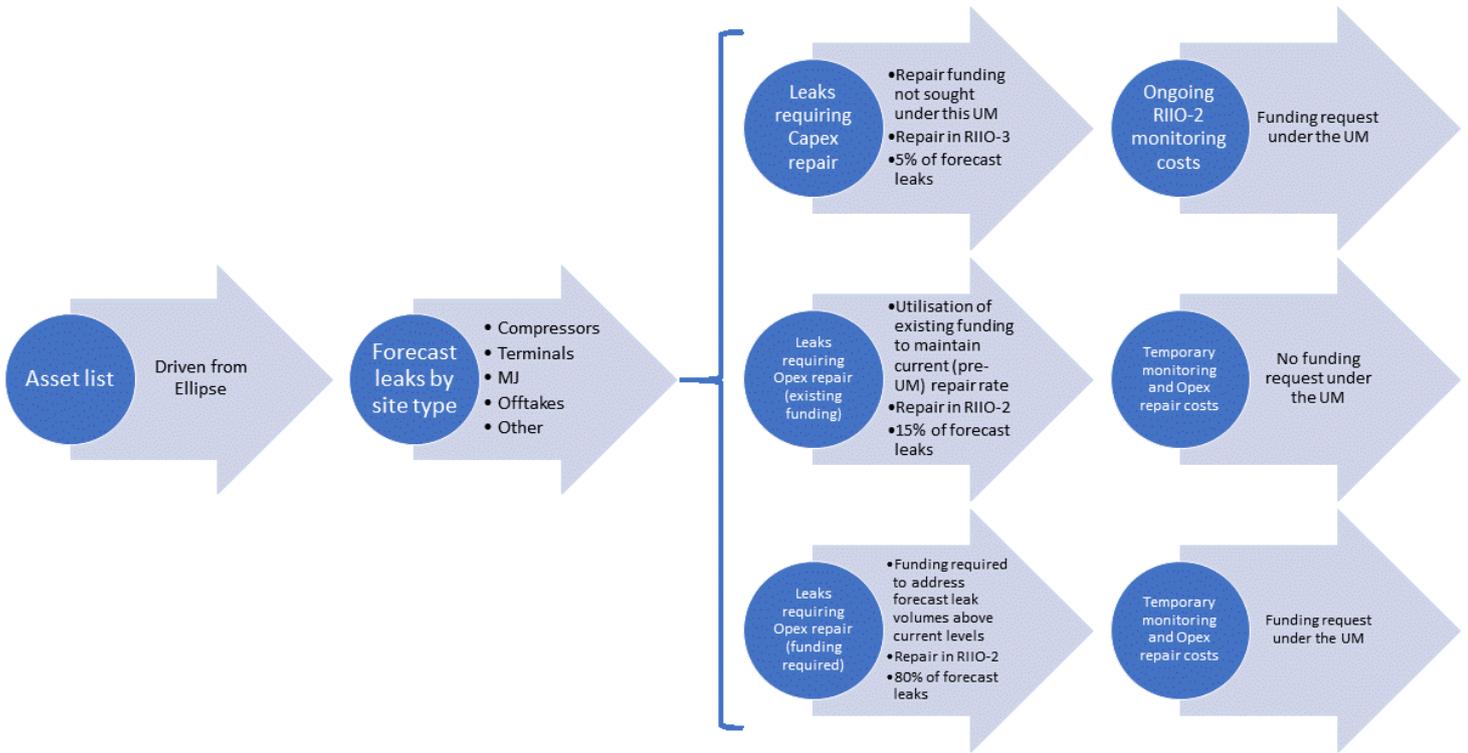


Figure 2 - Preferred option monitoring and repair cost build-up

d. Costs

The investment is to establish NGGTs methane emission performance by undertaking periodic fugitive monitoring and repair across its entire above ground asset base. The value of the investment is predominantly in the acquisition of knowledge and understanding relating to fugitive emission performance.

A cost benefit approach based on emission reduction, and a payback period calculated on the basis of that reduction, has, therefore, not been followed for this investment category. Emission reduction will be achieved through Opex repairs, but the amount of reduction cannot be quantified due to uncertainties regarding what gas escapes NGGT may find on a transmission network that has not been previously surveyed to the extent of the proposed survey programme. The extent of fugitive emission reduction that can be achieved from a periodic fugitive monitoring programme can be found in the studies of Cheadle and Ravikumar referenced in the '2a Needs Case'.

The monetary carbon value of known fugitive emissions from NGGTs survey of compressors and terminals has been provided along with the wholesale value of that gas for information.

Table 3 - Costs, assumptions, risks, and mitigations of periodic fugitive gas escape detection programme.

Periodic fugitive monitoring	Option 4 - Implement enhanced risk-based proportional periodic fugitive gas escape detection programme at all AGIs on the transmission system. Undertake Opex repair of gas escapes identified - for example where an injection of grease is required. Apply a gas escape monitoring programme to gas escapes where a Capex investment is required to resolve.
Category value (CO2e)	£1.75m. Note – based on limited current periodic monitoring programme, covering compressor stations and terminals only
Wholesale gas value	£0.06m
Capex	£0.0m
Opex	██████████
Assumptions & rationale:	<ul style="list-style-type: none"> • No Capex required to implement periodic monitoring survey programme. MoRFE funding awarded in RIIO-2 final determination (£980k) has been repurposed and utilised to cover Capex requirements. • Periodic fugitive monitoring effort Opex is based on annual survey of compressors, terminals, multi-junctions, and one third of remaining AGIs being surveyed in each year remaining of RIIO-2. NGGT believes this is a balanced risk-based approach, focusing on monitoring frequency on those installations with the most potential gas escape sources. • Repair and monitoring of detected gas escapes Opex is based on the average number of gas escapes identified per periodic monitoring survey for compressors and terminals, and the number of pressure holding assets at these sites. A percentage of pressure holding assets found to have gas escaping has been calculated and the same percentage applied to the other sites to estimate the total number of gas escapes NGGT could potentially expect to find where no formal gas escape detection has previously been undertaken. A gas escape repair cost has been estimated from Ellipse work order records and historical records of gas escape repair costs.

NGGT METHANE REOPENER APPLICATION
DETECTION & ANALYTICS – OCTOBER 2022.

	<ul style="list-style-type: none"> Opex has then been calculated for the repair of these gas escapes, where no Capex investment is required, together with the monitoring effort associated with checking gas escapes from the point of identification to the point of repair, and the ongoing monitoring of gas escapes where Capex investment is needed to resolve. NGGT is required to monitor gas escapes it identifies to ensure these do not get worse over time thereby posing a greater environmental or safety risk. NGGT has assumed a 10% reduction in the number of gas escapes identified for each year of the enhanced periodic monitoring programme. A Capex repair allowance has not been requested. Gas escapes requiring Capex investment will be included in RIIO-3 asset health investment.
Risks, mitigations and further commentary	<ul style="list-style-type: none"> Actual emissions in this category, and Opex/Capex requirements needed to reduce emissions, will be better defined once monitoring is installed and further analysis takes place over the remainder of RIIO-2. This will inform NGGTs Capex investment strategy to drive down unresolved gas escapes and allow an optimised fugitive monitoring strategy to be developed, combining both periodic and continuous detection methods for RIIO-3. There is a risk that the assumptions made to forecast the Opex associated with gas escape monitoring and repair are not realistic. These assumptions drive the requested allowances so if, for example, more gas escapes are identified than NGGT forecasts, or the Opex cost associated with repair is greater, NGGT risks not being able to deliver the periodic monitoring programme within requested allowances.

The cost phasing associated with the periodic fugitive monitoring preferred option in 2018/19 pricing, including a breakdown of the elements comprising the funding request, is outlined in Table 4.

Table 4 - Opex cost phasing for periodic fugitive monitoring preferred option in 2018/19 pricing.

RIIO-2	22/23	23/24	24/25	25/26	Total
Periodic survey programme	£0m				
Gas escape monitoring of 'capex' repairs	£0m				
Gas escape monitoring of planned repairs	£0m				
'New' repair Opex	£0m				
Total	£0m				

e. Delivery plan

The periodic fugitive monitoring that NGGT wishes to implement will be delivered according to the following delivery programme and will be delivered in-house by the NGGT Operations department. NGGT has a ISO17025 accredited stack emission monitoring laboratory and, whilst not currently accredited for the measurements required under this monitoring programme, NGGTs intention is to obtain this accreditation within the RIIO-2 price control to provide quality assurance and control on the measurements being undertaken.

In establishing its delivery plan in Table 5, and the costs for its proposed periodic monitoring programme, NGGT has assumed that each site can be reached by a 50-mile journey and that an overnight stay would be required for four nights in a five-day working week. It is envisaged that the programme will be delivered by a dedicated team, with sites to be surveyed undertaken in one-week blocks, with reporting and data analysis taking place the following week. This rationale has been followed for the cost build-up and delivery plan.

Table 5 - Periodic fugitive emissions monitoring delivery plan.

RIIO-2	2021/22	2022/23	2023/24	2024/25	2025/26
Deliverables		Procurement of periodic fugitive emissions monitoring equipment and desktop/site-based training for the team. Shadowing of third-party contractor carrying out existing periodic fugitive surveys for 2022/23. Development of monitoring procedures using own equipment.	Periodic fugitive surveys in-house of all compressor stations, terminals and multi-junctions using developed procedures. Survey 1/3 of other AGIs. Participate in proficiency testing as a provider of periodic fugitive monitoring services and apply for accreditation.	Periodic fugitive survey at all compressor stations, terminals and multi-junctions. Survey 1/3 of AGIs not yet tested. Obtain accreditation for periodic fugitive monitoring methods to bring within scope of ISO17025 accredited laboratory.	Periodic fugitive survey at all compressor stations and terminals and multi-junctions. Survey remaining 1/3 of AGIs not tested so all assets have been fully monitored at least once.

NGGT has already begun the process of upskilling existing staff for successful delivery and can deliver the programme described to deliver a measurement-based methane emission baseline for the NTS by the end of the RIIO-2 period, subject to successful recruitment of additional headcount following award.

By the end of the RIIO-2 price control period, NGGT will deliver:

- A measurement-based above ground network methane emission performance baseline, combining understanding from periodic and continuous fugitive detection.
- An annual periodic monitoring campaign covering a proportion of its above ground assets. To allow the periodic monitoring campaign to be delivered within allowances agreed under this uncertainty mechanism submission, and mitigate the risk outlined in Table 3 that Opex costs are assumption driven. The periodic monitoring programme to be delivered shall be agreed with Ofgem on an annual basis taking the learning of gas escape performance from the preceding year to allow the agreed programme to be delivered within allowance.

- A report outlining NGGTs optimised fugitive gas escape detection strategy combining periodic and continuous monitoring methods. The report will also include an analysis of the typical sources of fugitive emissions from NTS assets and the costs of repair. The report and analysis will contribute to, and inform, NGGTs RIIO-3 fugitive gas escape detection and repair strategy.

NGGT will report on progress within the Regulatory Reporting Pack (RRP) Net Zero strategic narrative for the remainder of RIIO-2. Within its narrative, NGGT will report on progress on the deliverables and outputs detailed above, to include efficient delivery of the periodic fugitive monitoring programme.

3 Continuous fugitive monitoring

a. Needs case/problem statement

Problem statement

NGGT, with partners, have developed a continuous fugitive monitoring system for research and development purposes and investigated its value for fugitive methane gas escape detection in a series of innovation projects. These projects showed that NGGT has short duration fugitive emission events at ground level and at height, which would otherwise be missed by periodic detection alone. These short duration events are large enough to potentially contribute a significant amount to the total site fugitive emissions and, therefore, require detection and management. Deployment of continuous monitoring at compressors and terminals would bring approximately 70% of pressure holding assets on the NTS under permanent fugitive gas escape monitoring.

In addition, NGGT will use the capability of these continuous fugitive monitoring systems to automatically issue alerts of fugitive emission events to individuals permanently based at the sites where monitoring systems are installed, so that they can investigate the source and implement appropriate remediation.

NGGTs innovation work in this area began in 2013 with NGGTs involvement as an industrial partner in the Climate KIC co-ordinated project “Fugitive Methane Emissions from hard-to tackle sites and sources”. In this project, NGGT partnered with the National Physical Laboratory, academics at Laboratoire des Sciences du Climat et de l’environnement (LSCE) in Paris and industrial partners Veolia, CEREAL, ARIA Technologies and Cuadrilla Resources. The Climate KIC project deployed a prototype continuous fugitive monitoring system and demonstrated how the system could be valuable for identifying fugitive emission events that would be missed by periodic survey and inspection.

NGGT followed up this initial deployment of a prototype continuous fugitive monitoring system by partnering with the National Physical Laboratory to fulfil Special Condition 8J of the Gas Transporter Licence; Greenhouse Gas Investigative Mechanism (GHGIM). The prototype was deployed at the Bishop Auckland and Moffat compressor stations and, through trials at these installations, NGGT has gained an improved understanding of sources of venting and fugitive methane emissions at compressor stations and quantified these. In addition, NGGT validated the monitoring system output with periodic survey, tested the portability of the prototype, and produced probability maps of the likely venting and fugitive emission source areas within the test installations. Ofgem agreed that NGGT had fulfilled the requirements of the Special Condition and that deliverables set out in the original business plan had been fulfilled. NGGT were awarded full recovery of costs incurred.

NGGT followed up the proof-of-concept demonstration of the continuous fugitive detection system developed in the GHGIM with the Monitoring of Realtime Fugitive Emissions (MoRFE) project funded through the Network Innovation Allowance (Ref. NIA_NGGT0137). MoRFE took the proof-of-concept monitoring system at TRL3 to TRL7 Inactive commissioning and involved extended trials at two compressor stations and a gas terminal. MoRFE also investigated lower cost materials and instrumentation to try to lower the capital cost of implementation of the continuous monitoring system, improvements to the monitoring methodology, and a work package to investigate into the use of optical gas imaging cameras for fugitive gas escape detection.

The GHGIM and MoRFE projects both demonstrated the value of continuous monitoring for detection and quantification of whole site fugitive emissions, and their ability to detect short duration emission events at ground level and at height, which would otherwise be missed by periodic detection. NGGTs innovation and

NGGT METHANE REOPENER APPLICATION DETECTION & ANALYTICS – OCTOBER 2022.

trials to date demonstrate the needs case for this technology and its ability to detect fugitive emissions occurring in between periodic survey. Figure 3 below shows the variation in emission rates detected during the site measurement campaigns conducted during the MoRFE innovation projects. NGGTs current periodic monitoring programme estimates Bacton Terminal's fugitive emission performance at approximately 30 tonnes per year. Greater fugitive emissions are being detected at Bacton Terminal by the continuous monitoring system, indicating presence of fugitive emissions which are being missed by periodic survey alone.

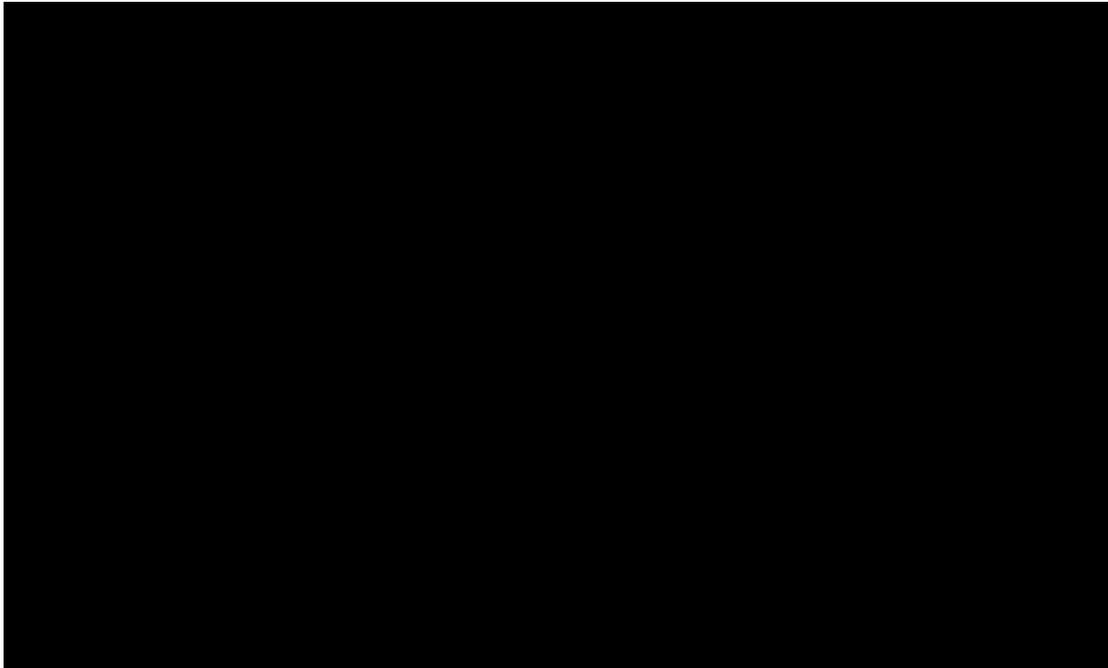


Figure 3 - Weekly mass emission rate estimates from MoRFE field campaigns.

A deployment of continuous monitoring at compressors and terminals will allow NGGT to consider potential extended roll out in RIIO-3 at other AGIs as part of an optimised efficient gas escape detection programme, combining periodic and continuous monitoring methods.

b. Options and selection methodology

NGGTs selection criteria and identification of its preferred option is one that delivers a measurement-based above ground network methane emission performance baseline by the end of the RIIO-2 period. Furthermore, the level of continuous detection employed are proportional to the risk of fugitive emissions that NGGT could reasonably expect to identify, based on its experience from its current periodic gas escape detection programme, innovation work developing a continuous fugitive emission monitoring system and its view on the likelihood of identifying fugitive gas escapes at sites not previously surveyed.

There is a large variation in the size of each of the installations which comprise the AGIs on the NTS. At their smallest, a typical block valve, and largest, a gas terminal. The number of potential gas escape sources - and therefore the gas escape potential risk - is proportional to asset size, therefore a proportional risk-based approach to implementing continuous monitoring is to deploy at the largest sites with most potential gas escape points and/or pressure holding assets. NGGT has only considered deployment of continuous monitoring at compressors and terminals, building on the short duration deployment in previous innovation projects.

Development of continuous fugitive emission monitoring systems is an area of rapid development with more commercially available solutions coming to market as the focus on methane emissions from natural gas supply has increased. NGGT is, therefore, not specifying the technology or monitoring method it wishes to deploy in this submission. The technology and methodology selection will be locked down post-award and following a tender process with qualifying suppliers. NGGT has provided a range of quotes from different continuous monitoring suppliers to justify the investment requested.

NGGT METHANE REOPENER APPLICATION
DETECTION & ANALYTICS – OCTOBER 2022.

An Opex lease-based business model with suppliers is preferred by NGGT as this provides NGGT with the flexibility to review the marketplace at the point of establishing its RIIO-3 business plan, with consideration given to an optimised gas escape detection programme combining both periodic and continuous monitoring methods. This allows NGGT, if appropriate, to move to a different technology for RIIO-3 should an improved offering come to market. In addition, this approach would enable NGGT to potentially enter into a contractual agreement with a provider which does not have tie-ins beyond year five of RIIO-2. A technology provider which allows this flexibility may have higher costs associated with it. However, given the developing market conditions for this monitoring technology, it is preferred to mitigate the risk of having outdated or sub-optimal equipment. The availability of these options from suppliers has been used in the selection of the preferred option.

In summary, the criteria NGGT has used in its selection of the preferred option, and quote selection, are:

1. A proportional implementation based on the largest sites with most potential gas escape points and/or number of pressure holding assets to be continuously monitored, while considering what NGGT has already learnt regarding the value of continuous monitoring through previous innovation projects.
2. Availability of Opex only hire/rental option so as not to tie NGGT into a particular solution, given this is an area of rapid technological development.
3. Availability of Opex only hire/rental with flexible hire periods allowing phased deployment.
4. The maturity of the technology and the extent of implementation in the oil and gas industry.

NGGT has considered the following options related to the deployment of continuous fugitive monitoring systems on the NTS:

Continuous fugitive monitoring (note – repair and monitoring effort of detected fugitive gas escapes is included in periodic monitoring)

Table 6 - Continuous fugitive emission monitoring survey options.

Option	Preferred	Narrative
Option 1 - Do nothing	No	Do not implement continuous fugitive monitoring at compressor stations and terminals on the NTS. This is not preferred as NGGT does not have full visibility of methane emission performance across its asset base and previous innovation work has shown short duration spikes in methane emissions from its largest assets which would only be detectable with continuous monitoring. These short duration spikes in emissions also generally occur from elevated sources (vents) which are best suited to detection by continuous monitoring methods. This option does not align with the opportunity identified in BEIS commissioned report by Fraser Nash on future fugitive hydrogen emissions in a future hydrogen economy. The report recommended work to improve the estimates for natural gas emissions from the NTS.
Option 2 – Implement a flexible length lease/hire agreement with a continuous fugitive measurement system provider for enhanced continuous fugitive gas escape detection from compressor stations and	Yes	Work undertaken by NGGT to fulfil special condition 8J of the Gas Transporters Licence in the RIIO-1 periodic known as the Greenhouse Gas Investigative Mechanism (GHGIM) and subsequently further developed in the Network Innovation Allowance (NIA) project has shown short duration emission spikes from

NGGT METHANE REOPENER APPLICATION
DETECTION & ANALYTICS – OCTOBER 2022.

<p>terminals on the transmission system to allow phased deployment.</p>		<p>elevated sources, which can only be detected by continuous monitoring methods.</p> <p>NGGT considers it proportional, based on the improved understanding on fugitive emission sources from its innovation work, to install continuous fugitive emission monitoring systems at its compressor stations and terminals. Deployment at these sites would mean approximately 70% of pressure holding assets on the NTS were being continuously monitored for fugitive gas escapes.</p> <p>NGGT can assess the effectiveness of these continuous monitoring systems for monitoring of fugitive methane emissions for the remainder of the RIIO-2 period and consider the appropriateness for a wider implementation of continuous monitoring in RIIO-3. The aim would be to provide an optimised gas escape detection programme combining periodic and continuous detection methods.</p> <p>Flexible length lease/hire arrangement allowing for phased deployment of continuous monitoring systems.</p>
<p>Option 3 - Implement a flexible length lease/hire agreement with a continuous fugitive measurement system provider for enhanced continuous fugitive gas escape detection on 50% of compressor stations and terminals on the transmission system.</p>	<p>No</p>	<p>The GHGIM and MoRFE NIA demonstrated the value of continuous fugitive monitoring in detecting emissions of short duration and those occurring at height at compressors and terminals. If NGGT only implemented this monitoring at 50% of compressors and terminals, NGGT would not be taking the learning from the previous innovation projects and implementing this into improved business processes and business as usual.</p> <p>This option gives a limited opportunity to understand how a continuous fugitive emission monitoring system fits into an optimised gas escape detection programme combining continuous and periodic methods for RIIO-3.</p>
<p>Option 4 - Implement a fixed length lease/hire agreement with a continuous fugitive measurement system provider for enhanced continuous fugitive gas escape detection from compressor stations and terminals on the transmission system.</p>	<p>No</p>	<p>Rejected as this would not allow NGGT flexible phased deployment across terminals and compressor stations.</p>
<p>Option 5 – Purchase continuous fugitive measurement systems for deployment at compressor stations and terminals on the transmission system.</p>	<p>No</p>	<p>Rejected as this could lead to NGGT being left with a stranded asset as the marketplace for continuous fugitive methane monitoring systems is developing quickly to respond to the measurement and detection requirements of the oil and gas industry. Although marginally cost efficient over lease/hire for the</p>

NGGT METHANE REOPENER APPLICATION
DETECTION & ANALYTICS – OCTOBER 2022.

		deployment NGGT proposes, it generates a risk of being left with out-of-date equipment.
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c. Preferred option

NGGTs preferred option is to implement continuous fugitive emission detection at compressor stations and terminals on the NTS. This option builds on the learning from NGGTs understanding of fugitive emission performance, from its innovation projects as part of the GHGIM and Network Innovation Allowance funded project MoRFE. These projects demonstrated the value of continuous monitoring for identifying short duration fugitive emission events and detecting at height fugitive emission sources. The value of continuous fugitive monitoring and recognition of what NGGT achieved in the GHGIM was acknowledged by Ofgem in its GHGIM award letter of the 27th March 2018⁵.

Implementing continuous monitoring at all compressors and terminals, in combination with periodic monitoring in parallel at these sites, will allow NGGT to assess the capability of continuous monitoring systems for fugitive emission detection and management. Deployment of continuous monitoring, of the scale within the preferred option, will provide NGGT with the evidence it needs to propose an efficient optimised fugitive emission management programme for RIIO-3, combining periodic and continuous monitoring methods.

In its selection of the preferred option, NGGT has worked through the different options of compressor and terminal deployment, from limited compressor and terminal site deployment to full deployment at these sites. In addition, available hire, lease, and purchase arrangements, have been explored with potential suppliers, along with the cost benefits and risks associated with the different arrangements. The technology maturity of the supplier solutions has also been considered, along with an indicative assessment as to their delivery capability.

NGGT will go to tender following any funding award where these factors will be explored in greater depth and a quantitative assessment made on the supplier to deliver NGGTs preferred option to ensure best value for consumers. At the point of this submission, NGGT remains technology and supplier agnostic.

NGGT has provided quotes from different suppliers of continuous fugitive monitoring systems as evidence of the costs associated with the implementation of this technology at compressors and terminals. Of the supplier quotes provided NGGT has selected [REDACTED] as the best suited to meet NGGTs requirements and the best fit to the selection criteria is outlined in Section 8C of this submission.

d. Costs

As with periodic monitoring, this investment is to contribute to NGGTs understanding of its methane emission performance by implementation of continuous fugitive monitoring across compressors and terminals on the NTS.

A cost benefit approach based on emission reduction, and a payback period calculated on the basis of that reduction, has therefore not been followed for this investment category.

The monetary carbon value of known fugitive emissions from NGGTs survey of compressors and terminals has been provided, along with the wholesale value of that gas for information.

⁵ Ofgem GHGIM award letter dated 27th March 2018
https://www.ofgem.gov.uk/sites/default/files/docs/2018/03/20180312_ghgim_decision_letter_2018_final.pdf

NGGT METHANE REOPENER APPLICATION
DETECTION & ANALYTICS – OCTOBER 2022.

Table 7 - Costs, assumptions, risks and mitigations of continuous fugitive gas escape detection programme.

Continuous fugitive monitoring	Option 2 – Procure and implement monitoring equipment for enhanced continuous fugitive gas escape detection from compressors stations and terminals on the NTS.
Category value (CO2e)	£1.75m. Note – based on limited current periodic monitoring programme covering compressor stations and terminals only.
Wholesale gas value	£0.06m
Capex	£0m
Opex	██████
Assumptions & rationale:	<ul style="list-style-type: none"> • Annual Opex is for supplier-hosted data management and analysis. • No further annual Opex is sought, as the repair and monitoring Opex requested in periodic monitoring will cover Opex gas escape repair and monitoring of detected gas escapes found through both periodic and continuous monitoring. • Annual benefits may increase or decrease over time depending on the true condition of the network, the actual impact repairs have on network emissions, and the rate at which new emission sources are found. • A Capex repair allowance is not included in NGGTs investment request. Gas escapes requiring Capex investment will be monitored and repaired once investment is secured through RIIO-3 Asset Health investment.
Risks, mitigations and further commentary	<ul style="list-style-type: none"> • Actual emissions in this category, and Opex/Capex requirements needed to reduce emissions, will be better defined once monitoring is installed and further analysis takes place over the remainder of RIIO-2. This will inform NGGTs Capex investment strategy to drive down unresolved gas escapes and allow an optimised fugitive monitoring strategy to be developed combining both periodic and continuous detection methods.

The cost phasing associated with the continuous fugitive monitoring preferred option in 2018/19 pricing including is outlined in Table 23.

Table 8 - Opex cost phasing for continuous fugitive monitoring preferred option in 2018/19.

RIIO-2	22/23	23/24	24/25	25/26	Total
Continuous fugitive monitoring	£0m	██████	██████	██████	██████

NGGT will check costs prior to award to mitigate risks related to equipment price changes associated with exchange rate and RPE changes. 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.

e. Delivery plan

The continuous fugitive monitoring that NGGT wishes to implement will be delivered according to the following delivery programme for the remainder of RIIO-2. NGGT will take responsibility for operation and maintenance, however these units are designed to be autonomous with near-zero maintenance required. In general, a replacement on unit failure approach will be followed and it is envisaged that the selected supplier will hold spares to be deployed at short notice in the event of failure for NGGT replace, to ensure continuity of monitoring. This oversight of the continuous monitoring systems deployed at compressors and terminals will require no additional headcount for delivery.

Table 9 - Continuous fugitive emission monitoring delivery plan.

Financial Year	2021/22	2022/23	2023/24	2024/25	2025/26
Deliverables		Procurement of continuous fugitive emissions monitoring equipment and desktop/site-based training on operation of selected system for deployment.	Install and commission continuous monitoring systems at eight compressors and terminals on the NTS.	Install and commission continuous monitoring systems at seven compressors and terminals on the NTS.	Install and commission continuous monitoring systems at seven compressors and terminals on the NTS.

Note – Moffat and Warrington compressor stations have been excluded from deployment as these stations are to be decommissioned.

NGGT has already begun the process of upskilling existing staff for successful delivery and can deliver the continuous monitoring programme described to contribute to the formulation of a measurement-based methane emission baseline for the NTS by the end of the RIIO-2 period.

NGGT by the end of the RIIO-2 price control will deliver:

- A measurement-based above ground network methane emission performance baseline combining understanding from periodic and continuous fugitive detection.
- Deployment of continuous fugitive monitoring systems at compressors and terminals on the NTS.
- A report outlining NGGTs optimised fugitive gas escape detection strategy, combining periodic and continuous monitoring methods.

NGGT will report on progress within the Regulatory Reporting Pack (RRP) Net Zero strategic narrative for the remainder of RIIO-2.

4 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 methane emission and detection 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 gas escapes 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 to implement enhanced fugitive methane emission detection and analytics across our network. 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 Detection and Analytics is submitted as a separate application in order to adhere to the materiality threshold. It is noted that our submission is over the £10.7m threshold as specified by Ofgem. However, NGGT and Ofgem, through bi-lateral discussions, have agreed that this submission may be submitted over the threshold, pending a licencing change on the materiality threshold being implemented ahead of a decision on this re-opener.
- 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 detection 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.

5 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
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
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
QRA	Quantitative Risk Assessment
TSO	Transmission system operator
UM	Uncertainty mechanism